



Garden Resource Guide

SUPPORTING GARDEN INTERVENTION DESIGN AND IMPLEMENTATION

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Acronyms

BC	Behavior Change
BCC	Behavior Change Communication
CCFLS	Community-Led Complementary Feeding and Learning Sessions
CDNIP	Community Driven Nutrition Improvement Project
cm	Centimeter
CRS	Catholic Relief Services
CTAS	Centre Technique Agroécologique du Sud
DFAP	Development Food Assistance Program
DHS	Demographic and Health Survey
DiNER	Diversification for Nutrition and Enhanced Resilience
DND	Doer/Non-Doer
DSD	Direct Seed Distribution
ECHO	Educational Concerns for Hunger Organization
ECS	Evaporative Cooling System
FA	Field Agent
FAO	Food and Agriculture Organization of the United Nations
FASO	Families Achieving Sustainable Outcomes
GLEE	Global Learning and Evidence Exchange
gm/cc	Green Manure/Cover Crop
HDDS	Household Dietary Diversity Score
HIV	Human Immunodeficiency Virus
IEE	Initial Environmental Examination
IFAD	International Fund for Agricultural Development
IP	Implementation Plan
IPM	Integrated Pest Management
KAP	Knowledge, Attitude and Practice
LSP	Livelihood Support Programme
M&E	Monitoring and Evaluation
MAD	Minimum Acceptable Diet
MDD-W	Minimum Dietary Diversity—Women
MEAL	Monitoring, Evaluation, Accountability and Learning
MICS	Multiple Indicator Cluster Survey
NGO	Nongovernmental Organization
OFSP	Orange-Fleshed Sweet Potato
OP	Open Pollinated
PERSUAP	Pesticide Evaluation Report and Safe Use Action Plan
PIRS	Performance Indicator Reference Sheets
PM	Program Manager
PRA	Participatory Rural Appraisal
PRIZE	Promoting Recovery in Zimbabwe
PROGRESA	Program of Business Management, Health and Rural Environment
PSP	Private Sector Partner
PVC	Polyvinyl Chloride
PWD	People With Disabilities
RAPID	Resilient Arid Lands Partnerships for Integrated Development
RDI	Rural Development Institute
REAAP	Resilience through Enhanced Adaptation, Action-Learning, and Partnership
RH	Relative Humidity

ROI	Return On Investment
SBC	Social Behavior Change
SDC	Swiss Development Corporation
SEGAMIL	Seguridad Alimentaria Enfocada en los Primeros 1,000 Días
SILC	Savings and Internal Lending Communities
SMART	Skills for Marketing and Rural Transformation
SMART	Strengthening Marriages and Relationships through Communication and Planning
SOP	Standard Operating Procedure
SPHI	Sweetpotato for Profit and Health Initiative
SPRING	Strengthening Partnerships, Results, and Innovations in Nutrition Globally
SSSA	Seed System Security Assessment
SVF	Seed and Voucher Fair
TOPS	Technical and Operational Performance Support
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USG	United States Government
VPC	Vegetative Propagated Crops
WALA	Wellness and Agriculture for Life Advancement
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization
WUA	Water-User Association
ZECC	Zero-Energy Cool Chamber

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Chapter 1: Introduction

Gardens are a widely implemented intervention in development programming that can deliver positive results in the areas of nutrition, agricultural income and women’s empowerment. Gardens are used in many different contexts to achieve varying objectives. In Ethiopia, projects have used gardens to strengthen household resilience and nutrition (REAAP, 2014–2017; DFAP, 2011–2016). In Timor Leste, mothers were taught about gardens to increase dietary diversity (CDNIP, 2014–2018). In Burkina Faso, large irrigated communal plots were successfully developed for women’s groups to support food diversification and revenue generation (USAID FASO, 2010–2018). In Kenya, farmers invested in shade netting to increase productivity for home consumption and market sales (RAPID, 2015–2020). In Nicaragua, farmers established highly commercial production plots linked to supermarkets (USDA PROGRESA, 2015–2019).

Gardens are typically implemented to improve nutrition, with the potential benefits of increased income and women’s empowerment, and can also be used as a basis for a small business. A recent systematic literature review found that the success of gardens in achieving nutrition objectives was contingent on nutrition education and gender-sensitive strategies (Girard, Self, McAuliffe and Olude, 2012)¹ as well as having an explicit nutrition objective.

There are three main pathways along which gardens can lead to improved nutrition. First, by directly increasing dietary diversity and micronutrient intake. Second, by using the income from the sale of garden products to buy other nutritious foods or support household health by buying water, sanitation and hygiene (WASH)-related products, such as soap or health services. Third, by supporting women’s empowerment. Women tend to be the main caretakers of gardens, and well-designed interventions that consider existing gender dynamics can result in women having greater influence over household decisions, income use and their personal time allocation.

With significant use of gardens in development programming, it is important to centralize good practices in a toolkit. This resource guide, a component of the *Garden Toolkit*, can be considered the next iteration of Catholic Relief Services’ 2008 *Homestead Gardening: A Manual for Program Managers, Implementers, and Practitioners*.



The success of gardens in achieving nutrition objectives is contingent on nutrition education and gender-sensitive strategies.

1. Gender-sensitive strategies:

- Enhance women’s roles in agriculture—including contributing to decision-making over what is produced, why, and how—through increased access to assets, inputs and services
- Facilitate women’s access to opportunities to generate income and increase their participation in decisions on the use of household income
- Promote a more equitable division of time and labor needed to ensure better nutrition (USAID 2014)

Whereas the previous manual was a compilation of best practices coming from one specific project in Lesotho, this one compiles best practices derived from multiple countries and spans multiple sectors, such as agriculture, nutrition, behavior change, gender, postharvest handling, marketing, and monitoring and evaluation to support teams in implementing successful, sustainable gardens. Contributions are from many experts and the manual includes examples from several CRS programs across the globe.

This resource guide is intended for staff members who are supporting the design and/or implementation of gardens. It is a resource of 14 chapters that provides overall knowledge and good practices related to specific garden subject areas. Chapter 2 provides two types of assessment that are intended to help project designers and program managers understand the local context. The first assessment supports project designers in making decisions about the inclusion of garden interventions into the project implementation plan. The second assessment supports program managers in better understanding cultural preferences, gender dynamics, constraints and opportunities to help tailor the garden intervention design to the local context. Chapter 3 focuses on the broad aspects of planning a garden, including a description of seven types of gardens that can be promoted to target audiences based on their available resources, needs, constraints and opportunities. Chapter 4 describes key factors that influence what crops to promote in the garden. Chapter 5 discusses how to apply a gender lens to garden design and implementation, and shares examples of ways to ensure that the garden intervention is *at least* gender responsive—if not transformative. Chapter 6 supports teams in using a nutrition lens for planning a garden intervention as well as practical approaches for encouraging consumption of garden produce.

Chapters 7 to 10 focus on the agriculture-related technical aspects of gardening, including seed, soil health, pests and disease management, and water resources. Chapter 11 supports program managers in understanding the difference in the postharvest chain for home consumption versus the market, and shares recommended practices for postharvest handling, storage and processing. Chapter 12 considers what is needed to support clients when using the garden outputs to engage with the market. Chapter 13 shares behavior change (BC) principles and approaches to help increase gardening adoption. Chapter 14 shows how to monitor the performance of garden interventions to measure progress toward results, and how to make adjustments to reach results, as needed.

Given your existing knowledge and the project’s local context, use this as a reference guide by selecting chapters to learn about areas that affect garden design and sustainability that are less known to you or that are relevant to your project’s local context, as identified through the assessments in Chapter 2. Note that many chapters cross reference one another. The chapters are purposely succinct with additional relevant resources listed for those who want more information on a given topic.

Select chapters to learn about areas that affect garden design and sustainability that are less known to you.



Companion resources to the *Garden Resource Guide* include the *Project Design Guide*, *Program Manager Guide*, Field Agent Lesson plans and job aid. A series of lessons are also available to train staff on the toolkit content.

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- Girard** AW, JL Self, C McAuliffe and O Olude. 2012. The effects of household food production strategies on the health and nutrition outcomes of women and young children: A systematic review. *Paediatric and Perinatal Epidemiology* 26 (supplement 1): 205-222.
- USAID**. 2014. *Multi-sectoral nutrition strategy 2014–2025 technical guidance brief: Gender considerations for achieving nutrition outcomes through agriculture*. <https://www.usaid.gov/sites/default/files/documents/1864/gender-sensitive-ag-tech-guidance-brief-edit-508.pdf>



Chapter 2:

Assessing Local Context

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Learning objectives

After studying this chapter and its links and resources, you will be able to:

- Determine whether a garden is the right solution for your project.
- Assess the context to guide the garden intervention.

Key messages

- Many garden projects fail; a preliminary assessment will help ensure that major barriers to sustainable gardens are considered before including them in the project design.
- Each context is different, so a deeper analysis with identified target audiences will help address constraints or challenges, and capitalize on opportunities related to gardens.
- Assess garden options with communities before making investments.

Key questions for decision-making

- Based on preliminary assessment results, should the project include a gardening component?
- Based on the assessment results, what support or activities will the project undertake to support successful, scalable gardens (use project design guide to support the selection of activities)?

Assessments are important to gardens

Making decisions on the right type of garden, the costs, suitable crops and the right support, and setting expectations are important aspects in successfully establishing gardens with communities. Assessments provide information to help make these decisions and guide the garden approach so that the gardeners will continue to enjoy their harvests through the seasons and particularly after project support ends.

Higher-level outcomes addressed by scaling gardens

There are three outcomes that gardens can support: improved nutrition, increased income and women's empowerment. Understanding the broader context (related to nutrition and markets) at the outset is the first step to making sure a garden is an appropriate intervention. The design team should understand the nutrient deficiencies, dietary diversity levels, and market availability and affordability of nutritious foods to determine whether a garden can help improve these outcomes.

- **Nutrient deficiencies:** Gathering information on nutrient deficiencies will help the design team understand the overall nutrient constraints women and children face and help determine whether gardens can help improve the availability of foods that can contribute to reducing the identified micronutrient deficiencies. For example, if data shows that there are Vitamin A and iron deficiencies, then a garden may be appropriate as there are crops that can contribute to these micronutrients. Micronutrient data can be gleaned from secondary sources, such as the [Demographic and Health Surveys](#), as well as national nutrition surveys, such as the United Nations Children's Fund [Multiple Indicator Cluster Surveys](#) and the [Global Nutrition Report](#). More information on nutrition can be found in Chapter 6 of this guide.
- **Dietary diversity levels:** Information on dietary diversity levels provides useful insights if the target audience faces constraints to consuming diverse foods that help address different micronutrient deficiencies. Comparing dietary diversity information and nutrient deficiency data can provide some awareness of the garden's potential contribution to nutrition. For example, if dietary diversity data show regular consumption of high-iron foods, but there is still an iron deficiency, gardens may not be the solution, i.e. the deficiency may result from other causes and more investigation would be needed. When reviewing dietary diversity data, disaggregated information is preferred since nutrition-related projects target specific groups (e.g., pregnant and lactating mothers, children under 5, children under 2, and adolescent girls). If available, teams should review data on the average Household Dietary Diversity Score (HDDS), Minimum Dietary Diversity—Women (MDD-W), and Minimum Acceptable Diet (MAD) for children 6–23 months (see Annex 1 on Page 14 for a description of these indicators). Much of this information should be available in literature, including USAID Food for Peace desk reviews and existing project surveys. If the relevant information is not available, collect dietary diversity data.
- **Market availability of nutrient-rich foods:** Understanding whether there is sufficient quantity and quality of nutrient-rich foods in a functioning market will help design teams know where to focus their attention. If there is insufficient supply in the market and/or food is unaffordable for the target audience, then home production through gardens may be appropriate. It may also represent a market opportunity if there is unsatisfied market demand, making gardens an attractive option to generate income for households. If, on the other hand, there is an adequate and affordable market supply, the approach may shift from home production of fruit and vegetables to supporting market purchases. If secondary information is not available to help guide this decision, teams can draw on local knowledge from staff and partners working within the community and conduct a rapid market assessment.



Gardens can improve nutrition, increase income and empower women.

Knowing the target audience is important when conducting assessments

The target audience will vary based on the outcomes of the garden. There are three targeting components: households that will garden, members of the household who have specific garden roles, and the end user of garden products. The profile of a target family who will use the end product (fruit, vegetables, pulses, etc.) needs to be defined. The project also needs to decide whether the end users of the garden product will be the same as those who produce the garden products or a different group altogether. For those households that produce the garden products, decide who within the household will be targeted for intervention-related support (training, inputs, etc.). If targeting women, who are often responsible for gardens, read Chapter 5 for ideas on how to support a gender-responsive or even a gender-transformative approach. Knowing who the target families are for the garden intervention will guide who needs to be interviewed. This ensures that the constraints, opportunities and needs reflect the views of those who will implement the gardens and those who will benefit from the gardens.



**Who will garden?
Who will have roles in the garden?
Who will use the produce?**

Examples of target audience along with outcomes

- **Nutrition outcome:** Families with children under 5 who can produce nutrient-dense foods for their own households
- **Market opportunity:** Households (with existing gardens) who need production and business skills to engage in the market to sell surplus
- **Developing local businesses:** Investment-ready entrepreneurial farming households with more than 0.5 acres of land selling most of their produce

Factors affecting the decision to promote gardens

The initial assessment (Table 1) should help determine whether there are major barriers to overcome in investing in gardens. These may be related to culture, access to land, and availability of water, tools, seed and labor.

Cultural preference for gardens

The existence of gardens in the target area is an indication that gardening is culturally acceptable. An initial assessment can be conducted through an observation walk. If there are few gardens observed, then follow-on interviews with those who have gardens and those who do not could provide insights into their acceptability and highlight any constraints that could be used in designing the intervention for a proposal.

Access to land

It is important to know the proportion of the target audiences who have access to suitable land/space for gardening. Access refers to land that is available and can be used for a garden. It could be land that is owned, rented or loaned, including community land. This may vary quite significantly for male and female members within the target families. Guided group discussions and key informant interviews could be held with male and female community members to assess land quality and access. See Chapter 3 for land requirements for each type of garden.

Access to water

Gardens are often rainfed so access to water is key if not the most important determinant in gardens being established (Hirvonen and Heady 2018). To support year-round gardening, investment in some form of irrigation, especially during the dry season, will be needed. The amount of water needed depends on the climate, crop type and crop growth stage (See Chapter 10 on Water Resources for more information).

It is important to assess the availability of water during the year to ensure the project develops a strategy that will support gardens being established and flourishing. Will the project provide technical and/or financial support to households? The project also needs to consider whether increased demand for irrigated water places unsustainable stress on the public water supply, limits water access for other families, and/or negatively affects children's school attendance or increases their risk of mistreatment, as these are not acceptable trade-offs. To gather this information, a resource map could be drawn that identifies water sources for agriculture, gardens and domestic use, along with a series of interview questions.

Costs, materials and inputs

Gardens need materials and inputs to be successful. The items budgeted for should be *affordable* for the target households, and families should be willing to *invest* their own resources to set up, improve and maintain their gardens. These are conditions that can make gardens a viable and sustainable strategy.

At this stage it is important to identify what kinds of materials and inputs are available and accessible locally to help determine whether the project can support the target audience to access them. Interviews with market vendors and private-sector input-supply companies will be helpful to identify available resources and materials in the market, along with pricing and demand. It is also useful to understand the household's interest in allocating resources to support a successful garden, which can be gathered through guided focus group discussions or semi-structured interviews.

Available labor

The size and type of garden, crops promoted, soil health, pests and diseases present, available water resources, and the gardener's capacity will influence the amount of labor and time needed to establish and maintain a garden. At this time, it is important to know whether labor is already allocated to gardens to better understand the potential increase in workload. Furthermore, it is important to know whether those who are targeted with this intervention will have sufficient time to maintain the garden, since paid labor is often not used to support gardens. The daily calendar, which is part of a gender analysis, can help guide the design team's understanding of the context.

Gardens are often rainfed so access to water is key.



Table 1: Preliminary assessment questions and methods

Adapted from Mitchell and Hanstad 2004.

Theme	Question	Method
Garden acceptability	Are gardens present in the community?	Observation
	If yes, what benefits do gardeners presently receive from the garden?	Key informant interviews (KII) with gardeners in the community
	If no, do gardens provide benefits to families in communities with similar resources and climate?	Secondary literature
Land	How much of the land is allocated to gardens? Why is this amount allocated?	KIIs with gardeners in the community
	What is the quality of the land available for gardens?	Guided focus group discussion with target families ² /gardeners KIIs with community leaders
	Who makes decisions within the household on the use of land for gardens? ³ G	Guided focus group discussions with target families / secondary literature
	Is there land available from common property resources that could be loaned for gardens? If yes, do women have access to this loaned land? G	KIIs with community leaders
Water resources	How far are the water sources from potential garden locations?	Resource map
	How does the target population access this water? G	Questions included with resource map activity
	What is the cost for the water?	
	Is the target audience willing to bring water to gardens? If not, why?	
	Who is responsible for bringing water for the garden? G	
	Is the target audience willing to use greywater for irrigation? If not, why?	
	Is it technically feasible to supply adequate amounts of water for scaling gardens? What is the cost per family?	KII with water resource ministry/ commission
Labor and income control	What is the availability of labor for gardening among the target families? G	Guided focus group discussions with target families using daily calendar
	What gender considerations are prevalent among target families regarding gardening labor?	Guided focus group discussions with target families
	Who controls the income earned from the garden? G	
Resources	What materials and inputs are locally accessible to target families? What is the estimated cost of acquiring these? Are they affordable for the target audience?	KIIs with vendors/guided focus group discussions with target families
	Are families willing to invest their own resources, time and labor?	Guided focus group discussions with target families

2. Focus group discussions should be held separately for men and women.

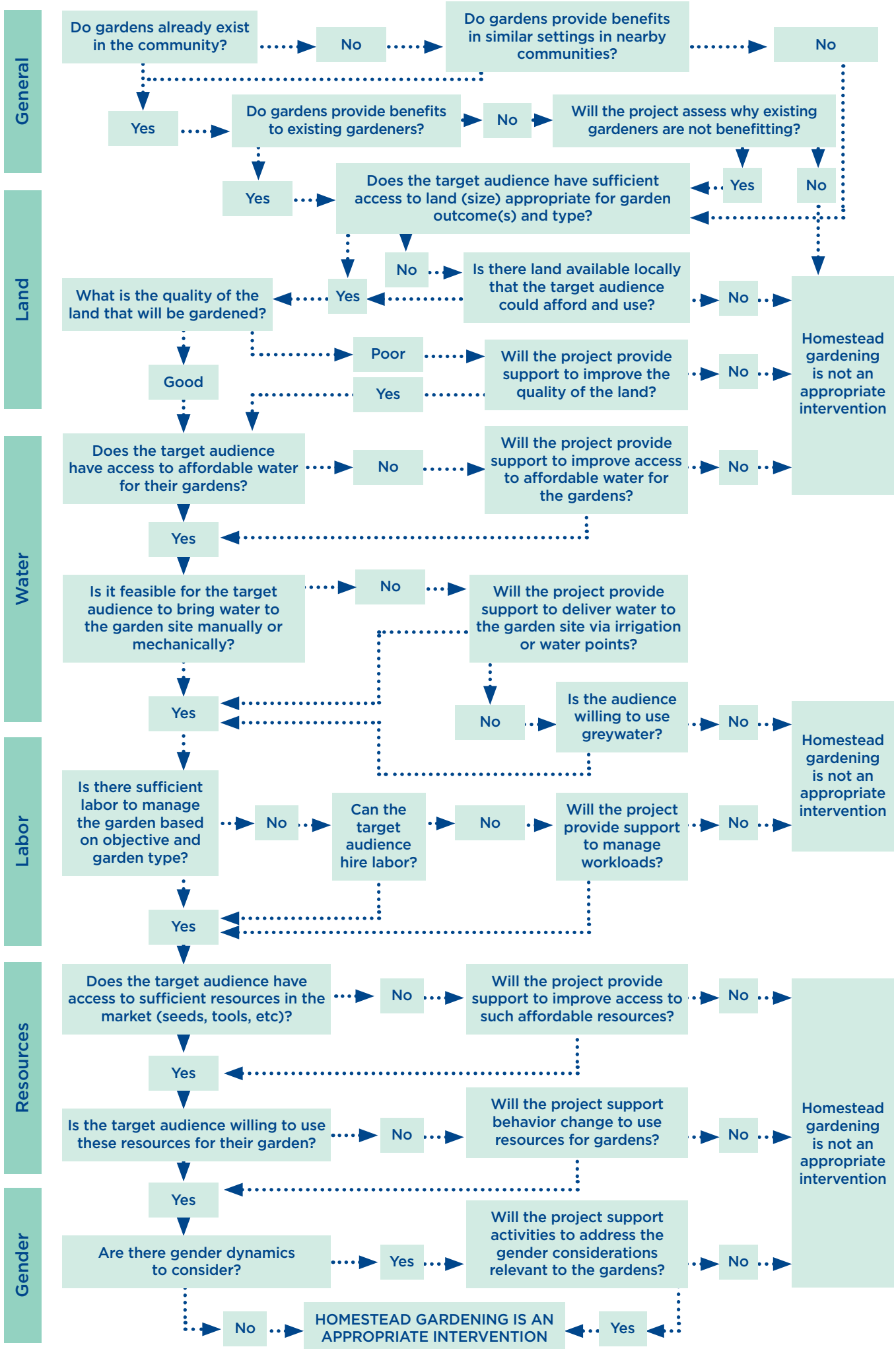
3. **G** = This question is gender-related

How to use the information from the preliminary assessment

The information gathered from the preliminary assessment will help the design team come to a decision on scaling gardens as a project intervention. Design teams should use this information to answer the questions in the garden decision tree (Figure 1, Page 10). The design team will also need to decide what support it will provide to target audiences to establish and maintain gardens. Will the project only provide technical support or will it support target families with financial resources or in-kind contributions, such as subsidized seed, equipment to establish gardens (e.g., wheelbarrows), or provision of water pumps, drip irrigation and watering cans.



Figure 1: Decision tree to assess whether gardening is an appropriate intervention in the target community



Adapted from Mitchell and Hanstad 2004.

Factors that affect garden intervention design

After a project with garden interventions is awarded, the next step is for the program manager to gather information to confirm the garden design developed during the proposal phase. Below are a series of questions to help assess the local context for gardens with the target audiences. Information for these questions can come from secondary literature and data, rapid and participatory appraisal approaches, and other assessments. The assessment questions consider gender dynamics, nutrition, markets, seed access, soil health, pest and disease management, postharvest handling and behavior change. Many of these questions could be incorporated into other project assessments, such as a market assessment, livelihood assessment and gender analysis. Be sure to interview both men and women in this process to gather both their perspectives.

This series of questions helps assess the local context for gardens with the target audiences.



Table 2: List of potential questions to contextualize/validate design during project start-up⁴

Theme	Question	Method
Production	1. What nutrient-rich foods (vegetables, legumes, fruit, animal source foods) do the target families currently produce?	<ul style="list-style-type: none"> Guided focus group discussion with target audience
Nutrition	2. What are the nutritional deficiencies of the target families (e.g., women of reproductive age, children under 2)? 3. What foods do the target families currently consume? 4. Are there foods the children and/or pregnant and lactating women cannot consume? 5. How is the income earned from existing gardens used?	<ul style="list-style-type: none"> See preliminary assessment results, demographic and health surveys (DHS) by region, and other secondary data Guided focus group discussions with target audience
Marketing (community members)	6. What nutrient-rich foods (vegetables, fruit, legumes, etc.) does the household buy? 7. What nutrient-rich foods that have been conserved (e.g., dried and pickled products or fruit made into jam) does the household buy? 8. Where does that household buy the nutrient-rich foods? 9. What nutrient-rich foods would the family like to consume but are unable to find in the market?	<ul style="list-style-type: none"> Guided focus group discussions with community members
Marketing (vendors)	10. What nutrient-rich foods do vendors buy from farmers and resell to consumers on a regular basis? 11. What nutrient-rich foods do vendors buy or sell that have been processed (e.g., dried and pickled products or fruits made into jam)? 12. Which of these products are in high demand or does the vendor sell most of?	<ul style="list-style-type: none"> Kills with buyers (vendors) of garden produce
Garden planning	13. What type(s) of gardens are present? 14. What type of garden is most appropriate? 15. What do households do to protect the garden from animals? 16. What equipment do households have for establishing and maintaining a garden?	<ul style="list-style-type: none"> Observation Guided focus group discussions with target audience

4. Selected questions included in Table 3 are drawn directly from Chapters 3 to 13 of this guide.

Theme	Question	Method
Seed	17. What types of seeds do households have access to for gardens?	<ul style="list-style-type: none"> ■ Seed system security assessment ■ KILs with private sector companies
	18. How do households access this seed?	
	19. What constraints does the private sector face in reaching the target audience with affordable seed?	
Soil health	20. What is the quality of the soil the garden produce will be grown in? What growing problems does the household face?	<ul style="list-style-type: none"> ■ KILs with extension agents ■ Guided focus group discussions with target families/gardeners
	21. What practices does the household use to restore soil fertility? Does the household find these practices beneficial or damaging?	
	22. What pests does the household have in their garden?	
Pest and diseases	23. What diseases does the household have in their garden?	<ul style="list-style-type: none"> ■ Guided focus group discussions with gardeners
	24. What pests and disease management practices does the household use? Are they working?	
	25. When does the household have sufficient access (availability and affordability) to water for use on their garden?	
Water resources	26. Identify distance to the nearest water source from potential garden site.	<ul style="list-style-type: none"> ■ Seasonal calendar ■ Resource map ■ Questions included with resource map activity
	27. Is there anything that inhibits use of water from the identified water resources for gardens, including greywater?	
	28. If gardens already exist, what are the current methods used for watering them?	
	29. What postharvest issues does the household face with garden produce?	
Postharvest handling	30. What actions does the household take to address these postharvest issues?	<ul style="list-style-type: none"> ■ Guided focus group discussions with gardeners ■ KILs with agricultural extension offices
	31. What preservation techniques does the household currently use?	
	32. If the household already has a garden, who manages it? Who works on it?	
Gender ⁵	33. Who has access to land for gardening?	<ul style="list-style-type: none"> ■ Guided focus group discussions with target audience ■ Roles and responsibilities table ■ Access and control table ■ Power relations table
	34. Does access to inputs and tools differ for men, women and other vulnerable groups?	
	35. Does access to resources (e.g., extension services, training, irrigation and labor) differ for men, and women and other vulnerable groups?	
	36. If women are responsible for gardening, what decisions do they have more control over than others?	
	37. Who decides or influences what is grown in the garden and what to do with it after it is harvested?	
	38. What cultural practices or social norms enable and/or restrict women's ability to take advantage of opportunities, capitalize on assets, or use resources that are accessible to them for gardens?	
	39. Are there any other constraints faced with producing or using garden produce?	
Constraints	40. Are there any constraints in adopting practices previously shared with you for implementing gardens?	<ul style="list-style-type: none"> ■ Guided focus group discussions with gardeners / KILs with extension services

5. If the project is planning a gender analysis, some of these questions can be addressed in it, depending on its focus.

Conclusion

A well-designed garden intervention relies on knowledge and evidence of the local context. Assessing the context during the proposal phase will ensure that a garden intervention will be included in the project if appropriate. Assessing the context before implementation will help ensure that it is designed to be successful and sustainable, with adequate human and financial resources.

Quiz

1. True or false: The project design team does not need to conduct an initial assessment to determine whether the garden intervention is appropriate.
2. Before developing assessment tools, which two aspects need to be determined (check all that apply).
 - a. Land is available
 - b. Target audience has been identified
 - c. Community members have been consulted
 - d. Objective of garden has been identified
3. True or false: Once a decision to include a garden intervention in a project is made, a second assessment is needed during implementation to contextualize it and reaffirm the garden design.

Activity

Based on an existing or upcoming project, use staff knowledge and secondary literature to answer the questions in the second assessment tool (Table 3) to the best of your ability. What information are you missing that you need to dig deeper to understand?

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Chapter 2, Annex 1: Dietary diversity score indicators

Indicator	Data level	Description	Calculation sources
Average Household Dietary Diversity Score (HDDS)	Population	Uses a 24-hour recall period but does not include meal frequency information. There are seven food groups and each group represents 1 point in a dietary diversity score. Proxy for household-level access to food.	https://www.fantaproject.org/monitoring-and-evaluation/household-dietary-diversity-score
Minimum Dietary Diversity for Women of reproductive age (MDD-W)	Population	Developed as a proxy indicator to reflect the micronutrient adequacy of women's diets. Measures whether women have had a minimum of 5 out of 10 food groups. It cannot be used to describe diet quality for an individual woman because of day-to-day variability in individual intakes (FAO and FHI 360 2016)	http://www.fao.org/3/a-i5486e.pdf https://www.usaid.gov/sites/default/files/documents/1866/Part%20I_Baseline%20and%20Final%20Evaluation_04.13.2015.pdf
Minimum Acceptable Diet (MAD) for children aged 6–23 months	Population	This combines two indicators: Those children who meet minimum dietary diversity (4 out of 7 food groups) and minimum meal frequency (minimum depends on a child's age).	https://index.nutrition.tufts.edu/data4diets/indicator/minimum-acceptable-diet-mad https://www.usaid.gov/sites/default/files/documents/1866/Part%20I_Baseline%20and%20Final%20Evaluation_04.13.2015.pdf

Chapter 3: Planning a Garden

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Learning objectives

After studying this chapter and its links and resources, you will know:

- Key aspects for planning a garden.
- Different types of garden that meet varying needs of the homestead and its objectives.
- What is needed to establish and maintain each type of garden.
- How to monitor the quality of the garden design.

Key messages

- Before building garden(s), it is important to select the right location(s).
- There are many different types of gardens; selecting the most appropriate will help utilize resources appropriately and benefit the gardeners.
- Field agents need to observe, assess, and provide feedback on the establishment and maintenance of gardens to support their sustainability.

Key questions for decision-making

- What garden type(s) will the project promote?
- What approaches will the project promote to protect gardens?
- What resources/support will the project provide to support gardeners in implementing the selected garden type(s) to be promoted?

It is important to plan for the garden

To ensure the garden successfully produces quality products, it is important to support gardeners in planning their garden. The planning process includes determining the location and size of the garden, understanding the basics of planting crops, and deciding what type of protection the garden will need and what type of garden to build. The planning process will also require gardeners to think about access to quality seed, improving soil health, managing pests and disease, accessing water resources, supporting nutrition, addressing gender dynamics, engaging in the markets if desired, and planning harvest and postharvest activities as determined in Chapter 2 on Assessing Local Context. Information related to these topics is described in subsequent chapters.

Support gardeners in planning their garden.

Key considerations to determine garden location and size

Before building a garden, gardeners need to determine the best location(s) to build their garden based on sun exposure, potential wind, and distance from water and the house.



Sun exposure: Different plants require different amounts of sun. The gardener will need to identify locations on their homestead that will be suitable for crops with different sun preferences; otherwise, the plant will not produce as well.

- a. **Full sun** is 6 to 8 hours of direct sun. Most vegetables, especially fruiting plants—such as peppers and tomatoes—need a minimum of 6 hours to yield well. The amount of sun does not have to be all at one time each day but can be broken into two blocks of time with a time for shade in between.
- b. **Partial sun** is 4 to 6 hours of sun. Typically, this would be sun in the morning and shade in the afternoon during the hottest time of the day. Crops that like partial sun include leafy plants (e.g., lettuce, spinach, Swiss chard) or roots (e.g., radishes, beetroot, carrots).
- c. **Partial shade** is 2 to 4 hours of sun.
- d. **Shade** is less than 2 hours of sun (Banks and Bradley 2015; Hubbard 2018).



Wind: If the area experiences strong wind, the gardener will need to select a location that includes a natural barrier; otherwise a human-made barrier may be needed to protect the crops and the soil. See below for more information on fencing.



Distance from water: Water is heavy to carry a long distance and is often a common barrier to sustainable gardens, so gardening near water is preferred. If a water source is not close by or readily available, then the project will need to determine how it will support gardeners technically or financially to access water. See Chapter 10 on Water Resources for more information.



Distance from house: A garden close to the house eases maintenance, allows for easy observation of when water is needed and the monitoring of pests/disease, and offers ease of daily access to the food for cooking (Nardozzi n.d.).



Size: In addition to identifying the correct location to build the garden(s), a gardener may need help determining the size of the garden, which in turn affects its location options. Garden size can vary based on the household's food needs, available space to plant with appropriate sun exposure, distance from water and the house, time available to maintain the garden, purpose of the garden, and the type of crops to be grown (Masabni and Lillard n.d.). Gardens do not need to be in one single plot and portions can be spread throughout a larger area to accommodate space issues and sun exposure requirements. Garden beds can be as small as 1 foot x 1 foot (30 cm x 30 cm) (Bartholomew 2013). For first-time gardeners, we recommend starting small to get experience (Boeckmann 2019; Bartholomew 2013).

Planting the garden

When it is time to plant the garden, you need to consider five factors to guide when, where, and how to plant.

- **Sun exposure:** As discussed above, each crop has its optimum amount of sunlight. When deciding where to plant a seed or seedling, it is necessary to plant based on the amount of sun needed to grow well. Too much or too little sun will inhibit the crop from performing at its peak level (Boeckmann 2019).
- **Plant spacing:** Each crop requires a certain amount of space between plants and between rows so the plants can grow well. Too little space may impede plants from growing to their full potential. For example, a cabbage needs 12 to 24 inches of space. Cabbage seeds planted 12 inches apart will have smaller heads than cabbages grown 24 inches apart. Proper spacing reduces competition for light for sun-loving plants and reduces competition for soil nutrients. The local extension agent should be able to share information on proper crop spacing based on non-mechanized plots. Spacing suggestions on seed packages are often based on mechanized fields.
- **Soil and air temperature:** It is important to know the temperature at which seeds will germinate. If the soil is too cold, the seed will not germinate well when placed in the ground. In addition to soil temperature, each crop has a preferred air temperature to grow its best. Some crops have a broad range of temperatures that they can tolerate, but most have a smaller range in which they are most productive. Some crops will bolt and go to seed quickly if a certain temperature is reached. The wrong temperature may also affect the taste of the produce.
- **Companion planting:** This is when several different types of crops are planted near each other that can improve plant health and yields. Some plants attract beneficial insects while others repel pests with their scent (see Chapter 9 on Pest and Disease Management). Some plants may help make nutrients—like nitrogen—available that other crops need (Lohmiller and Lohmiller 2018), while others will compete for the same nutrients, sunlight or water. When considering what crops to promote, it is important to know whether they are compatible with one another and how they can support each other's growth and health. If plants are not compatible they could harm each other, thereby reducing yields.

- **Succession planting:** This type of planting includes sowing vegetable seeds every few weeks so there are multiple harvests, or planting a quick-maturing crop close to a slower-maturing one, allowing for availability of different food types within a season. Succession planting extends the availability of fresh food and reduces excessive harvests.

See Chapter 4 on Crop Selection for more information.

Equipment for establishing and maintaining gardens

A few basic tools are useful for preparing the garden. Usually these are fabricated locally or can be found in nearby market towns.

- **Hoe:** Used to break up soil and remove weeds
- **Shovel:** Used to move soil, especially when constructing water management structures like berms
- **Rake:** Used to level the soil during bed construction
- **Digging fork:** Used for double digging compacted soil

For larger gardens, low-cost, low-tech mechanization can be used, which will likely save labor and energy.

Fencing: Protecting the garden

Gardens may need to be protected from animals and wind depending on where they are located. If there are livestock like goats, sheep and chickens living near the garden, it is important to block their entrance to the garden to:

- Ensure the food remains safe from fecal contaminants
- Protect the food from being eaten
- Protect the garden soil from being compacted

If the area experiences strong winds, a barrier may be needed to protect the crop from damage or the soil from erosion.

Materials to make a fence may not be readily available and/or may be expensive to buy. Besides a traditional fence (Diagram 1), consider a living fence, which not only provides protection but also food for human or animal consumption. It supports pest management by providing beneficial insects with a protected place to settle when the field is being cleared. There are three types of living fences:

- **Simple living fence:** Made up of different types of shrubs or trees
- **Fruiting living fence:** Made up of fruiting shrubs or small trees
- **Windbreak living fence:** Blocks wind from the field

When deciding on a living fence, four factors should be considered:

1. Trees that require less pruning to minimize labor/energy requirements
2. Competition between trees and garden crops for sun, nutrients and water
3. Invasiveness of trees and shrubs
4. Livestock inclination to eat the trees/shrubs (Martin 1991)

Diagram 2 shows an example of a living fence as a wind break. When the wind comes across the field, the trees block it. To learn more about building a living fence see the ECHO Technical Note #23 on the [Living Fence: Its Role on the Small Farm](#).



Double digging is when the topsoil is temporarily removed from the bed, the subsoil beneath is loosened with a fork and the topsoil then replaced.

Diagram 1: Traditional fence

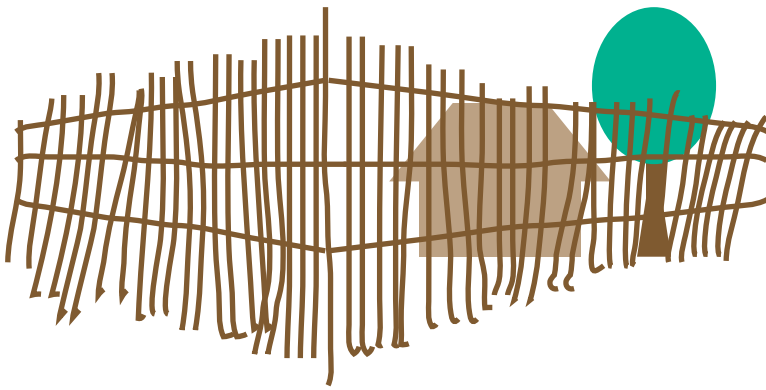
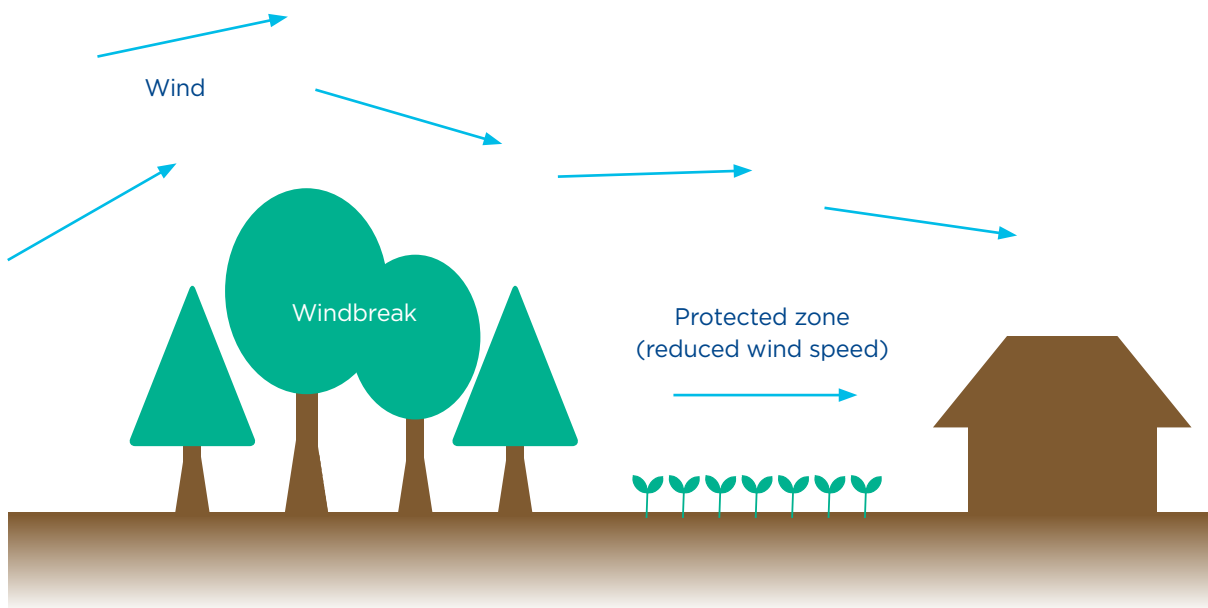


Diagram 2: Windbreak / Living fence



Selecting the right garden type is important for productivity

Selecting the right type of garden will capitalize on the resources available, including sunlight, water, compost, land, labor and others. Choosing the most appropriate garden type will permit the best outcomes in plant productivity, labor and household objectives. To select the most appropriate garden type, use information gathered in the assessment.

Garden types

There are numerous garden types. This chapter shares information on seven: container garden, conventional row garden, keyhole garden, permagarden, raised bed, sunken bed and vertical/multi-level garden. Besides describing each garden—including its requirements, benefits and constraints—a checklist is provided to help field agents ensure the garden is designed and maintained appropriately.

Table 1: Types of gardens: Summaries

Type	Land size	Climate/location/use	Labor requirements	Water resources	Suitable crops	Materials (besides basic tools)	Advantages	Constraints
Container	Small	Urban area/landless	Minimal effort to establish and maintain. Requires regular attention to water needs.	Requires close attention to soil moisture.	Any crop is suitable as long as it has ample space. Ensure containers of appropriate size are used.	Non-toxic containers; soil mixture consisting of sand or gravel, soil and generous amounts of compost	Use where there is limited space or soils are unsuitable or not cultivable (rocky, infertile, contaminated, rooftops, bricked areas, etc.); requires little labor or purchased resources, and recycled materials can be used for containers	Limited production so may not produce sufficient vegetables to meet household needs. May require frequent watering, especially if placed inside, or on verandas or other covered places.
Conventional row	Medium/large	Rural	Minimum effort to establish. More difficult to maintain as garden is larger and there will be more weeds.	Varies depending on soil quality and type. Large area may require significant time for watering.	Suitable for most crops and can be integrated with agroforestry systems (e.g. fruit trees).	Best used with mechanization, such as pump or drip irrigation, motorized tillers, animal traction and others.	Larger fields allow for staggered planting. Greater production may permit surplus to be sold for income generation.	Not intensive so requires more land to produce same volume as intensive production. Because of greater distance between plants, needs weed management.
Keyhole	Small	Semi-arid climates; dry season; location with rocky, difficult-to-cultivate or infertile soils; limited space	Medium effort to difficult to establish as many materials are required. Easy to maintain.	Designed for moisture retention. Uses greywater.	Suitable for root crops, leafy crops/greens, carrots, beets, garlic, herbs. Unsuitable for peppers, eggplant, maize and large/vining plants.	Stones, manure, ash, rotting logs, dry and green grass or leaves, other available organic materials, woven basket.	May be physically appropriate for those with disabilities.	May need to establish multiple keyhole gardens to meet household consumption needs. Some materials may be difficult to access.

Type	Land size	Climate/location/use	Labor requirements	Water resources	Suitable crops	Materials (besides basic tools)	Advantages	Constraints
Permagarden	Medium/large	All seasons, but especially suitable for dry season	Medium effort/difficult to establish as careful attention must be given to the construction. Medium maintenance effort as it requires close attention.	Designed for moisture retention and flood control.	Suitable for all crops.	Hoes, pangas/machetes; 4 watering cans; containers to carry manure, ash, etc.; 4 empty maize seed bags (100 kg); manure, wood ash, charcoal dust; 6-8 jerry cans for water; vessel to hold a bag of manure or chopped leaf material suspended in water; fencing material; nails (1 kg); hammer; twine; bamboo or sticks used to make an A-frame.	Designed to address soil and water constraints. If designed correctly, will optimize use of water and soil nutrients even in the face of drought or other climate shocks.	Uses primarily perennial crops (bushes and trees) and fewer annual crops. The design stage is more intensive than some of the other gardens described. Maintenance will likewise require more time, care and attention from the gardener.
Raised bed	Small/medium	Moist climates or during the rainy season.	Medium effort required to construct the garden. Easy to maintain. Weeds are minimal.	Good drainage, but may need frequent watering in the dry season.	Most plants grow well, but shallow-rooted plants are preferred, such as vegetables, herbs and berry bushes. Large vining plants will take up space. Stake/trellis may be used to reduce space needs.	Frames are not required. If using frames, they can be made out of concrete block, bricks, stone, nylon sacks, etc. Wood is not recommended because it rots easily. Tires should not be used as they may be toxic.	Size is determined by gardener to accommodate available labor, space and food needs.	In arid, dry climates, the soil may get too hot and dry out.

Type	Land size	Climate/location/use	Labor requirements	Water resources	Suitable crops	Materials (besides basic tools)	Advantages	Constraints
Sunken bed	Small/medium	Dry areas, dry season, nursery.	Medium effort to establish given double digging. May be more difficult to maintain for those with disabilities or chronic illness as crouching is required.	Designed for moisture retention as it limits water runoff and serves as a water catchment system. Maximizes use of available water found deeper in the soil.	Suitable for all crops, except roots and tubers due to the depth required for optimal growth.	Organic matter/compost.	Supports rebuilding soil health and keeps roots cool in hot climates.	Not suitable for areas prone to flooding or heavy rains, or for soils with poor drainage. Nearby erosion may fill in the bed.
Vertical/Multi-level garden	Small	Urban area/landless	Minimal effort to establish and maintain. Requires regular attention to water needs.	Because garden is compact with less soil, frequent watering is likely needed. Water needs to be distributed evenly. Simple drip irrigation is needed if garden is larger.	Trellises are suitable for vining and sprawling plants, such as cucumbers, peas, tomatoes, melons and pole beans. Suspended containers or poles may be used to support leafy greens or herbs.	Can be made of trellises, nets, strings, cages, poles, suspended containers, sacks, bamboo, etc. Nutrient-rich soil needed.	Maximizes constrained space and permits gardening in areas with unsuitable soils (poor, rocky, hilly, etc.). Can help prevent crop damage by animals if hung out of their reach.	Limited production to meet homestead needs. Because of the limited amount of soil used, it must be very fertile to meet plant needs. Plants need to be closely monitored for nutrient stress, and compost should be added regularly. If containers are elevated, irrigation can be difficult when lifting is required.

Container gardens



A hanging garden and a sack garden. *Photos by Anza Muenchow for CRS*

Container gardens are simply containers filled with soil and compost. This type of garden can increase the area available for planting, and can be used in constrained spaces, including urban or peri-urban areas. Containers must have proper drainage, should be placed where they can receive adequate sunlight and water, and where they will not be damaged by heavy winds or rains.

Constructing the garden

- **Size:** Small plants (greens, herbs) need a container at least 15 centimeters (6 inches) in diameter with a 20-centimeter (8-inch) soil depth. Larger plants, such as peppers, require larger containers such as tubs.
- **Structure:** Containers should be porous or have holes for drainage. Recycled materials can be used as containers, including nylon feed/grain sacks, hollow logs or plastic buckets/tubs/pipes with drainage holes cut into the bottom. When considering recycled materials, be aware that they may be toxic (e.g. contaminated plastic containers) or could become toxic over time (e.g. tires).
- **Establishment:** Fill containers with a soil mixture that allows for good drainage (course sand or gravel should be mixed with soil to improve water filtration). Mix in generous amounts of compost. Place containers where they will receive adequate sunlight. Containers can also be suspended, which is useful for reducing crop damage by animals. If suspended, ensure that the container can support the weight of soil, plants and water.

Crops, planting, water, soil fertility, weeding and other considerations

- **Crops:** Any crop is suitable as long as it has ample space; make sure that adequately sized containers are used.
- **Planting:** If growing different types of plants together in one container, ensure that they have the same growing requirements (water, sunlight, nutrients). Clay soils are not appropriate for container gardens.

- **Water:** Pay attention to soil moisture and drainage (make holes in the bottom of containers for water drainage). Containers should never be allowed to dry out completely between waterings; likewise, avoid overwatering as roots can rot. If containers dry out, they may need to be soaked for a few days to allow the center of the soil mass to rehydrate. To retain moisture, cover the soil surface with mulch. Course sand or gravel should be mixed with soil in the container to improve water filtration.
- **Soil fertility:** Given the low soil volume, soils should have a high nutrient content. Regular compost is needed to meet plant nutrient needs.
- **Weeding:** Although there will be minimal weeds, they need to be removed when they germinate to avoid competition for soil nutrients.

Additional resources on container gardens include:

- *Extension Gardener Handbook, Plants Grown in Containers* (Chapter 18)
<http://content.ces.ncsu.edu/18-plants-grown-in-containers>

Conventional row gardens



Conventional row garden.
Photo courtesy of [Paulo O.](#),
licenced under [CC BY 2.0](#).

These are larger gardens that often use irrigation. Plants are spaced more widely than in sunken or raised beds and therefore compete less for nutrients and sunlight. But given the wider spacing, weeds are more of a concern than in other garden types. The soil is subject to compaction due to movement around the garden. These gardens permit the use of larger tools, equipment or animal traction.

Constructing the garden

- **Size:** Maximum garden size is 50 square meters to enable a family to carry out the labor required.
- **Structure:** Conventional row gardens are in straight lines level with the ground. Crops should be planted in straight lines to aid cultivation, fertilizing, weed management and harvest. To make a straight row, drive a stake into the ground at each end of the row and draw a string taut between the stakes as a guide. Add organic matter during bed establishment to improve fertility.
- **Garden access:** Delineate walkways to avoid trampling plants and compacting the soil. When determining pathway width, consider irrigation choices, the height of the gardener, and the equipment or tools used for planting, maintenance and harvest. Pathways can be covered with mulch to suppress weed growth.
- **Maintenance:** Regular weeding is required.

Crops, planting, water, soil fertility, weeding and other considerations

- **Crops:** Most crops are suitable, but local conditions should be taken into account.
- **Planting:** Plant in straight lines to facilitate cultivation, weed management and harvest.
- **Water:** Because of the large area, the garden needs to be accessible to a reliable year-round water supply. Drip system watering is recommended because overhead watering increases weed production between the rows (see Chapter 10 on Water Resources).
- **Soil fertility:** To maintain or increase soil fertility, consider crop rotation, intercropping and other methods. Organic matter should be added during establishment and at each season to improve soil fertility, as well as during the growing season (see Chapter 8 on Integrated Soil Health Management).
- **Weeding:** Expect more time and effort for weeding given the wider spacing. Hoes or other equipment can be used if plants are in straight rows.

Keyhole gardens



Keyhole gardens.
Photo by CRS staff

Keyhole gardens are compact raised beds, often waist-high, and constructed with layers of organic material inside stone walls to improve water retention and soil fertility. Keyhole gardens were designed to be used by people with limited mobility (e.g., the elderly, people with disabilities or people living with HIV) because once they are constructed, they are easy to manage—no bending over and relatively minimal maintenance is needed.



Keyholes gardens for people with disabilities

If promoting keyhole gardens to people with disabilities, consider adaptation of the garden design to accommodate the disability, such as a wider keyhole or lower walls if the gardener is in a wheelchair.

How to prepare and manage

- **Supplies:** Stones, manure, ash, rotting logs, dry and green grass or leaves, and other available organic materials.
- **Site assessment:** The garden should be constructed on flat or level land near the home.
- **Structure:**
 - Use a spade to measure 1 meter in four directions from the center and mark those points. Then draw a circle connecting the four points, which will be 2 meters (2 spade lengths) in diameter.
 - Weave a simple 1-meter-high basket of thatching grass (or palm/bamboo/reeds, depending on what is available) and place it upright in the center of the circle. Form a frame around the basket with three or four large sticks to hold it in place and prevent it from collapsing as layers of soil and organic material are added. As an alternative, use wire mesh instead of grass. The garden will have a gap—a “keyhole”—to allow access to this basket.
 - Lightly hoe the surface of the soil within the circle to level it.
 - Place the first layer of logs, leaves, branches, cardboard or other organic matter (like hay or grasses). Place stones or logs around the edge of the circle. Add a layer of soil on top, then a thin layer of ash. Add another thin layer of soil, then a thick layer of aged manure. Continue to add soil and organic matter to achieve the desired height.

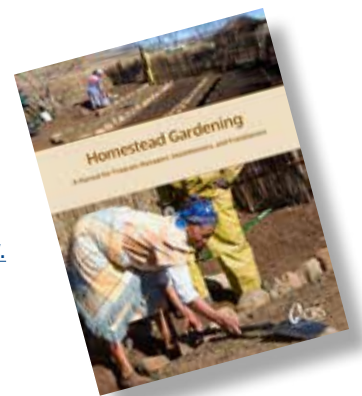
- **Top layer:** Use a rich mixture of soil and aged manure or compost (approximately a 1:1 ratio) as this is where the seeds will be sown.
- **Slope:** Slope the top layer slightly, like the roof of a house, to keep it from sinking toward the middle of the keyhole.
- **Maintenance:** Add soil as needed and make sure that the basket stays upright in the center of the garden.

Crops, planting, water, soil fertility, weeding and other considerations

- **Crops:** The keyhole garden is suitable for root crops, leafy crops/greens, carrots, beets, garlic and herbs. It is not recommended for peppers, eggplant, maize and large/vining plants (beans, squash, pumpkin, peas, tomatoes) that might require staking or trellising. However, tomatoes have been planted along the outside edge of the garden so the vines hang over, creating a vertical garden. Plant a mix of crops to prevent pests and disease, and to promote diversified diets.
- **Planting:** Planting seeds in circular or curved rows helps keep the topsoil from running off when watering the garden.
- **Water:** The garden should be located near a reliable water source. Greywater (see Chapter 10 on Water Resources) is added to the center basket, although additional fresh water will likely need to be applied to the top of the garden during the dry season.
- **Soil fertility:** After planting, add kitchen scraps to the center basket on a regular basis to continue to add fertility to the lower layers of soil in the garden, permitting continual planting.
- **Weeding:** Close plant spacing and well-composted soil should prevent excessive weed growth.

Additional resources on keyhole gardens are:

- *Homestead Gardening: A Manual for Program Managers, Implementers, and Practitioners.* <https://www.crs.org/sites/default/files/tools-research/homestead-gardening.pdf>
- Video: The Keyhole Garden: A Simple Key to Better Nutrition <https://www.youtube.com/watch?v=grritAZ7CHI>



Permagardens



Permagarden.
Photo by Thomas Cole

This type of garden is designed for both rainy and dry seasons. The use of raised or sunken beds, swales⁶ and berms⁷ helps gardeners improve soil fertility and water management. A permagarden's design process is more intensive than some of the other gardens that are described. Its maintenance will likewise require more time, care and attention from the gardener.

Establishing the garden⁸

- **Garden size:** Size varies depending on household space and labor constraints, but gardens are typically around 16 square meters.
- **Bed size:** Build meter-wide raised beds, following the instructions for raised beds below, and double dig the soil for added benefit. Note that the beds are not built within frames and may follow contours rather than being perfectly rectangular or level.
- **Preparation:** Prepare the garden by removing weeds, roots and rocks.
- **Water management:** Assess the slope to guide the construction of swales and berms for water harvesting.
 - Build the swale (a shallow trench) on the upslope side at the highest point to stop water before it reaches the beds. Make sure it is built on the contour to prevent water from flowing away from the garden. Swales redirect water to the garden or store it for later use.
 - Berms (raised earthen structures) are built downhill to protect the garden from runoff water and provide space to grow useful perennial crops. Mound soil in a line along the contour or in half-moons. Follow the “slow, spread and sink” principle. This also prevents erosion, maintaining soil fertility. For more details on water harvesting for permagardens, read: *Permagarden technical manual. Second edition*. <https://www.fsnnetwork.org/tops-permagarden-toolkit>.

6. Swale: An on-contour depression dug to ensure water slows and filters into the soil instead of running over it.

7. Berm: A raised earth mound running across a slope.

8. Guidance heavily drawn from USAID TOPS [Permagarden Technical Manual. Second edition](https://www.fsnnetwork.org/tops-permagarden-technical-manual) (2017).

- **Homestead integration:** A living fence should be planted around the garden with a mix of trees or shrubs (e.g., fruit trees, fast-growing trees, grasses and shrubs). Mulch around the base of plants and trees for weed suppression and water retention.
- **Paths:** Pathways are mulched.

Crops, planting, water, soil fertility, weeding and other considerations

- **Crops:** All crops are suitable.
- **Planting:** Use a triangular pattern to maximize space and improve root health.
- **Water:** Use water management and harvesting techniques (i.e. berms and swales) to increase the amount of water stored in the soil. Water the garden as needed.
- **Soil fertility:** Regularly enrich the soil with compost and other organic matter.
- **Weeding:** Use mulch, perennials and close plant spacing to suppress weed growth. If weeds have gone to seed, do not use them as green manure.

Additional resources on permagardens include:

- *Permagarden Field Manual: Growing Vegetables and Fruits to Impact Household Nutrition and Economic Strengthening.* http://pdf.usaid.gov/pdf_docs/PA00KWCK.pdf
- *Permagarden Technical Manual. Second Edition.* <http://www.fsnnetwork.org/sites/default/files/pg-technicalmanual-mono.pdf>



Use a triangular planting pattern to maximize space and improve root health.

Raised beds



Raised beds.
Photo by CRS staff

The raised bed is the most common type of small garden. A raised or mounded bed is a flat-topped garden created by simply mounding soil, compost and rotted manure into a rectangular shape that is generally 3 to 4 square yards/meters. This type of bed is useful in wet climates or during the rainy season because it allows for good drainage and prevents plants from being damaged by waterlogging. These beds permit deep root growth and increased plant density and are highly productive. Because the soil in the bed is not disturbed by equipment or trampling, there is reduced risk of soil compaction. Raised beds can be framed or unframed. If framed beds are promoted, make sure that the materials used for the frames are non-toxic.

Constructing the garden

- **Garden shape:** Beds tend to be rectangular.
- **Size:** The width of each bed will depend on the farmer's height and the available space, but usually it is about 1 meter wide or less. The gardener should be able to comfortably reach into the center of the mound without having to step on the planting area—the soil in the bed should never be compacted by trampling or any weight. The length depends on the area available and access to labor. If there is sufficient space to permit numerous beds, more beds of shorter length can be easier to manage than one or two long beds. If using irrigation, this will also play a role in the length of the bed; consider how the hoses will reach the whole garden area or how a drip irrigation system will be arranged.
- **Depth:** This should be at least 16 to 20 centimeters (6 to 8 inches) and can be significantly deeper.

Establishing the garden

- **Double dig:** For new gardens where the soil is highly degraded and compacted, the land may need double digging. Double digging should only be applied once.
- **Full mound:** Organic material, such as leaves, grass, composted plants or rotted animal manure, is needed to make full mounds (see Chapter 8 on Integrated Soil Health Management to learn more about composting). Topsoil from areas designated as walkways can be added to the mound to add more rich soil. The mounded bed should be raked flat and level to ensure water will not flow off it.



Double digging is when the topsoil is temporarily removed from the bed, the subsoil beneath is loosened with a fork and the topsoil then replaced.

- **Structures:** To protect against erosion from wind and rain, and from disturbance by livestock or people, raised beds can be built with or without frames (made from concrete blocks/bricks, or stone). Frames may also be necessary to contain the soil if it is very deep. Remember that the frame must support not only the weight of the soil but also water and plants. If constructing a bed with frames, construct the frame first and then fill with the soil and organic matter. Using wood for frames is not recommended as it rots easily, and nor are tires as they can become toxic.
- **Access to the garden:** Pathways can be made by shoveling the topsoil onto the raised beds. Paths should be covered with mulch to suppress weed growth. Pathways between beds should be wide enough—30 to 60 centimeters (12 to 24 inches)—to permit the gardener to work comfortably without disturbing the beds, including any equipment (buckets, hoes).
- **Other:** When properly cared for (weeding, adding organic matter, avoiding compaction), raised beds are “permanent” and do not require additional tilling of the soil, except when turning in new compost.

Crops, planting, water, soil fertility, weeding and other considerations

- **Crops:** Most plants grow well in this type of garden, but shallow-rooted plants are preferred, including vegetables, herbs, annual and perennial flowers, berry bushes and small shrubs. Large, vining plants such as squash or stake/trellis plants will take up substantial space and should be considered if appropriate for the garden.
- **Planting:** Plant in a triangular pattern to optimize use of space and crowd out weeds. Because of the rich, loose soil, succession planting and relay planting can be used, which permit harvest year-round (limited only by water and labor availability).
- **Water:** Use clay pots or small-scale irrigation to supplement natural rainfall during dry periods. Water more frequently during dry months.
- **Soil fertility:** After harvest, plant residue from the garden can be left to decompose to augment soil organic matter. Additional compost can be added before the next planting. Review Chapter 11 on Postharvest Handling and Chapter 8 on Integrated Soil Health Management to learn how to make compost and understand its application to minimize health concerns and maximize benefits.
- **Weeding:** Because of the deep topsoil, roots are able to penetrate more deeply and plants can be spaced more closely together, reducing competition with weeds. Triangular planting also helps eliminate weeds. Furthermore, woven bags can be cut and laid out flat over raised beds, and holes cut into the bags in which seedlings can be planted.

Additional resources on raised bed gardening are:

- Raised bed gardening <https://catalog.extension.oregonstate.edu/fs270>



Plant in a triangular pattern to optimize use of space and crowd out weeds.

Sunken beds



Sunken beds.
 Photo courtesy of
[Terrie Schweitzer](#), licenced
 under [CC BY-NC-SA 2.0](#)

Sunken beds are dug into the ground and are therefore lower than the surrounding area. This is done to maximize water use. They are generally used in dry, arid climates or during the dry season because they conserve or divert water, alleviate water runoff, and create a microclimate that helps keep plants moist, cool and protected from wind. When preparing these beds, it is important that the soil is prepared and amended in a loose manner to allow for greater pore space. Sunken beds are often the preference for plant nurseries that will later be transplanted to raised beds in the rainy season.

Constructing the garden

- **Size:** Usually no more than 1 meter wide and can be as long as desired.
- **Depth:** Total depth should be 60 to 75 centimeters (24 to 30 inches). This encompasses what is below the ground and the walls built above the ground.
- **Walls:** The wall should be 30 centimeters (12 inches) or more above ground for sunken beds on level land. If the land is sloped, then the wall on the downhill side needs to be taller.
- **Double digging:** This is a two-step process to facilitate deep root penetration and access to groundwater. Dig up and set aside the topsoil—the dark, rich soil found at a depth of about 5 to 20 centimeters (2 to 8 inches). After setting the topsoil aside, dig to 30 to 45 centimeters (12 to 18 inches), loosening the soil to allow for greater water and root penetration. Set aside some of the deeper, nutrient-poor soil for raised pathways or to create a short wall around the bed.
- **Organic matter:** After the soil has been loosened, add a layer of organic matter such as leaves, hay or grass to further enrich the soil. Mix soil with compost and place on top of this organic matter as the top layer of the bed.
- **Accessing bed:** Always avoid stepping in the bed as this will compact the soil.
- **Maintenance:** Maintain short walls around the bed to prevent nearby erosion from impacting the bed and to avoid compaction from people and animals. Note that after a few seasons, with additions of organic matter, the soil level will rise and may no longer be sunken, so gardeners will need to dig out the bed again or change to a different garden type given the soil fertility level.

Capitalizing on labor

In some countries, such as Kenya, clay soil is used for building bricks, leaving depressions that can be filled with compost and topsoil for use as sunken beds.

Crops, planting, water, soil fertility, weeding and other considerations

- **Crops:** The sunken bed is suitable for all crops except roots and tubers, due to the depth required for optimal growth.
- **Nursery:** As a nursery bed, seeds can be sown, monitored and cultivated for one to two months and then carefully picked out for transplanting in the main part of the garden.
- **Planting:** To save space, staking or trellising vining plants is suggested.
- **Protection:** Palm fronds or other materials can be laid across the bed to protect young plants.
- **Water:** Sunken beds are appropriate for dry-season gardening; however, they will still require regular watering.
- **Fertility:** Soil fertility is managed through additions of organic matter.

Additional resources on sunken gardens are:

- *A Permaculture Design Course Handbook: Sunken Beds*
<https://treeyopermacultureedu.wordpress.com/chapter-9-earth-working-and-earth-resources/sunken-beds/>

Vertical/multi-level gardens



Vertical garden.
*Photo by Anza Muenchow
for CRS*

Vertical gardens are especially good for maximizing constrained spaces, since plants can grow vertically, not just horizontally. This garden type uses trellises, nets, strings, cages or poles to support growing plants as well as plants grown in suspended mediums. Suspending plants can also help prevent potential animal damage.

Preparation and management

Several different designs of vertical gardens are described below.

- **Water tower:** This is designed using a sack with a set of supporting poles and a gravel column placed at the center of the bag (e.g., woven plastic rice bag). The sack is filled with soil, ash and roots. Holes are cut into the sides of the bag, and leafy greens are planted in the holes. Greywater is then poured through the gravel column, which removes some of the debris or particles that may be in the water, to reach plant roots. The towers can be positioned at the back door of a house so that it is convenient to pour wastewater into the tower. To learn more, read this [case study](#) on greywater reuse with keyhole and vertical gardens in Ethiopia (IRC International Water and Sanitation Center 2013).
- **Slotted bamboo:** Cut circular holes into thick bamboo poles or remove a rectangular portion from the top to create a trough. Fill the hole/trough with a mixture of soil and compost, and plant seeds. Use vertical stakes to suspend poles horizontally.
- **Trellises:** Vining plants in other garden types (i.e. permagarden, raised bed, sunken bed) are trellised or trained up poles to grow vertically.
- **Container planters:** These are also considered vertical gardens because they can be suspended, which helps prevent damage by animals.

Crops, planting, water, soil fertility, weeding and other considerations

- **Crops:** Trellises are suitable for vining and sprawling plants, such as cucumbers, peas, tomatoes, melons and pole beans. Suspended containers or poles may support leafy greens or herbs.
- **Planting:** If growing different plant types together in one container, make sure that they all have the same growing requirements (water, sunlight, nutrients) and growth speeds. Plant crops that do not need as much water at the top of the garden since this dries out first.
- **Water:** Vertical gardens are compact with less soil so more frequent watering will likely be required. Ensure the water is distributed evenly. For large vertical gardens, a simple drip irrigation system—in which there are holes in the bottom of planters that allow water to drip down—can be set up.
- **Soil fertility:** This must be closely monitored. Using a liquid fertilizer or compost tea every month is advised, depending on the crop.
- **Weeding:** Weeds should not be a problem as plants are closely spaced.

Additional resources on vertical gardens include:

- Greywater towers. <https://sswm.info/sswm-university-course/module-6-disaster-situations-planning-and-preparedness>

Conclusion

One of the first steps to ensuring a successful garden is to plan it. This entails identifying the proper location; understanding basic planting needs; choosing a garden type that is appropriate to the local context; respecting the resources available, including land, water and labor; and considering soil fertility. Not all gardens will be appropriate to the context, so use the assessment tool in Chapter 2 to support your decision.

Quiz

1. Garden types include container gardens, conventional row gardens, keyhole gardens, permagardens, raised beds, sunken beds and vertical/multi-level gardens.
 - True or false: All of the above garden types are suitable for all households.
2. What garden types could be used for constrained spaces?
3. Name three of the four factors to be considered when deciding where to build garden beds.

Activity

For the target audience, identify the type of gardens that a current or proposed project would promote, using the table below. Explain why the selected garden type(s) were selected.

Factors to determine garden type	Local context and anticipated project support	Garden types appropriate for this local context and anticipated support						
		Container garden	Conventional row garden	Keyhole garden	Perma garden	Raised bed	Sunken bed	Vertical garden
Climate/location								
Land size								
Water resources								
Labor available								
Food preference								
Materials available								

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Chapter 3, Annex 1: Garden checklist

Field agent's name:

Gardener's name/ID number:

Gardener's gender (circle): Male | Female

Location:

Date:

Quality control checklist: General garden aspects

Criteria	Agent's observation	Agent's recommendation to gardener	Follow-up visit status
Crops planted are compatible with each other			
Water is accessible nearby			
Crops look sufficiently watered			
Soil is enriched with organic matter			
Pests detected (identify the pests)			
Diseases detected (identify the diseases)			
Plants do not show signs of nutrient depletion			
Weeds are under control			
Postharvest—plant residue remains on garden bed			

Container garden

Criteria	Standard	Agent's observation	Agent recommendation to gardener	Follow-up visit status
Container structures	<ul style="list-style-type: none"> ■ Recycled materials (nylon feed/grain sacks, hollow logs, or plastic buckets/tubs, pipes with drain holes cut into the bottom) - Non-toxic ■ Porous or have drainage holes in the bottom ■ If hung, container is supporting the weight of soil, plants, and water 			
Container location	Plants receive adequate sunlight and water			
Size	Small plants (greens, herbs) are in containers that are at least 15 cm (6 inches) in diameter with a 20 cm (8 inch) soil depth; bigger plants such as peppers are in larger containers such as tubs			
Soil	<ul style="list-style-type: none"> ■ Soil mixture allows for proper drainage ■ Soil covered with mulch 			
Soil fertility	Compost regularly added to container			
Planting	Plants in same container have the same growing requirements (water, sunlight, nutrients)			
Water	Containers are moist			

Conventional row garden

Criteria	Standard	Agent's observation	Agent recommendation to gardener	Follow-up visit status
Bed construction	Straight lines that are level with the ground			
Size	Maximum 50 square meters with family labor only			
Soil fertility	Uses crop rotation, intercropping and/or organic matter during establishment and each season, and during growing season			
Pathways	Delineated walkways covered in mulch			
Pathway width	Appropriate for size of gardener, equipment (e.g. planting, maintenance, harvesting), and irrigation choice			
Tillage	Soil is tilled as needed for weed control and aeration			
Unsuitable crops	Most are suitable, but based on local conditions			
Planting design	Straight lines			
Planting	Staggered planting; rotate plant families			
Water	Small-scale irrigation system			
Mechanization	Pump/drip irrigation, motorized tillers, animal traction			

Keyhole garden

Criteria	Standard	Agent's observation	Agent recommendation to gardener	Follow-up visit status
Climate	Dry			
Bed construction	Keyhole garden is on flat/level land			
Bed construction	Walls of keyhole garden are strong			
Bed construction	Layers of soil content include manure, ash, rotting logs, dry and green grass or leaves, and other available organic materials			
Bed construction	Top layer of keyhole garden is sloped			
	Thatch basket in center is in good condition			
Size	2-meter circumference			
Depth	Waist-high; adapted based on disability			
Soil fertility	Household organic (kitchen) waste is added to the center basket to enrich soil; manure is aged			
Access path	Keyhole large enough for gardener to get access to basket			
Unsuitable crops	Peppers, eggplant, maize, and large/vining plants unless used as a vertical garden over the side (squash, pumpkin, tomatoes)			
Planting design	Circular or curved lines			
Water	Greywater tossed inside basket; during dry season; top layer of soil watered			

Permagarden

Criteria	Standard	Agent's observation	Agent recommendation to gardener	Follow-up visit status
Size	Initial size: 16 square meters			
Width	1 meter (if planting trees, the bed will be wider)			
Visible condition	Rocks and roots not visible			
Soil fertility	Organic matter added; crop rotation; compost pit nearby			
Structure	<p>Swales:</p> <ul style="list-style-type: none"> ■ Built on upslope side at the highest point ■ Built on contour to prevent water from flowing away from the garden ■ Redirects water to the garden or storage <p>Berms:</p> <ul style="list-style-type: none"> ■ Built downhill ■ Soil is mounded in a line along the contour or in half-moons ■ Living fence is planted around the garden (fruit trees, fast-growing trees, grasses, and shrubs) 			
Pathways coverage	Mulch			
Weed management	Mulch around trees and plants			
Planting design	Planted in a triangle			

Raised bed

Criteria	Standard	Agent's observation	Agent's recommendation to gardener	Follow-up visit status
Climate	Wet climates/rainy season			
Shape	Rectangle			
Width	Gardener can reach center easily without stepping on soil (approximately 1 meter)			
Length	Approximately 2.5 meters (shorter beds are easier to manage)			
Depth	16-20 cm minimum			
Soil enriched with organic matter	Yes (leaves, grass, composted plants, animal manure, topsoil)			
Structure	Made using non-toxic materials			
Frame strength	Able to support soil and water			
Pathways coverage	Covered in mulch			
Pathways width	Wide enough so the gardener can walk with tools without disturbing garden beds (60-90 cm)			
Soil compaction	None			
Tillage	When breaking new ground or adding new compost only			
Unsuitable crops	Large, vining plants (e.g., squash) unless staked/ trellised			
Planting design	Planted in a triangle			
Planting	Succession and relay planting			
Water	Water nearby or irrigation, especially during dry season			

Sunken bed

Criteria	Standard	Agent's observation	Agent recommendation to gardener	Follow-up visit status
Climate	Dry, arid climates preferred; not in areas that flood and not used during rainy season			
Bed construction	Double digging used to construct bed only; wall height is at least 30 cm (12 inches); if on sloped land, wall is higher than 30cm (12 inches)			
Width	Gardener can reach center easily without stepping on soil (about 1 meter)			
Length	No standard length			
Depth	45-60 cm (18-24 inches)			
Soil enriched with organic matter	Yes (leaves, hay, grass, topsoil, compost)			
Pathways	Raised—made with nutrient-poor soil			
Pathways width	Wide enough so the gardener can walk with tools without disturbing garden beds (60-90 cm)			
Soil compaction	None (loose/aerated); not walked on			
Level of erosion around bed	Low/walls maintained			
Unsuitable crops	Roots and tubers			
Planting	Vining plants are staked/ trellised			
Water	Regular watering			

Vertical/multi-level gardens

There is a variety of vertical/multi-level gardens, so this checklist needs to be adjusted based on the type of vertical/multi-level garden being promoted.

Criteria	Standard	Agent's Observation	Agent Recommendation to Gardener	Follow-up visit status
Containers	<ul style="list-style-type: none"> ■ Suspended containers are appropriate for weight of contents ■ Containers are non-toxic 			
Construction materials	Uses trellises, nets, strings, cages, or poles to support growing plants			
Soil fertility	Liquid fertilizer or compost tea used every month depending on the crop			
Crops	<ul style="list-style-type: none"> ■ Trellises are suitable for vining and sprawling plants, such as cucumbers, peas, tomatoes, melons, and pole beans ■ Suspended containers or poles may support leafy greens or herbs 			
Planting	Crops are compatible (same level of water, sunlight, nutrients, and growth speeds)			
Water	Distribute water evenly			

Chapter 4: Crop Selection

Authors: Valerie Davis and Harley Stokes, with contributions drawn from other chapters⁹

Learning objective

After studying this chapter, you will know the:

- Key factors to consider when selecting crops to promote in a garden

Key messages

- Crop selection is based on a number of factors, including garden type, productivity, food preferences, nutrient value, gender preferences, soil health, seed selection, water requirements, pest and disease prevalence, and market demand.
- Use assessment findings to align crop selection with the context.

Key question for decision-making

- What crop/variety mix will the project promote to achieve its objectives within the local context?

9. This chapter is a compilation of content developed by the authors of specific chapters in this guide: Lindsey Jones-Renauld (gender); Harley Stokes (nutrition); Peter Marks (seed); Gaye Burpee (integrated soil health management); Sara Page, Bryan Sobel and Anne Turner (pest and disease management); Rupert Best (marketing); Elias Bakhsh and Chris Seremet (water resources); and Lisa Kitinoja (postharvest handling).

Crop selection is important

Choosing the right crop mix and the right varieties to promote in gardens will help with productivity, soil health and pest/disease management. Promoting crops that reflect local food preferences, demand and gender preferences will ensure the produce is used for home consumption, processing and/or market sales. Given the importance of water in ensuring sustainable gardens, there is a need to select crops whose water requirements align with water availability. Selecting crops by taking into account gender dynamics around who plants, harvests, sells the produce and controls the income may contribute to improved women’s empowerment.



Selecting crops by taking into account who plants, harvests, sells the produce and controls the income may help empower women.

Factors that influence crop/variety selection

Many factors affect decisions on what to plant, such as nutrient content, market demand, gender dynamics, crop compatibility, seed type and availability, perishability, food preferences, garden type, productivity, soil type, sun exposure and water requirements (see Annex 1 on Page 52 for a table that summarizes these factors for selected crops). Given that most gardens include a mix of crops, project teams and gardeners can choose the right mix of crops to meet their needs and context.

Nutrition

If the garden objective is to address malnutrition, selecting crops that are nutrient-dense in either vitamin A, protein, iron, vitamin C and/or zinc will support achieving this objective. Crop varieties may have different levels of nutrients. This becomes an opportunity to explore biofortified crop varieties such as orange-fleshed sweet potato (OFSP) and iron-rich beans. For more information on the nutrient content of selected crops, see the table in Annex 1. Use this table as a starting point to consider which crops are appropriate for the target population and your garden objective. This table is not comprehensive, as there are always local varieties and additional indigenous species that are only found in your country or region. In addition to this table, The Technical and Operational Performance Support Program’s [A Tool For Framing A Discussion Between Nutrition and Agriculture Specialists](#) supports nutrition and agriculture team members in coming to a decision on which agronomically appropriate crops to promote for nutrition. The tool will also be useful for thinking through the agronomic aspects of each crop the project would like to promote for its garden intervention. A CRS-adapted version is also available at [this link](#).

Marketing

If the garden objective is to sell some or all the garden produce, market demand and profitability will help drive the decisions on what crop mix to promote. To help determine the best crop mix and the most valued varieties for the market, the project team should conduct a simple market survey or use the market opportunity identification tool from the CRS *Value Chain Toolkit*. The surveys should determine volumes needed and sale prices. Crop production levels should be calculated based on expected production per area, maturity time, seasonality, material resources and any special requirements. This data will help determine potential profitability. A [Garden Business Workbook](#) is included in Chapter 12 to support this exercise.

Table 1: Questions gardeners can ask to understand market demand

Questions to ask FAMILIES in the community	Questions to ask local market STALLHOLDERS
<ul style="list-style-type: none"> What vegetables, fruit or herbs do you regularly buy for preparing food for your family? 	<ul style="list-style-type: none"> What vegetables, fruit or herbs do you buy and sell on a regular basis as a vendor?
<ul style="list-style-type: none"> Do you buy vegetables, fruit or herbs that have been conserved so that you can store them (e.g., dried and pickled products or fruit made into jam)? 	<ul style="list-style-type: none"> As a vendor, do you buy and sell vegetables, fruit or herbs that have been processed so that they can be stored (e.g., dried and pickled products or fruit made into jam)?
<ul style="list-style-type: none"> Which of these vegetables, fruit or herbs does your family like and consume a lot of? 	<ul style="list-style-type: none"> Which of these products are in high demand or do you sell most of?
<ul style="list-style-type: none"> Where do you buy the vegetables, fruit and herbs that you consume? 	<ul style="list-style-type: none"> Which of these products are scarce or difficult to obtain?
<ul style="list-style-type: none"> Which of these vegetables, fruit and herbs are you likely to buy and consume more of in the future? 	<p>For each of the high-demand or scarce products:</p> <ul style="list-style-type: none"> How often do you buy them? What is the minimum and maximum quantity you buy? What quality do you need (e.g., size and shape, freshness, color and maturity)? What is the price you are currently willing to spend? When will you pay the producer?
<ul style="list-style-type: none"> What vegetables, fruit or herbs would you like your family to consume but you are unable to find in the market? 	
<ul style="list-style-type: none"> If my family produces some of the vegetables, fruit and herbs that you mention, which ones would you like to buy from us and why? 	<ul style="list-style-type: none"> Which of the products that you have mentioned would you buy from us and why?

Garden type

The type of garden that is promoted can influence what type of crops can be grown. Although most crops can be grown in a variety of gardens, some grow better in certain garden types. For example, in *raised bed gardens*, most plants grow well, but shallow-rooted plants are preferred. Large, vining plants (e.g., beans, squash, pumpkin, peas and tomato) will take up substantial space and should be staked/trellised. In *sunken bed gardens*, roots and tubers are not recommended due to the depth required for optimal growth. In *keyhole gardens*, peppers, eggplant, maize and large/vining plants that may require staking or trellising are not recommended; however, tomatoes can be planted along the outside edge of the garden and hung over the side as in a vertical garden. In *vertical/multi-tiered-gardens*, trellises will be needed for vining and sprawling plants, such as cucumbers, peas, tomatoes, melons and pole beans. Suspended containers or poles support leafy greens or herbs best.

Gender

Local gender dynamics should influence what crops are being promoted. The crop selection process will need to take into account who makes decisions about the crop, who cultivates the crop, and who controls the output and income earned, which can vary by the crop being promoted. Since gardens interventions are often targeted at women, we want to make sure that the crops selected ensure that women, who are often more vulnerable, can equitably benefit from their efforts of growing specific crops. See Chapter 5 on Gender Integration to learn more.

Productivity

Productivity levels will vary according to such factors as crop variety, soil health and access to / source of year-round water. Understanding the estimated productivity levels based on current conditions and improved practices can help guide what crops to promote in a garden so that target households receive the maximum benefit from their efforts.

Companion planting

Companion planting is when the gardener plants several types of crops near each other to improve plant health and yields. It is important to know which plants grow well together, because if plants are incompatible, they may harm one another. For instance, some plants attract beneficial insects while the scent of other plants repels pests (see Chapter 9 on Pest and Disease Management to learn more). Some plants may help make available the nutrients (like nitrogen) that other crops need. For plants that need shade, planting a larger plant nearby may offer the needed shade. Vining and sprawling crops can be planted near tall plants like maize and sunflowers to use them as stakes or can be allowed to spread out and serve as ground cover and weed suppression (Lohmiller and Lohmiller 2018). When considering what crops to promote, determine whether the crops are compatible and identify how they can support each other's growth and health. The table in Annex 1 provides a list of compatible and incompatible crops for selected crops.

Seed selection

The availability, accessibility and affordability of certain seeds will guide decisions on what crops and specific varieties to promote in a garden intervention. The [Seed System Security Assessment](#), if available, can provide information on what seed varieties are available and how gardeners currently access specific seed varieties. If seed is not available for a particular crop variety and the project wants to promote it, the project will need to find ways of improving access to this seed by the gardener.

When considering seed variety, the project may want to consider varieties that are drought- and/or disease-resistant. It will want to consider seed varieties that are appropriate for fresh consumption or processing, as these will differ. To support nutritional and marketing aspects, varieties with short maturity, different harvest times and staggered ripening may be considered depending on the context. If seed saving is an important part of the project strategy, crop selection may be determined by the ease of saving seeds from season to season. The table in Annex 1 provides details on the ease of saving seeds on selected crops.



For plants that need shade, planting a larger plant nearby may offer the needed shade.

Soil characteristics

Soil type (relative amounts of sand, silt and clay) and pH level will influence the type of crops the project recommends to gardeners, so that crops can thrive in their preferred soil and pH level. Annex 1 provides information on soil types and the desirable pH ranges for selected crops.

Water requirements

Each crop variety has its own water requirements for optimum production. Knowing the water needs, along with water availability and accessibility, will guide crop selection. The project design team needs to assess how much water will be needed for the target crops across seasons—both wet and dry. Many situations will require more water than is available from a rainfed system, so the project design team must consider how to support water access (e.g., water points, irrigation). The project could also promote crop varieties that require less water or need water at strategic times, such as OFSP. Discussions among agriculture and water staff will help in making practical crop variety decisions related to water.

Soil and air temperature

Crops have preferred soil and air temperatures. Knowing soil temperature preferences is essential because seeds are not likely to germinate well if planted in soil that is either too warm or too cool. Crops also have preferred air temperatures for growing. If the temperature is too low, the plant will not grow well. If the temperature is too high, the plant may bolt and go to seed. Knowing temperature preferences of the crop along with weather information will guide seed selection and planting decisions.

Sun exposure

Crops have different sun exposure preferences. Most vegetables prefer full sun (6 to 8 hours per day) but others can do with less. When selecting crops to promote, including crops with different sun exposure preferences could help a family optimize the use of their existing land/space.

Conclusion

When determining what crops to promote, it is important to consider the various factors discussed in this chapter along with the local context of the target audience. The results from the assessments recommended in Chapter 2 could support this decision-making process. Because the factors are cross-sectoral in nature, program managers are encouraged to engage with relevant sectoral staff in agriculture, nutrition, water, gender and value chains.

Quiz

1. True or false: All crops have the same water requirements.
2. True or false: While most crops have a set of friends, some also have a set of enemies.
3. List four of the factors that influence crop selection.

Activity

Break into small groups. Using an existing or upcoming project, identify two crops to promote in a garden, based on the factors described in this chapter. Briefly describe each factor as it relates to the selected crops. Write details on flip chart paper and share with the whole group.



Crops have preferred soil and air temperatures for growing.

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Chapter 4, Annex 1

Factors affecting crops (with readily available information)

Crop	Ease of saving seed	Soil type best for the crop ¹⁰	pH level preferred by the crop	Average crop water needs (mm/total growing season)	Contains high levels of the following nutrients	Non-compatible crops	Perishability (very high: <2; high: 2-4; moderate: 4-8; low: 8-16; very low: >16)
Amaranth	Easy	Many soils	5.5-7.5	-	Vitamin A, iron, zinc	-	Very high
Avocado	N/A	Many soils if well drained	Tolerates 5.0-7.0 Prefers 6.0-6.5	-	Folate, zinc	-	High
Banana	-	Many soils if deep, well drained	5.5-6.5	1200-2200	-	-	Very high
Beet	Difficult	Loam or sandy soils, not clay soil	6.0-7.5	-	-	Mustard, pole beans	Moderate
Broccoli	Difficult	Many soils if well drained	6.0-7.0	-	Vitamin C	Cabbage, cauliflower, lettuce, pole beans, tomatoes	Very high
Cabbage	Difficult	Sandy loam to clay soil	6.0-7.0	350-500	Vitamin C	Broccoli, cauliflower, strawberries, tomatoes	Low
Carrot	Difficult	Sandy soil	5.5-7.0	-	Vitamin A	Dill, parsley	Moderate
Cassava	Vegetative propagated crops (VPC)	Sandy soil	5.0-8.0	-	Iron (leaves)	-	Very high
Chickpea	Easy	Well-drained loam and clay loam soils	6.0-9.0	-	Protein	-	Very low (dried)
Chili pepper	Easy	Sandy soil	5.0-6.5	-	Vitamin C	-	High
Chinese cabbage	Difficult	Sandy loam	6.0-7.5	-	-	-	Moderate
Citrus	Tree	Loam, sandy loam or sandy soils	Tolerates 4-8 Prefers 5.5-7.0	900-1200	Vitamin C, folate	-	Moderate
Common beans	Easy	Sandy loams or silty loams are best; can grow in any soil except clay	Tolerates 5.5-7.5 Prefers 6.0-6.5	-	Protein	Garlic, onions, peppers, sunflowers	Very high

10. The best soil for most vegetables is a loam.

Crop	Ease of saving seed	Soil type best for the crop ¹⁰	pH level preferred by the crop	Average crop water needs (mm/total growing season)	Contains high levels of the following nutrients	Non-compatible crops	Perishability (very high: <2; high: 2-4; moderate: 4-8; low: 8-16; very low: >16)
Cowpea	Easy	Many soils, but does best in sandy or sandy loam soils	5.5-7.0 Does not do well at 7.5 or higher	-	Protein	-	Very low (dried)
Cucumber	Easy	Loam soils are best	Tolerates 5.5-7.6 Prefers 6.0-7.0	-	-	Herbs, melons, potatoes	Very high
Eggplant	Difficult or moderate with training	Sandy soils, not clay soil	Tolerates 5.5-7.0 Prefers 6.3-6.8	-	-	-	High
Garlic	VPC	Sandy soil	5.5-8.0	-	-	Peas and beans	Low
Gourd	Easy	Many soils, but loams are best	5.5-7.5	-	Vitamin C	-	Very low
Guava	N/A	Many soils	4.5-8.2	-	Vitamin C (ripe)	-	High
Groundnut	Easy	Sandy soil	6.0-6.5	-	Protein, iron	-	Very low (dried)
Kale	Moderate or difficult	Many soils if well drained; prefers loam soils	Tolerates 6.0- 7.5 Prefers 6.5-6.8	-	Vitamin A	Strawberry, tomatoes	High
Labiab bean	Easy	Many soils if well drained	4.5-7.5	-	Protein	-	-
Lettuce	Moderate	Sandy soil	6.0-7.0	-	-	Broccoli	Very high
Lentils	Easy	Deep, sandy loams; needs good drainage	Tolerates 6.0-8.0 Prefers 7.0	-	Folate, protein	-	Very low (dried)
Mango	N/A	Many soils	-	-	Vitamin A (ripe)	-	High
Melon	Easy	Sandy soil	> 5.0	400-600	-	Cucumbers, potatoes	High
Moringa	-	Sandy loam to loam	Tolerates 5.0-9.0 Prefers 6.5-7.5	-	Protein, vitamin C, vitamin A	-	Leaves very high, seeds very low
Mung bean	Easy	Sandy loam	6.2-7.2	-	Protein, folate	-	Very low (dried)
Mustard	Easy	Sandy or sandy loam	5.5-6.8	-	Vitamin A, vitamin C	-	Seeds very low
Okra	Easy	Sandy soil	6.5-7.6	-	Folate	-	High

Crop	Ease of saving seed	Soil type best for the crop ¹⁰	pH level preferred by the crop	Average crop water needs (mm/total growing season)	Contains high levels of the following nutrients	Non-compatible crops	Perishability (very high: <2; high: 2-4; moderate: 4-8; low: 8-16; very low: >16)
Onion	Difficult	Sandy soil	5.5-6.8	350-550	Vitamin C	Beans, peas, sage	Low (dry)
Papaya	-	Many soils	5.5-6.6	-	Vitamin A (ripe), folate	-	High
Pea	Easy	Clay soil	6.0-7.5	350-500	Vitamin K, manganese, thiamin, copper, vitamin C, phosphorous, folate	Garlic, onions	Very high
Pepper	Easy	Medium clay soil	5.5-7.0	-		Beans	High
Pigeon pea	Easy	Sandy soil	5.5-6.5	-	Protein	-	Very low (dried)
Pineapple	VPC	Sandy soil or loams	4.5-6.5	-	Vitamin C	-	High
Plantain	VPC	Loams	4.6-7.8	-		-	High
Potato	VPC	Sandy or well-drained soils	4.8-6.5	500-700		Cucumbers, melons, squash, sunflowers, tomatoes, turnips	Moderate (immature); low (mature)
Pumpkin	Easy	Sandy soil	5.5-7.5	-	Vitamin A, zinc (seeds)	Potato	Low
Radish	Easy	Sandy soil	6.0-7.0	-		Potato, hyssop	Moderate
Regionally important/traditional greens	Easy	-	-	-	-	-	Very high
Soybean	Easy	Well-drained soil, but not sandy soils	6.0-7.0 Ideal 6.3-6.5	450-700	Protein, zinc	-	Very low (dried)

Crop	Ease of saving seed	Soil type best for the crop ¹⁰	pH level preferred by the crop	Average crop water needs (mm/total growing season)	Contains high levels of the following nutrients	Non-compatible crops	Perishability (very high: <2; high: 2-4; moderate: 4-8; low: 8-16; very low: >16)
Spinach	Moderate; some varieties need long days to produce seed	Many soils, but prefers sandy loam	Tolerates 6.0-7.5 Prefers 6.4-6.8	-	Zinc	-	Very high
Squash	Easy	Sandy soil	5.5-7.0	-	-	-	High (summer); low (winter)
Sweet potato (orange-fleshed)	VPC	Many soils; prefers fine sandy loam or well-drained clay loams	Tolerates 4.5-7.5 Prefers 5.8-6.2	-	Vitamin A	-	Low
Taro	VPC	Clay soil	-	-	-	-	Low
Tomato	Difficult or moderate with training	Loams and sandy loams; not clay soil	Tolerates 5.5-7.5 Prefers 6.0-6.8	400-800	Vitamin C	Broccoli, brussels sprouts, cabbage, cauliflower, corn, kale, potatoes	Very high (ripe); high (partially ripe)
Watermelon	Easy	Many soils, but prefers sandy loams	5.5-6.5	-	-	-	High
Yam	VPC	Many soils, but prefers a sandy clay loam	5.5-7.0	-	-	-	Low

Chapter 5: Gender Integration

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Learning objectives

After studying this chapter and its links and resources, you will know:

- Key gender issues related to gardens.
- How to apply the results of gender analysis to the design of garden interventions.
- Potential risks related to gender dynamics and gardens.

Key messages

- Women are often responsible for cultivating gardens, but this varies by geography and context. Although they may be responsible, this does not necessarily mean that they have primary decision-making power over the gardens.
- Practitioners should be wary of making assumptions and generalizations about gender. It cannot be assumed that women's limitations are all the same.
- A gender analysis is necessary for practitioners to be aware of how gender dynamics influence gardens.
- Garden interventions can be an entry point or a foundation for women moving into higher-value work and leadership opportunities.
- Two key gendered risks of garden programs are 1) increased marketability of crops that results in women losing autonomy over the produce, and 2) increased workload/time burden, impacting women's energy expenditure and time available for childcare and feeding.

Key questions for decision-making

- What steps will you take to ensure that gender is integrated into garden assessments, and that gender-related results are incorporated into the garden design?
- What garden-related activities need to be designed or adjusted to be gender responsive?
- What are the opportunities for gender-transformative garden-related interventions?

Gender is important for gardens

“Why are men’s plots called ‘farms’ and women’s plots called ‘gardens’?”

Presenter, USAID Gender Global Learning and Evidence Exchange, 2013

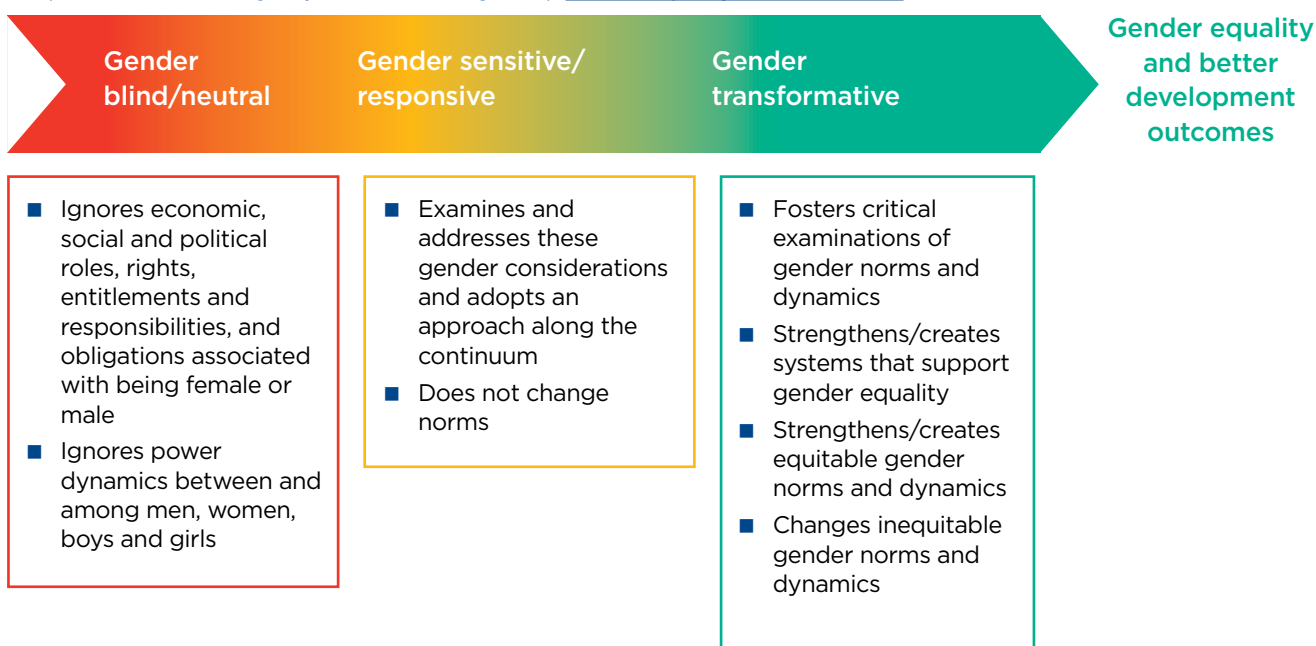
At the Gender Global Learning and Evidence Exchange (GLEE), which was hosted by USAID in 2013 at the onset of the U.S. Government’s Feed the Future initiative, a speaker posed the question: “Why are men’s plots called ‘farms’ and women’s plots called ‘gardens’?” This pointed to the biases in how society categorizes and places value on work that is associated with men differently from work that is associated with women, even though the work is similar. Because gardens are usually small plots of land that are used for subsistence farming, they are often more accessible to women and associated with women’s work. These gender biases about women’s work and gardens often mean that practitioners, policymakers, enterprises and service providers treat gardens differently from other plots, even though women could benefit from the same resources (e.g. extension knowledge, seed, fertilizer) to make both women and their gardens successful.

Different levels of gender integration

The Gender Integration Continuum (Figure 1) classifies interventions into three categories: 1) Gender blind or neutral, 2) Gender sensitive or responsive, and 3) Gender transformative. According to the CRS gender strategy, all programs must put in place activities that are, at a minimum, gender responsive, with the goal of incorporating transformative programming that more directly influences changes in norms and systems to facilitate equality.

Figure 1: Gender integration continuum

Adapted from the Interagency Gender Working Group [Gender Equality Continuum Tool](#)



Applying the Gender Integration Continuum to gardens includes four steps.

Step 1: Assess the gender dynamics of the project context. Gender dynamics vary across cultures, location, age, disabilities and context, which is why gender analysis within the local context is an important first step toward designing and implementing any programming. Practitioners need to conduct a gender analysis to assess, analyze and attempt to understand the following six gender domains:

Gender analysis within the local context is an important first step toward designing and implementing programming.

- Roles, responsibilities and time use
- Access to / control of assets and resources
- Power relations and decision-making
- Participation and leadership
- Knowledge, beliefs and perceptions, including cultural practices
- Legal and policy environment

Gender analysis can be incorporated into a garden assessment, as seen in Chapter 2, or conducted as a separate study.

Step 2: Use the analysis results to design project interventions. For each gender dynamic revealed in the analysis, practitioners need to ask:

- How can we make the program gender responsive?
- Where are the opportunities for the program to be gender transformative?

For each of the six gender domains, a table is included to illustrate how practitioners can adapt the garden intervention to be gender responsive and gender transformative using the analysis results. See Table 1 for an example.

Table 1: Using gender analysis results to design interventions

Gender dynamic	How can the program respond to this dynamic?	How can the program transform the situation to facilitate equality?
Women are the primary managers of gardens <i>(Domain 1: Roles, responsibilities and time use).</i>	Ensure that women can meaningfully participate in trainings about gardens.	Support an initiative for women participants to become trainers.

Step 3: Prioritize interventions. Use the tables in the sections below and help brainstorm ways the project could be made gender responsive or gender transformative.

Since this chapter gives only a brief introduction to gender dynamics and how to respond to them, practitioners can also reference the following resources to deepen their gender integration work:

- The CRS Gender Analysis Training of Trainers Toolkit ([internal](#)) has information on how to conduct gender analysis and the various methodologies that can be used to solicit answers to the proposed questions.
- The [Intervention Guide for the Women’s Empowerment in Agriculture Index](#) is a comprehensive collection of agricultural development activities that can promote gender equality and women’s empowerment (Stern et al. 2016).

Domain 1: Roles, responsibilities and time use

Assessment questions: Roles, responsibilities and time use

- If respondents already have a garden, who manages it? Who works in it and how frequently? What do they do with their time when they are not working in the garden?
- Where are there other differences in roles or responsibilities according to social identities, such as age, marital status or ethnic group?
- Who is responsible for buying or growing food for the household?



A mother and son in their vegetable garden in Char Goalia, Monpura, Bangladesh.
Photo by Map Mahmud for CRS

Women are usually responsible for gardening, but practitioners should not assume that it is always or primarily their domain. In some places, such as in South America, women are often the sole or primary caretaker of gardens, whereas in others, such as in Indonesia and Sri Lanka, they only work in the garden during planting and harvesting or at other critical and laborious times (Galhena et al. 2013). Even if women do most of the work in a garden, they may not have full control over the decisions about what to plant and whether to eat the produce, save the produce, store the seeds, sell the produce, or a combination thereof (see Domain 3: Power Relations and Decision-Making).

Even if women do most of the work in a garden, they may not have full control over the decisions made about it.

Gardening can be an accessible way for even time-poor women to access some form of income or food for themselves and their families. This is because the closeness of gardens to the home means that women can simultaneously attend to their household and caretaking work, which are almost always their responsibility (Galhena et al. 2013).

Another possibility to take into consideration is that gardening could have a negative impact on the nutrition of women and their children if it increases women’s energy expenditure, reduces their caring capacity (United Nations Children Fund 2011) and/or they do not retain control over the produce grown or the income earned to be used for nutrition-related purchases. However, if women have the bargaining power to choose how to spend their time and are experiencing benefits from their greater workloads, the opportunity cost may be worth it to them (SPRING 2014). This means that practitioners need to take a nuanced approach to analyzing and responding to time-use-related gender dynamics. It is important to recognize that women have the right to determine whether increasing their time spent on gardening is a positive or negative outcome for themselves and their children.

Gardening can have a negative impact on the nutrition of women and their children.



Table 2 gives some examples of gender-responsive and gender-transformative interventions related to roles, responsibilities and time use. Please note that Tables 2 to 9 offer examples of selected gender dynamics so practitioners need to understand their specific context and adapt accordingly.

Table 2: Applying the Gender Integration Continuum to roles, responsibilities and time use

Gender dynamic	How can the program respond to this dynamic?	How can the program transform the situation to facilitate greater equality?
Women are the primary managers and workers in gardens, but all members of the household provide some labor in the garden.	<ul style="list-style-type: none"> ■ Ensure that women can meaningfully participate in trainings by scheduling them at times and locations where they can attend, providing childcare, and hiring female trainers. ■ Engage male partners to ensure that women have their support to participate. ■ Monitor the amount of time men, women and children spend working in the garden; if it changes significantly, conduct research to understand the nuances and potential negative impacts (e.g., on childcare). 	<ul style="list-style-type: none"> ■ Support an initiative for women participants to become trainers. Engage men in the process.
Men are the primary managers of gardens. Male children work in the garden on a regular basis. Women and female children work in the garden during critical times, particularly during harvest. They are also responsible for postharvest handling and processing.	<ul style="list-style-type: none"> ■ Provide support to women in their postharvest handling and processing responsibilities. Provide support to men in garden establishment and maintenance. ■ Engage male partners to ensure that women have their support to participate. ■ Monitor the amount of time women spend on the garden and whether it changes significantly. Conduct research to understand the nuances and potential negative impacts (e.g., on childcare). 	<ul style="list-style-type: none"> ■ Support an entrepreneurial program for women who are interested in starting or expanding their microbusinesses in postharvest handling, processing, or other goods or services. Engage men in the process.

Domain 2: Access to and control of assets and resources

Gender inequality in access to assets and resources is widespread. The Food and Agriculture Organization found that if female farmers had the same access to land, inputs, technology, financial services, information and markets as male farmers, their production could increase by 20 to 30% (FAO 2011). This section discusses assets and resources separately, as they often present different issues.

Access to and control over assets

Assessment questions: Access to and control over assets

- Who in the family has access to land for farming and/or gardening? Who has title over the land?
- How close is the garden to their home?
- Is there communal land that can be accessed for starting a garden? How does one access it? Are both men and women able to access it?

Gender inequality in land access and ownership is one of the reasons that gardens tend to be more accessible to women. Women are far less likely than men to have control over land assets, but because a garden is usually on a small parcel of land next to the home—instead of a separate plot of land—it is usually more accessible to women as well as other marginalized groups. Rural women in developing countries generally access land for gardens through men (World Bank et al. 2009). However, while a woman may have access to land, she may not control its use. A review of a gardening program in Cambodia found that:

“... home gardens are not totally under women’s control as they appear to be. A closer look into how home garden resources are managed and controlled reveals a more nuanced picture of power dynamics between women and men in rural Cambodia. Though women can access land for home gardens, when household land is limited, men will choose which crops to plant and will probably overrule women’s priority food crops.”

(Nguyen et al. 2016)

Case study: Inequities in access to assets for market gardens in Mali

Horticultural production in gardens used to be women’s primary domain in Mopti, Mali. As men noticed that it was becoming increasingly lucrative, they also began growing horticultural crops in market gardens. Because they had greater access to capital, land and labor for production—and women were overburdened by household and childcare responsibilities—women struggled to maintain their role as horticultural producers amid the competition from men (USAID 2016).

It is worth noting that there are new technologies that are making vertical and hydroponic gardens possible, making land even less of a requirement for gardening (Galhena et al. 2013). Still, ownership or access to that technology would be a necessary asset in lieu of land.

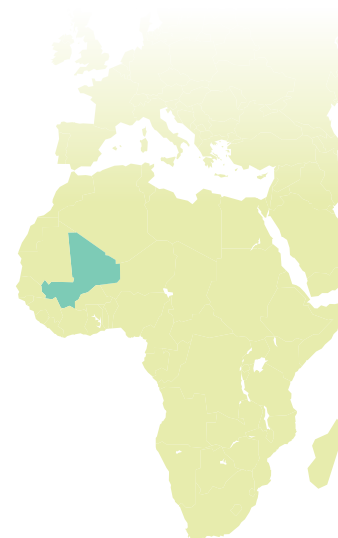


Table 3 presents examples of gender-responsive and gender-transformative interventions for addressing gender dynamics related to access to and control over assets.

Table 3: Applying the Gender Integration Continuum to access to and control over assets

Gender dynamic	How can the program respond to this dynamic?	How can the program transform the situation to facilitate equality?
In households that have land, very few women are included on the land title. Men in the household provide land access, which women use to cultivate household gardens.	<ul style="list-style-type: none"> ■ Communicate with men that even though they own the land, because women work on the land, they should be able to participate in program activities (e.g., trainings, access to inputs and fertilizers). Connect women to these resources. ■ Monitor for positive and negative changes in women’s access to land and resources. If negative changes occur, conduct research to understand the nuances. ■ Engage men in gardening programs so they understand why particular crops and gardening practices are being promoted (e.g., for nutrition and income) and encourage them to work with their female partner on allocating land for garden use. 	<ul style="list-style-type: none"> ■ Help women secure land tenure, engaging men in the process. See the intervention examples at the end of this chapter.
There are some households where women have land tenure.	<ul style="list-style-type: none"> ■ Target these women for enhanced opportunities, such as participation in producer or marketing groups. Engage men in the process. 	<ul style="list-style-type: none"> ■ Mobilize these women into leadership roles where they can mentor and advocate for other women to also have land tenure. Engage men in the process.

Access to and control over resources

Assessment questions: Access to and control over resources

- Where do members of the family get their inputs for their different plots? How does it differ for men and women?
- Are there resources (e.g., extension services, training and labor) that others in the household or community use for farming that are not currently accessible to or used for the garden? How does it differ for men and women?

When women cultivate household gardens, it is often considered to be an extension of their domestic tasks that does not require the same type of resources as commercial farming operations (Verhart et al. 2014). Enterprises and organizations that provide access to resources—such as agricultural inputs, extension services, training, and membership in water-user associations (WUAs)—are not as likely to extend those services to gardeners.

Labor is another resource that is often less available, depending on the size of the garden, the physical ability of the person responsible, and the time they have available to work on it. Home gardens rely on labor from women, children and the elderly (Galhena et al. 2013) who also tend to be the less powerful and more vulnerable members of the family.



CRS-led Promoting Recovery in Zimbabwe (PRIZE) program beneficiaries hold a small gasoline-powered pump they use to irrigate their garden. *Photo by David Snyder/CRS*

Table 4 presents examples of gender-responsive and gender-transformative interventions that can be applied to address gender gaps in access to and control over resources.

Table 4: Applying the Gender Integration Continuum to access to and control of resources

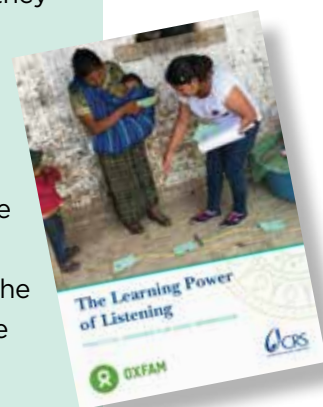
Gender dynamic	How can the program respond to this dynamic?	How can the program transform the situation to facilitate equality?
<p>Women manage household gardens but do not have access to very many inputs. Men in the same household manage larger plots for cash crops, and they access inputs through farmers' groups and input dealers in the cities. Women are not members of these groups and rarely travel to the cities because of their household responsibilities.</p>	<ul style="list-style-type: none"> ■ Hold voucher fairs in the villages to bring vendors to women who are unable to travel to the cities, and prioritize women receiving vouchers for gardening inputs. ■ Hold trainings for women to teach them how to use the inputs. ■ Hold forums with men to explain why they should buy and share inputs with women for the household garden. 	<ul style="list-style-type: none"> ■ Organize women into groups to help them access inputs directly. Engage men in the process. ■ Build up a community-based input distribution network of enterprises and help women farmers become owners of these enterprises. Engage men in the process.

Domain 3: Power relations and decision-making

Assessment questions: Power relations and decision-making

- If women are responsible for gardening, are there some decisions that they have more control over than others?
- Who decides or influences what is grown in the garden and what to do with it after it is harvested (e.g., eaten, saved as seed, sold, bartered or other)?

Asking these questions directly of a group of farmers may not elicit accurate results. Interviews with local stakeholders may provide a better overview of these dynamics. Or, practitioners can use participatory tools—described in the *CRS Gender Analysis Toolkit* or *The Learning Power of Listening*—that guide and probe target audiences to provide more in-depth information.



Gender inequality often means that men have the power to assert their agency over women. Gendered power relations between people—such as a women and men within the same household or between a widow and others in the community—can influence the effectiveness of gardens. Power over these decisions about what to plant, what to eat, what to sell, and how to spend the profits varies by household, community and context. For example, while a woman’s decision-making and bargaining power in relation to men in the household might be limited, she may have more autonomy over the garden than over other areas or decisions about the household.



In Nigeria, Jennifer Anongo and her husband, Agbidye Anongo, say they have benefited from him attending men’s forum meetings, where men from the area discuss gender and family issues. *Photo by Laura Elizabeth Pohl/CRS*

A literature review conducted for CRS about the impact of gender on agricultural livelihoods found that increases in income and employment are related to changes in decision-making; however, other requirements or changes in circumstances are often necessary to enable a woman to maintain or assert her bargaining power over that income (Serra et al. 2017). The review also found that access to and control over assets is recognized as being a greater influencer of increased bargaining power than access to income, as is level of education (Serra et al. 2017).

Some garden programs have become case studies for how good-intentioned agricultural development programs can lead to poor outcomes for women by expanding their access to resources and markets but not helping them equalize the power relations with men in the household. As the exotic vegetable production in Mali case study below shows, men can exploit women’s limited bargaining power, labor, knowledge and resources, leaving them worse off. These can also have nutritional and food security implications if women are no longer able to use gardens to provide food for their family (Garcia et al. 2006).

Case study: Exotic vegetable production in Mali marginalizes women’s household gardens

A case study of the Bamana region in Mali shows how men dismissed agrobiodiversity and the local knowledge held by women. The introduction of exotic vegetables for market production, a mainly male-driven enterprise, led to a shift from subsistence production of a wide variety of indigenous food plants to market gardening of a limited number of exotic food varieties. This process has led to a change in gender roles, with men taking over women’s traditional vegetable gardens to establish commercial enterprises. Although traditionally responsible for growing local plant varieties for direct consumption, women were displaced to marginal lands. This has implications for women’s contribution to the food security of their household (reduced income and food production for household consumption) and their social standing in the community. Moreover, women’s exclusion from the garden realm may have led to changes in culinary patterns, a possible decline in nutritional status, and a reduction in local plant diversity and overall environmental stability (World Bank et al. 2009).



Given the dominant role of men over women, it is essential that men be included and involved in gender-responsive and gender-transformative programming. Table 5 presents examples of possible gender-responsive and gender-transformative interventions to address power relations and decision-making dynamics.

Table 5: Applying the Gender Integration Continuum to power relations and decision-making

Gender dynamic	How can the program respond to this dynamic?	How can the program transform the situation to facilitate equality?
Men are the ultimate authorities in the household. Women have some autonomy about what foods from the garden the family will eat and what to sell in the local market. But their male partners own the land, so they have ultimate decision-making authority.	<ul style="list-style-type: none"> Integrate appropriate nutrition- and gender-relevant messages into agriculture lesson plans (e.g., Zambia integrated field agents and volunteer lesson plans). Monitor for changes in men’s and women’s decision-making, roles and responsibilities, particularly if men begin to take over responsibility of gardens from women. 	<ul style="list-style-type: none"> Use couple communication approaches such as the CRS SMART Couples approach to strengthen joint decision-making. Use community approaches for building knowledge of gender issues such as inequitable decision-making. Mobilize and train women in groups to learn about and advocate for their rights. Work with male gender champions to support changes in gender dynamics.

Domain 4: Participation and leadership

Assessment questions: Participation and leadership

- What types of groups, programs and/or networks are men and women in the community commonly a part of? How does their participation differ?
- What is the proportion of women to men in leadership positions in these groups?
- How can women use their experiences of gardening as leadership opportunities?

To understand gender dynamics in participation, it is important to look at the different types of groups, programs and networks that men and women are a part of and how their participation differs. These groups could include:

- Farmer organizations, cooperatives or associations
- Networks with buyers and other value chain actors
- Programs that provide access to resources, such as extension service organizations or water-user associations
- Government-run safety net programs
- Savings groups, self-help groups or other groups that may not be related to agriculture or gardening but provide access to resources and are a source of agency

The domain of leadership includes leadership in organizations as well as in enterprises. Practitioners need to find out the proportion of women who hold leadership positions in organizations and enterprises in comparison to men. If women are not as represented in leadership positions as men, the project needs to understand why, how this affects the organization meeting the needs of those less-represented members (ie, women), and agree on actions to take to improve the situation.



Nguyen Thi Nguyen, left, a community leader of a group of men and women, discusses the Green Shield project with CRS project officer Duong Thi Bach Nguyen. The project strengthened community resilience to coastal hazards in Central Vietnam. *Photo by Jennifer Hardy/CRS*

For resource-poor women, gardening may be transformative in and of itself by providing them with a source of income and food for their family (Galhena et al. 2013). But practitioners should work with women who have access to more resources, time and assets, to enable them to use home gardening as an entry point for new goals and opportunities for themselves and their families. Do not limit women’s opportunities in your program to home gardening activities only. For example, some gardening programs have found that because women are predominantly responsible for growing a diversity of produce in their gardens, they have a wealth of knowledge about biodiversity (World Bank et al. 2009). This may be particularly true for elderly women (Marsh 1998). In a global agricultural market system that incentivizes monocropping, knowledge about biodiversity could be a niche opportunity for leadership.

Other examples of ways women could graduate from gardening:

- Sell seeds or seedlings they have cultivated through village seed programs
- Become trainers of other farmers
- Explore the availability of common or communal land to increase the size of their plots
- Connect to value chain actors to access inputs, credit and markets
- Become aggregators of produce for selling to more lucrative buyers
- Represent women gardeners on community boards or in local organizations
- Use postharvest processing/value addition of garden produce for income generation

Access to these opportunities must be accompanied by efforts to ensure women have the resources, power and time to reap the benefits. Table 6 presents examples of gender-responsive and gender-transformative interventions related to gender dynamics in participation and leadership.

Table 6: Applying the Gender Integration Continuum to participation and leadership

Gender dynamic	How can the program respond to this dynamic?	How can the program transform the situation to facilitate equality?
Married women are primarily responsible for gardens but are rarely official members of farmers’ cooperatives. Some cooperatives have women’s groups for members and members’ wives. Some women are members of separate savings groups or Savings and Internal Lending Communities (SILC).	<ul style="list-style-type: none"> ■ The program can meet with cooperative members and explain the importance of reaching female farmers with information and resources for their gardens, and suggest that there be trainings held for the women’s groups (or separate trainings held for female members of existing cooperatives). Also, reach out to women through the SILC groups. ■ Form new women-only groups or cooperatives where they do not currently exist. 	<ul style="list-style-type: none"> ■ Work with women to use home gardening as an entry point for new goals and opportunities for themselves and their families, such as leadership opportunities in the cooperative or value-added enterprise opportunities. ■ Work with cooperatives to review and revise their constitutions accordingly to encourage active female participation and leadership.

Domain 5: Knowledge, beliefs and perceptions, including cultural practices

Assessment questions: Knowledge, beliefs and perceptions, including cultural practices

- What are the motivations of women and men in the household for having a garden (e.g., to eat the food, save seed, sell produce to earn income, or a combination)?
- What cultural practices or social norms enable and/or restrict women’s ability to take advantage of opportunities, capitalize on assets, or use resources that are accessible to them?
- Are there different perceptions held by men and women about what men and women are capable of in relation to gardening?

Knowledge, beliefs and perceptions are intertwined with many of the other domains, such as roles, responsibilities and time use. For example, women’s responsibility for garden work is often rooted in the perception that the crops grown there require few inputs and have low productivity, and therefore can be an extension of household tasks, which are also believed to be women’s responsibility (Verhart et al. 2014). The implication of this knowledge, and these beliefs and perceptions is the possibility that should the crops in the garden become more productive and valuable, this role/responsibility can change and become a man’s instead of a woman’s. As a result, women may lose their agency over the garden and access to the food and income that it produces.

Cultural practices related to mobility and interactions with members of the opposite sex also influence gardening. For example, the location of gardens near the family’s home often makes them more acceptable places of work for women, particularly in contexts where social norms or cultural practices limit their mobility, or where they may be at risk of gender-based violence. Table 7 presents examples of gender-responsive and gender-transformative interventions that could address gender dynamics in beliefs, knowledge, perceptions and culture.

Table 7: Applying the Gender Integration Continuum to knowledge, beliefs, perceptions and culture

Gender dynamic	How can the program respond to this dynamic?	How can the program transform the situation to facilitate equality?
Most of the extension/field agents are men, and women generally feel uncomfortable participating in training sessions with unrelated men. However, when they do encounter a female trainer, they worry that she is not as smart as the male trainer because she is a woman.	<ul style="list-style-type: none"> ■ Hire and train both male and female field agents who initially visit communities together. Invite male and female partners to attend the jointly led training. ■ Develop a community-based peer-to-peer training model that is easier for women to participate in as trainers and participants. 	<ul style="list-style-type: none"> ■ Train field agents—both men and women—in the gender gaps and barriers that gardeners face. Also train them how to address the gender stereotypes that they themselves face as trainers (e.g., women are not as smart as men and men are dangerous).

Domain 6: Legal and policy environment

Assessment questions: Legal and policy environment

- Do women and men have equal rights to own land and inherit property? Do official statutes supersede local or customary laws?
- To what extent is your target population aware of their legal rights?
- Are there policies in community or value chain organizations and institutions (e.g., cooperatives and extension service providers) that tend to discriminate against women, whether explicitly or implicitly?

The legal and policy environment can both mitigate and perpetuate the inequalities and biases of the other gender domains. Practitioners need to look at government laws and policies, and the policies and processes of organizations and institutions in the community. The policies at nongovernmental institutions or organizations may be easier than government laws to change and make more gender responsive and inclusive of women. Some laws and policies that are most likely to influence gardening are:

- Property rights and land tenure
- Family law
- Bylaws governing farmers' groups and associations
- Government or private extension or input supply policies and programs
- Laws related to gender-based violence and harassment

Table 8 presents examples of gender-responsive and gender-transformative interventions related to legal and policy environment.

Table 8: Applying the Gender Integration Continuum to legal and policy environments

Gender dynamic	How can the program respond to this dynamic?	How can the program transform the situation to facilitate equality?
Most of the existing farmers' cooperatives have bylaws that stipulate that only one person from each household can be a member of the cooperative. Women are primarily responsible for gardens, but they make up only 13% of cooperative members.	<ul style="list-style-type: none"> ■ The program may need to reach women farmers through a different mechanism than the farmers' cooperative, such as through SILC or other groups where women are already members. Or, they could encourage male members of cooperatives to bring their wives to trainings and meetings, where childcare is provided. 	<ul style="list-style-type: none"> ■ Help the cooperative see the value of including women as members. Help them review their policies so that more than one member of a household can be a member of the cooperative. Help them develop a gender policy, targets for women's membership and leadership, and an implementation plan to achieve those targets.

Cross-cutting domain: Awareness of intersecting identities

Gender identity is one of the most common systems of marginalization, but there are other social identities that intersect with gender to multiply the forms of marginalization a person may face. Most people are marginalized in some way, and while practitioners will not be able to understand all forms of marginalization, especially if they are an outsider to the community, they need to be aware that there are multiple forces of marginalization and learn which are dominant in the project context. Some common social identities to be aware of are:



Gender identity is one of the most common systems of marginalization.

- **Ethnicity, tribe, religion and/or class affiliation.** These vary by culture and context. In some contexts, one ethnicity may be more powerful, but when moved to a different context, it becomes the minority and then less powerful.
- **Disability.** Mental or physical disabilities are a common source of marginalization around the world. Although systems and institutions can be changed to accommodate people with disabilities, they often are not.
- **Age.** Adults often make decisions for and about young people. In the context of gardens, young people are often expected to provide labor, as are the elderly.
- **Marital status.** Many cultures apply negative social status to women who are widowed, divorced or abandoned. A study of urban gardening in Cameroon found substantial differences between married and unmarried women’s experiences of gardening including: 1) unmarried female gardeners were poorer, 2) no additional male labor was available to support the garden (including land preparation), and 3) there was a lack of farm equipment (Ngome and Foeken 2012).

Table 9 presents an example of how practitioners could use results from analysis of intersecting identities to design gender-responsive or gender-transformative interventions.

Table 9: Applying the Gender Integration Continuum to awareness of intersecting identities

Gender dynamic	How can the program respond to this dynamic?	How can the program transform the situation to facilitate equality?
<p>There are several widows and single women in the community who do not have access to land, so they spend their time foraging for resources (firewood, wild edible foods, grazing goats, etc.) on common land and selling their goods for money.</p>	<ul style="list-style-type: none"> ■ Take care to ensure the program does not negatively affect their access to these common land resources. ■ Promote gardening technologies that are suitable for very small land areas (e.g., sack or container gardens). 	<ul style="list-style-type: none"> ■ Advocate with community leaders to see if some communal land can be allocated to widows where they can start gardens. Help them secure tenure over the land, such as through multi-year leases, to avoid losing control when land is more fertile.

Gender interventions: Examples for garden programs

The following are examples of gender-responsive and gender-transformative interventions from research and practitioner experience in implementing garden activities.

Gender training for trainers and extension workers: Trainers and extension workers who work with gardeners need to be able to understand and respond to the gender dynamics of the homestead. Hiring and training both male and female trainers to be able to respond to the gender dynamics of gardens will better enable women farmers to meaningfully access information provided by trainers, and participate in their trainings. In addition, as demonstrated in the case study from Cambodia below, trainers need to have the knowledge and skills to respond to the gender stereotypes they themselves face. The *CRS Integrating Gender into Private Agricultural Service Provider (PASP) Services* manual is an example of such materials.

Case study: Gender stereotypes about garden trainers in Cambodia

A project in Cambodia found that female gardeners had different—and nuanced—opinions about receiving advice from female trainers compared to male trainers. Many of them felt more comfortable seeking advice from female trainers, and yet they worried that the female trainers would not have time to help them, assuming that female trainers would be too busy spending time on their own household duties. Some gardeners also worried that the female trainers did not have the same level of expertise as male trainers. It is important for practitioners to be aware of these nuanced biases about the trainers and empower them to deal with them. Both male and female trainers need to be tasked with debunking these stereotypes. The study recommends that practitioners train male and female trainers how to address and deal with stereotypical perceptions they may face in technical extension roles (Nguyen et al. 2016).

Household approaches to livelihood and agricultural trainings: These work through local organizations or enterprises to train and engage both the men and the women of the same family—whether together, separately, or a combination of both. These household approaches facilitate joint livelihoods planning and decision-making about resources, assets and earnings, and how those will influence the health, nutrition and wellbeing of everyone in the household. They apply participatory training techniques to raise awareness of the value of men’s and women’s work, and how a fair distribution of inputs and resources could increase production and the family’s nutritional status. Many integrate direct messages about gender equity and equality. There are various publicly available training curricula that use participatory activities to implement these household approaches, including the International Fund for Agricultural Development (IFAD) *Household Methodologies: Gender, Targeting and Social Inclusion*, the Hivos *Sustainable Coffee as a Family Business* toolkit, the CRS Strengthening Marriages and Relationships through Communication and Planning (SMART) Couples Approach ([internal](#), [external](#)), and the CRS Case Worker Model used in Nigeria ([internal: facilitator manual](#), [flip chart](#)).



The SMART Couples approach coaches couples on household communication and joint decision-making, while challenging negative gender norms. It includes two training curriculums—The Faithful House for Christian participants and Islamic Family Life for Muslim participants.



Case study: Helping households plan, work and make decisions together in Uganda

The Community Connectors program in Uganda worked through women’s savings groups to provide technical training on crop production and nutrition. Trainers helped them plan for members’ household and agricultural spending. At first, the program found that the garden component was increasing women’s workloads. The program was then adjusted to help women manage cash crop production in their gardens and use the income to buy a diversity of nutritious foods. The trainers worked with entire households to plan, work and make decisions together to reduce women’s time and labor burden (SPRING 2014).

Farmers’ groups and associations: Farmers’ groups and associations can be effective ways for farmers to access a range of resources—such as information, training, extension, seeds and fertilizers—and assets, including land or group credit and savings programs. Even so, women are often excluded from these groups. Practitioners can work with existing, male-dominated groups to give women access and power to assert their agency, such as in the case study below about water-user associations in Ghana. In contexts where women have very limited scope to act in their household and community, integrating women into male-dominated groups will likely be ineffective. Instead, women-only groups can be more effective. They can provide a safe space for women to gradually and collectively challenge cultural practices and social norms, and reduce the risk of sanction—whether socially or through more serious measures, such as violence or harassment. If designed to do so, women’s groups can also be platforms for women to assert their influence within the group as well as to other stakeholders in their lives. For more information on how to conduct these types of interventions, see [Intervention Guide for the Women’s Empowerment in Agriculture Index](#) (Stern et al. 2016).

Case study: Water-user associations in Ghana

An irrigation and agricultural development program in Ghana helped connect gardeners to a range of resources by working through water-user associations. Increasing women’s access to dry season irrigated garden plots was one of the program’s primary goals. It helped the associations revise their membership so that it was not limited only to farmers already associated with irrigation or to only one member of the household. It also set quotas for women’s participation, hired a gender officer to support the associations, hosted farmer training demonstrations for the members, and set up complementary functional literacy groups. As a result, women made up 38% of membership and 40% of participants in farmer training demonstrations. By the end of the program, women had a much greater role in the management of irrigation systems and could grow vegetables more easily because of it (World Bank et al. 2009).

Land tenure for gardeners: Project examples from Mali (see case study below) and India (Nielsen et al. 2006) show the benefits of pairing gardening programs with efforts to extend access to and control over land to women. This is particularly relevant to women who do not have secure control over land, such as a woman who lives with a man who has a land title in his name only or a widow or abandoned mother who does not have land in her name. Practitioners can educate men and women on their legal land rights, and work through local organizations to encourage joint land titling. In some areas, it may be possible to secure a small plot for women on communally managed land. For additional guidance on land tenure, see [Landesa Center for Women's Land Rights](#) and the [FAO Gender and Land Rights Database](#).

Case study: Alatona irrigation project in Mali

A USAID literature review of gender and nutrition interventions in Mali highlighted the Alatona irrigation project, which secured 500 square meters of land on which 54 women's associations could manage market gardens. Each association was a legal entity, represented by an average of 20 households each. One of the greatest successes of this effort was that 40% of the beneficiary households adopted joint titling of their land, with the land in the name of both the husband and the wife (USAID 2016).



Conclusion

It can be tempting for practitioners to rely on assumptions about gender roles, responsibilities and power dynamics when designing gender-responsive or gender-transformative interventions. Indeed, there are many similarities among gender inequities in rural agricultural communities around the world. However, the ways in which a program responds to these will almost always vary; there is no one-size-fits-all solution for gender responsiveness and transformation. Practitioners can use information in this chapter as a starting point for interventions that they will need to customize and adapt on an ongoing basis to their particular situation and context.

Quiz

1. Which of the following is not one of the six gender analysis domains that need to be assessed before implementing a garden program?
 - a. Power relations and decision-making
 - b. Roles, responsibilities and time use
 - c. Education and literacy
 - d. Legal and policy environment
2. True or false: Female farmers tend to have less access to resources than male farmers.
3. True or false: Integrating women into mixed male and female farmers' groups is always the most effective way to address gender inequities.
4. Which of the following is a risk that stems from gender dynamics related to gardens?
 - a. When women's workloads increase while producing garden vegetables to sell in the market, taking time away from growing food for household consumption or breastfeeding children, household nutrition decreases.

- b. The market becomes oversaturated with vegetables grown in gardens, and the prices go down.
- c. Women in a Savings and Internal Lending Communities use some of their savings to buy tools for the garden, but after a few months they break and they cannot afford to replace them.
- d. Women's efforts to grow a new variety of tomato are wildly successful. A big buyer in a nearby town wants to buy them at a good price. The women's husbands and brothers take all the tomatoes to the town and sell them to the buyer, but do not share the profits with their wives or sisters.

Activity

Focusing on an existing or upcoming project, identify the gender constraints and opportunities of the target audience, using the gender domains (see below). After understanding the gender constraints and opportunities, consider how you would make a garden intervention gender-responsive and gender-transformative.

- Roles, responsibilities and time use
- Access to /control of assets and resources
- Power relations and decision-making
- Participation and leadership
- Knowledge, beliefs and perception, including cultural practices
- Legal and policy environment

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Chapter 6: Nutrition

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Learning objectives

After studying this chapter and its links and resources, you will know how to:

- Determine whether a garden will help contribute to the nutritional outcomes of the target audience.
- Plan a garden with a nutrition lens.
- Encourage consumption of garden produce.

Key messages

- **Garden objective:** Selecting nutrition as a garden objective will help you identify what kind of garden and what kind of crops to promote in your target communities based on nutrition needs.
- **Seasonality:** Consider planting crops that meet nutritional needs throughout the year. Consider what is needed in order to stagger planting so there is something to harvest (or preserve) throughout the year.
- **Childcare practices:** Consider who will be the primary caretaker of the garden as this may have an effect on the time available for childcare practices, including breastfeeding, that affect a child's nutrition. If mothers are the main caretakers of the garden, the project needs to work with households and communities to consider how workload associated with the garden will be shared, as well as technologies and practices that minimize workload so care practices can be carried out.

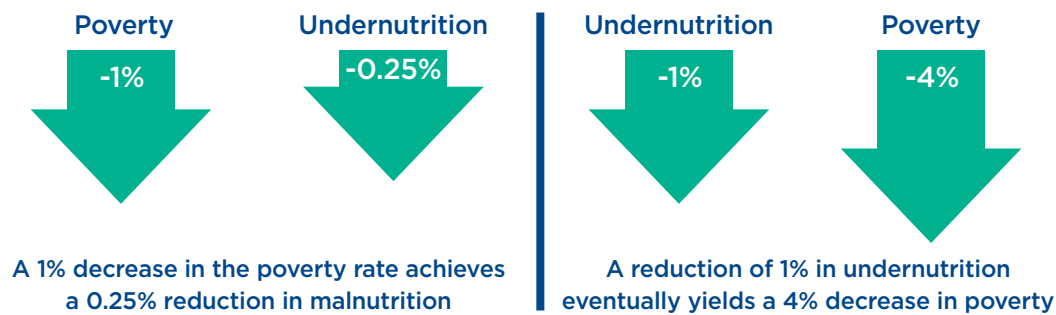
Key questions for decision-making

- What type of garden products will you promote based on identified nutrition gaps?
- What types of activities will you implement to support the nutrition objective of the garden?

Gardens are important for nutrition

Improving nutrition can help accelerate people out of poverty. Evidence shows that interventions reducing malnutrition make a greater and more rapid impact on poverty than economic growth *on its own*. A 1% decrease in the poverty rate achieves a 0.25% reduction in malnutrition; a reduction of 1% in undernutrition eventually yields a 4% decrease in poverty (Alderman 2005).

Figure 1: Improving nutrition has a greater impact on poverty than economic growth on its own



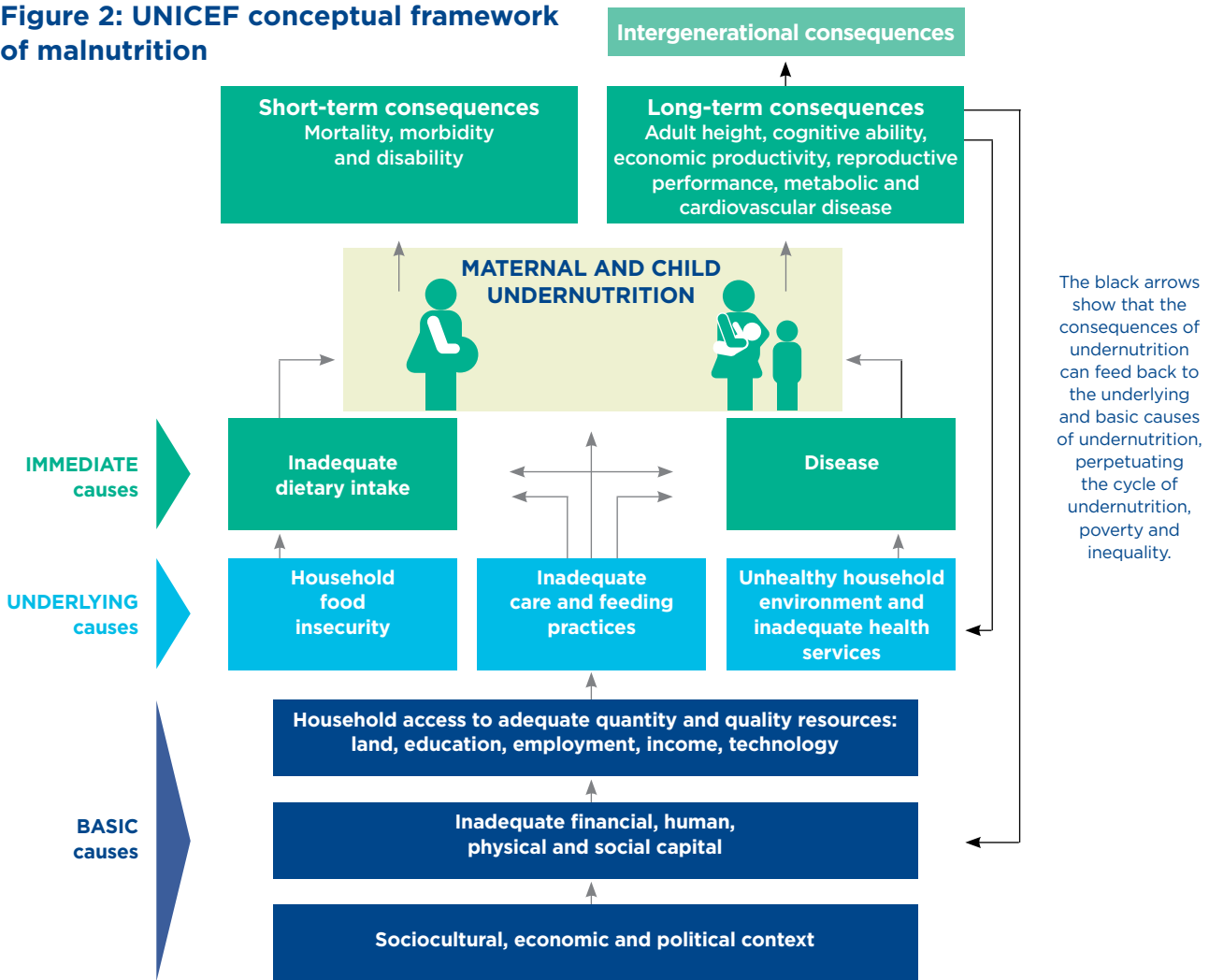
Source: Alderman H. Linkages between poverty reduction strategies and child nutrition: an Asian perspective. *Econ Polit Weekly* 2005;40:4837-42. In Tirado et al. 2013.

One way to promote better nutrition is through the use of gardens. Gardens can improve household and individual dietary diversity, which addresses inadequate dietary intake, one of the immediate causes of malnutrition (Figure 2). In the CRS Zambia Feed the Future Mawa Project, participating households that had a vegetable garden improved their dietary diversity by one full point. Gardens can also help improve micronutrient status, particularly of vitamin A (Thompson and Amoroso 2014).

Pathways to nutrition

Malnutrition can result from various or multiple conditions, such as deficiencies in the diet and the disease burden (Figure 2, over the page).

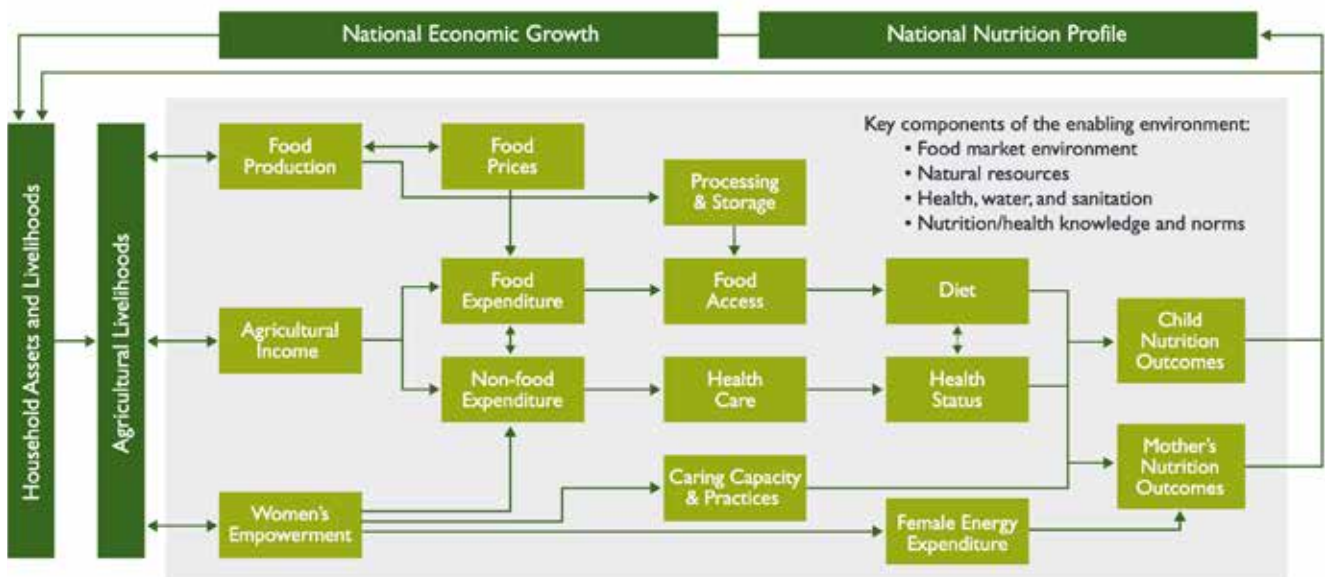
Figure 2: UNICEF conceptual framework of malnutrition



Adapted from UNICEF 1990 in *Improving Child Nutrition: The achievable imperative for global progress*, UNICEF, April 2013

There are three ways gardens can contribute to good nutrition as illustrated in Figure 3: 1) food production, 2) agricultural income, and 3) women’s empowerment.

Figure 3: Conceptual pathways between agriculture and nutrition



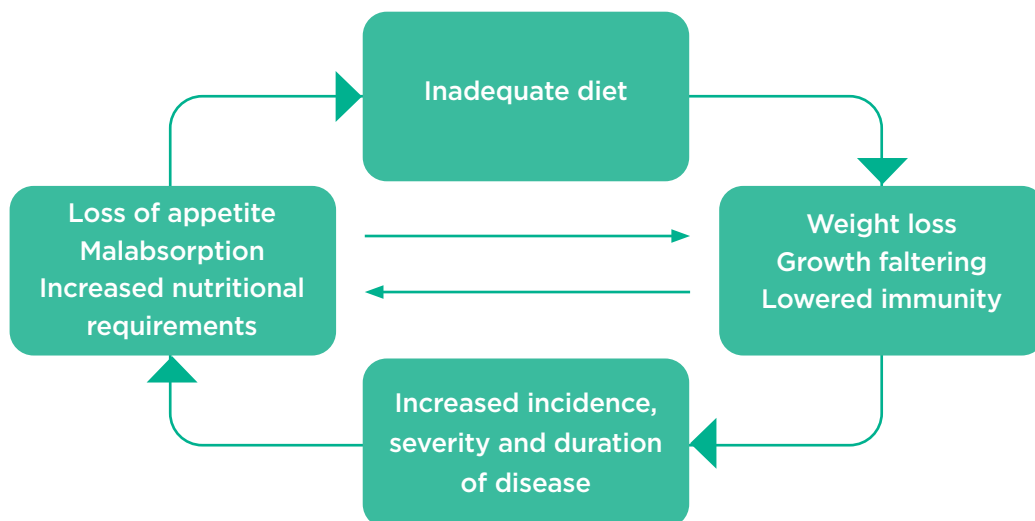
Adapted for Feed the Future by Anna Herforth, Jody Harris, and SPRING, from Gillespie, Harris, and Kadiyala (2012) and Headey, Chiu, and Kadiyala (2011).

- 1. Food production pathway:** Growing nutrient-rich garden crops for consumption is one pathway that could lead to improved nutrition outcomes through increased food access and improved dietary diversity. For this pathway to fully contribute, it is important to consider processing and storage of garden crops as part of the planned activities to extend their shelf-life. This will help to address some seasonal gaps and maintain health status by avoiding foodborne illnesses.
- 2. Agricultural income pathway:** If garden crops are sold, the agricultural income can be used to buy other types of nutritious foods (such as animal-sourced foods) or other nonfood nutrition-relevant items. This can include spending income on, for example, building a latrine or visiting a health center. There is a well-established link between repeated illness/infection and the inability to absorb nutrients (Figure 4), so even if a garden provides a more diverse diet, those nutrients may not be fully absorbed (Crane et al. 2015).

Figure 4: Infection-Undernutrition Cycle

Unicef [Infection-Undernutrition Cycle](#)

In practice, undernutrition and infection often occur at the same time because one can lead to the other. This is illustrated in the cycle below:



This vicious cycle needs to be broken by treatment of infection and improved dietary intake.

Parasitic worms

Parasitic worms (helminths) can cause anemia and vitamin A deficiency (FAO). They are transmitted through feces and are found in the soil where there is poor sanitation. Agricultural income could go toward building supplies for a pit latrine in the field or a visit to the health clinic for deworming and vitamin A supplementation.





CRS promotor Constantin Kabula speaks to Julia Tshiana next to a latrine installed at her home in the Democratic Republic of the Congo. *Photo by Sam Phelps for CRS*

3. Women’s empowerment pathway: It is important to consider how creating a garden will affect women’s nutrition as well as that of their children. If women’s time allocated to maintaining the garden interferes with practicing exclusive breastfeeding or attentive child-feeding practices, this will negatively affect the nutrition outcomes of young children. Similarly, if women are expending more energy/calories on the garden than they consume, it will negatively affect their nutrition outcomes, particularly those of pregnant or lactating women, who have higher daily energy requirements than non-pregnant women. Men can support women during these critical times to relieve their work burden. Also, practitioners should not assume that women have control over decisions about what food is grown or eaten in the household. Women do not always have the power to make decisions about the most nutritious foods for themselves or their families. Therefore, it is important that women are part of the household decision-making process when it comes to division of garden responsibilities, crop and market decisions, and food allocation among family members (Schaetzl 2014). See Chapter 5 on Gender Integration to learn more.

Planning the garden with a nutrition lens

Understand the nutrition situation

To get the most out of a garden, it is important to understand the nutrition situation of the target audience and how a garden can be used to address it. The following resources should provide national and/or district-level nutrition information.

- Project baseline report
- [Demographic and Health Surveys](#) data (conducted every 5 years)
- National nutrition surveys (conducted through the Ministry of Health)
- UNICEF [MICS surveys](#) (final report)
- [Global Nutrition Report](#) (+ country name)

Once nutrition issues in target communities are identified and prioritized, it can be determined how the garden can contribute to nutritional outcomes.

Nutrition and disabilities

When assessing the nutrition situation, it is important to understand different nutrient needs and access to nutritious foods by those with disabilities, who are often overlooked, placing women and children with disabilities at greater risk (UNICEF n.d.).

Understanding dietary preferences

When selecting garden crops, it is important to consider what food the target audience already eats to ensure the food will be consumed. If a crop is widely consumed, there are three considerations. First, the more commonly consumed crops might have relatively low nutrient density. Second, a traditional cooking method for a popular crop may not be optimal for nutrient retention, such as overboiling. Third, the crop may be sold rather than consumed in the household.

If the project is interested in promoting a crop that is new or not well-known to the community, a strong behavior change and technology adoption component must accompany this effort. For consumption, the project may need to include education on the nutritional benefits of the produce and how to cook it. This is also true for better-known varieties. For production, the primary gardener may need training on how to grow a new crop, support to access seed if not available, and proof that it will grow well in their context (demonstration gardens). For these reasons, if the project decides to promote less common crops or varieties, the project should only introduce one or two new crops so that people are not overwhelmed.







Know the nutrient profiles of garden crops

Common garden crops with a high nutrition value

Different produce will address different nutrient deficiencies: vitamin A, iron, zinc, calcium, vitamin D, and folate (UNICEF 2018). If your garden objective is to address malnutrition, it is important to identify crops that are nutrient-dense and can meet the nutrient deficiencies identified earlier. If you are working with a target population that faces many nutrient deficiencies, prioritize addressing deficiencies that can be adequately addressed with a garden. For further guidance on how to identify crops, see Chapter 4 on Crop Selection.

Table 1 provides a list of common vegetables that contain high levels of one or more nutrients. This list is *NOT* comprehensive, as there are always local varieties and additional indigenous species that are only found in a country or region. Use this table as a starting point to think about which crops are appropriate for meeting the nutrient gaps of the target audience(s).

Table 1: Nutrient profile of common garden crops

Nutrient Profile	Characteristics	Common vegetables	Deficiency leads to...
Vitamin A 	Yellow or orange vegetables and fruits Dark green leafy vegetables	Orange-fleshed sweet potato Carrots Pumpkin fruit Mango (ripe) Papaya (ripe) Amaranth	Night blindness Low immunity
Protein 	Dried beans Nuts	Dried beans Soya bean Lablab bean Groundnuts Moringa	Stunting Protein-energy malnutrition
Iron 	Dried beans ¹¹ Nuts Dark green, leafy vegetables	Dried beans Soya bean Groundnuts Young cassava leaves Amaranth	Anemia
Vitamin C 	Fruit Vegetables	Citrus fruits Ripe guava Moringa Peppers Green leafy vegetables Gourds	Low immunity Poor absorption of iron
Folate 	Fruit Legumes Dark green, leafy vegetables	Papaya Oranges Lentils Chickpeas Avocado Okra	Birth defects <i>Note: Folic acid is the synthetic form of folate which should be consumed by pregnant women. Women of reproductive age should be encouraged to eat folate-rich garden produce.</i>
Zinc 	Beans and legumes Nuts and seeds	Soya Pumpkin seeds Spinach Amaranth Pomegranate Avocado	Increased risk of diarrhea, respiratory tract infections, and malaria

Photos: Sweet potatoes: [publicdomainpictures/pixabay](https://www.pixabay.com/publicdomainpictures/) | Lablab beans: [publicdomainpictures/pixabay](https://www.pixabay.com/publicdomainpictures/) | Cassava leaves: [mayapuijati/pixabay](https://www.pixabay.com/mayapuijati/) | Peppers: [publicdomainpictures/pixabay](https://www.pixabay.com/publicdomainpictures/) | Okra: [buntysmum/pixabay](https://www.pixabay.com/buntysmum/) | Pumpkin seeds: [Siobhan Dolezal/pixabay](https://www.pixabay.com/SiobhanDolezal/)

11. Note: Dried beans are high in iron, but the nutrients may not be available in a form that the body can easily absorb. Soaking them before cooking can help release the nutrients in such a way that the body can absorb them.

Local and indigenous crops

Crops that are indigenous to the country or region can play a critical role in supporting nutrition. Local varieties often have superior nutritional profiles to similar non-native species and are more adapted to the local climate (Shackleton et al. 2009). For example, if there is a local variety of a dark green, leafy vegetable (such as African nightshade), it likely has high iron content and/or folate. If you plan to promote indigenous varieties, verify with the local or regional nutrition staff that the crops have been properly categorized to address the specific nutrient deficiency identified earlier. *African indigenous vegetables in urban agriculture* (Shackleton et al. 2009) provides nutrient content for many African indigenous vegetables. [Indigenous Wild Food Plants in Home Gardens: Improving Health and Income - with the Assistance of Agricultural Extension](#) is a helpful tool when including indigenous vegetables in a garden. Furthermore, CRS has an internal Indigenous Vegetable [Assessment Tool](#) available for use.

25,000 gardens for dietary diversity

Seguridad Alimentaria Enfocada en los Primeros 1,000 Días (SEGAMIL), the CRS-led Guatemala Food For Peace Development Food Assistance Program (DFAP), established about 25,000 home gardens from 2014 to 2018. The project prioritized the use of gardens to increase the dietary diversity of the families and the availability of leafy greens to pregnant and breastfeeding women. One of the key lessons in this work was to emphasize the use of native vegetables, such as *chipilín* (*Crotalaria longirostrata*), *epazote* (*Dysphania ambrosioides*), *hierba mora* (*Solanum nigrum*), amaranth (*Amaranthus cruentus*), *Q'ixtán* (*Solanum wendlandii*), and others. Every 25-square-meter garden needed to have at least four native species as there were several benefits to promoting native vegetables:

- Native plants were more drought-tolerant and pest-resistant
- They were easy to grow, serving as an entry point for those families unfamiliar with gardening
- Most plants were perennial (regrow every year) and produced during the dry season
- Family members, especially grandmothers, tended to know how to cook with them
- They were rich in iron, vitamin A and other key nutrients
- Indigenous seeds were widely available

Plan for seasonality

Identifying seasonal gaps when food is not available will not only address hunger but will also impact the nutrition status of mothers and children. Studies have shown that reduced intake of food by pregnant women during the hunger season can lead to their children having low birthweights. This can cause health complications for the child, including stunting (low height for age).



Reduced intake of food by pregnant women during the hunger season can lead to their children having low birthweights.



Additionally, a study in India showed that children born during the lean season had significantly lower height for their age than their counterparts born in other months (Tirado et al. 2013). These studies show the importance of having access to diverse, nutritious food throughout the year.

Chart the seasons

Use the seasonal calendar template to identify harvest times for each potential garden crop along with main staple crops. This will help identify where there are gaps at different times of the year and which garden crops can potentially fill those gaps to meet nutritious food needs, based on agronomic constraints. Specific areas of inquiry when using the seasonal calendar template are:

- Identify the rainy season(s) and the dry season(s)
- Identify when staple crops and garden crops are planted and harvested
- Identify the months that are considered the hunger season and when nutritious garden crops are or are not available
- Identify potential constraints and associated solutions for year-round gardens, such as water requirements and seed availability

With this information:

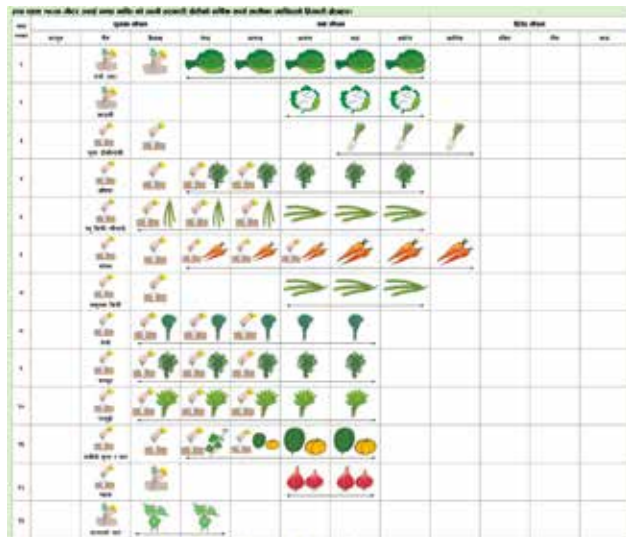
- Identify crops that could meet nutritious food needs at different times of the year
- Create a monthly crop calendar that allows for staggered planting in order to promote nutritious food production throughout the year

Charting when crops are needed based on this information will help the project team plan when seeds or other inputs can be made accessible and when other seasonal constraints that can impact the garden need to be considered (e.g., water availability). Consider including an activity at the beginning of the project that has households create their own crop calendar based on the above considerations. This may prompt them to think differently about the potential of a garden.

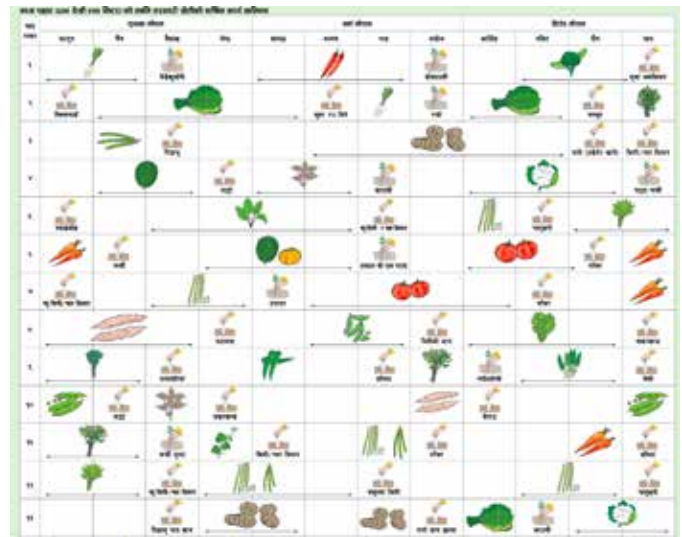
In Timor Leste, CRS agriculture and nutrition staff conducted the above exercise in order to identify 10 to 15 vegetable and bean varieties that would address nutrition needs, as well as seasonal gaps in food security. Staff members found opportunities to fill seasonal gaps with traditional crops planted at unconventional times of the year.

In Bangladesh, the Suaahara project also used crop calendars to increase vegetable diversity to maximize vegetable production from same area/piece of land and to increase household access to diverse vegetables. The key message was “diversify nutrient-dense vegetables in your garden throughout the year.”

Figure 5: Using the seasonal calendar to plan the garden



Typical planting calendar



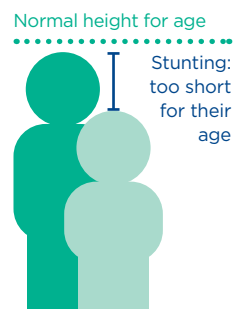
Diversified vegetables and harvest times

Source: *Suaahara Homestead Food Production Seasonal Crop Calendars*, 2014. Johns Hopkins Bloomberg School of Public Health/Center for Communication Programs. [Click here](#) for more examples of crop calendars.

Food storage

Proper food storage helps fill seasonal gaps and keeps food safe to eat. There are some garden crops that can be stored long-term such as dried beans, root crops, pumpkins and groundnuts. Other fresh vegetables, such as leafy greens, should be harvested and consumed the same day to avoid nutrient loss, but can also be stored through preservation for later consumption. Remember, the fresher a perishable vegetable, the more nutrients it retains. See Chapter 11 on Postharvest Handling for more information on food storage.

Some garden crops that can be stored longer term, such as beans and groundnuts, need to be thoroughly dried and properly stored to prevent aflatoxins and other molds or toxins. Aflatoxins are a highly toxic by-product of fungi that cause liver cancer and are linked to child stunting (Leroy 2013). A stunted child is too short for their age, having a height below -2 standard deviations of the World Health Organization’s reference height for their age and sex. In countries where people eat large quantities of groundnuts or beans, even small amounts of aflatoxin will amount to a high level of toxins due to the sheer volume consumed. It is also important to know that there is growing evidence that aflatoxins are also present in horticulture products.



For more information on aflatoxins, see CRS’ [Aflatoxin Management for Smallholder Farmers of Maize and Groundnuts: Practices and Technologies for Detection and Prevention](#).



Food preservation

Another way to address seasonal gaps is to teach basic food preservation methods, such as drying. “Food preservation refers to the different techniques that are applied to food to prevent it from spoiling” (Kikomoko and Bari, n.d.). Food preservation can play an important role in addressing food insecurity, especially if there are months when it is not feasible to grow fresh produce. If working in such an ecological zone, consider adding nutrition education lessons about food preservation techniques that retain nutrients, and about the appropriate seed variety to use. The elements of food safety through kitchen hygiene should be included, since foodborne illnesses can contribute to infections such as diarrhea, which can lead to chronic malnutrition.



Key elements of kitchen hygiene

- Thoroughly cook and reheat food
- Decrease the time cooked food is stored at room temperature
- Ensure adequate handwashing before and during food preparation and before eating
- Adequately wash and dry utensils and cookware
- Use safe water
- Avoid contact between raw and cooked foods
- Cover food until it is ready to be consumed



Laje Lyson demonstrates how she uses her drying rack to keep her clean dishes off the ground and away from animals in Malawi. *Photo by Megan Collins for CRS*

More information on food processing and food safety can be found in Chapter 11 on Postharvest Handling, and in the [Home Garden Technology Leaflet 18](#). The [WHO “Golden Rules” for Safe Food Preparation](#) is the industry standard for food safety. The [Small Doable Actions for Improving Household Water, Sanitation, and Hygiene Practices](#) is a job aid for village health educators. Also, many CRS nutrition-related programs include preservation techniques in their recipe books, such as the recipe book for the Community-Led Complementary Feeding and Learning Sessions ([internal](#), pp. 21-26) and the Malawi-led Food for Peace Wellness and Agriculture for Life Advancement Project ([internal](#), pp. 4-14).

Promoting consumption of garden crops

This section provides guidance on supporting activities that complement a garden and promote the consumption of garden crops.

Social behavior change

An important tool for promoting consumption of garden crops is social behavior change. SBC identifies motivating factors for the specific target audience—through positive deviance; doer/non-doer methodology; barrier analysis; Knowledge, Attitude, and Practice (KAP) surveys or other tools—and uses these motivators to promote the positive behavior to a target group—in this case, the production and consumption of garden produce. SBC messages are often used in community lesson plans, including cooking demonstrations and/or mass media, depending on the scale of the project. See Chapter 13 on Behavior Change. Another useful training resource is the USAID SPRING’s [Farmer Nutrition School](#).

Cooking demonstrations

A recent meta-evaluation of CRS food assistance projects identified cooking demonstrations as a best practice for improving nutrition (Khan 2017). Once your team has selected garden crops to promote, it is important to educate communities on proper cooking methods and nutritional benefits, especially for unfamiliar varieties. Cooking demonstrations are also an opportunity for education and demonstration of safe and hygienic food-handling practices.



Mother volunteers, Florinda Esperanza Gonzalez and Mara de los Ngeles Lopez, prepare ingredients from their poultry farms and home orchards during a food preparation demonstration in Guatemala.
Photo by Oscar Leiva/Silverlight for CRS

It is also important to include key nutrition messages during the cooking demonstration that support targeted behaviors for change. For example, if the recipe being demonstrated is using African nightshade (which is high in iron), the primary message could center on the importance of iron-rich foods in preventing iron-deficiency anemia among pregnant women and why that is important.

Some key resources to support projects in organizing and running successful cooking demonstrations include the CRS Recipe Development and Cooking Demonstration Guide, USAID’s [Standard Operating Procedures \(SOP\) for Organizing and Conducting Cooking Demonstrations](#) (Save the Children 2013), and the FAO’s [Promoting Improved Complementary Feeding \(with recipes\): 5.3 Cooking demonstrations](#) (pp. 38–42).

Eleven steps to a successful food demonstration

1. Identify your target group—assess their knowledge of the types of food in their locality and what the food does in the body.
2. Review objectives of the demonstration
3. Create up to three concise key messages along with questions to ensure understanding.
4. Be organized (i.e. gather necessary materials), confident and courteous
5. Use relevant recipes with affordable, locally available ingredients.
6. Be sure the demonstration area is clean and will capture the attention of the audience.
7. Emphasize nutrition messages and hygienic practices while demonstrating.
8. Ensure active participation of the group members in the food preparation tasks.
9. Allow all participants to taste the prepared food.
10. Observe good food safety and handling practices.
11. Obtain feedback for improving future food demonstrations.

Recipe books

Recipe books are a great way for those participating in cooking demonstrations to remember what they have learned. Using mostly photos or pictures will allow even those with low literacy to use the recipe book to prompt their memory. It will also allow for further knowledge-sharing in the household and community. Recipes should promote the best cooking methods and food combinations that provide optimal nutrient absorption. For example, to promote iron-rich foods, a recipe with dark green leafy vegetables should also include foods rich in vitamin C.



Recipe books using mostly images can act as memory aids to people with low literacy.

Recipe books should follow these general guidelines:

- Have mostly pictures/photos
- Use simple measurements (e.g., “a handful of beans” instead of “half a cup of beans”)
- Include few ingredients (five or fewer)
- Promote cooking methods that optimize nutrient absorption (see below)

Some recipe books available as resources include:

- [Complementary Feeding for Children Aged 6-23 Months: A Recipe Book for Mothers and Caregivers](#)
- [2007 Zambia Recipe Book \(internal\)](#)
- [2012 Zimbabwe Healthy Harvest \(internal\)](#)
- [CCFLS 2015 Harvest Season \(internal\)](#)

Cooking tips

These cooking tips can be included in both cooking demonstrations and recipe books to optimize nutrient intake of garden crops.

Enhancing nutrient absorption: When food is consumed, it is broken down into macronutrients (carbohydrates, protein and fat) and micronutrients (vitamins and minerals) for energy, growth and cell repair. However, the amount of nutrients that a body absorbs from food can range widely. Based on the nutrients in the food, the preparation/cooking method can make them more available to the body for absorption. For example, orange-fleshed sweet potato—which is rich in vitamin A—should be cooked with fat (i.e., oil) in order for the body to get the full benefit of the vitamin A.

Generally, loss of nutrients increases in direct relation to the length of cooking time and higher temperatures. Cooking methods that minimize time, temperature and amount of water will help preserve nutrients. Note: Even by closely following these methods, some vitamin C and folate may be lost during cooking.



Test kitchen, CRS Timor Leste. *Photo by Harley Stokes/CRS*

Preferred cooking methods to help retain nutrients:

- Cook vegetables in small amounts of water very briefly until just tender, or use recipes that do not require the water to be drained after cooking (e.g., soups and stews)
- Stir fry (i.e., frying very quickly over a high heat)
- Sauté (i.e., cooking in fat or oil in a pan)

Other ways to reduce nutrient losses:

- Harvest vegetables and fruit the same day you use them and store them in a cool place
- Clean and cut vegetables (including root vegetables) immediately before cooking
- Eat food soon after cooking, which is also important for food safety (Burgess and Glasauer 2004).
- Leave skins on vegetables (e.g., potatoes and carrots) as long as these are washed thoroughly in clean water before cooking

Table 2: Cooking tips for enhancing nutrient absorption

Nutrient	Cooking tips
Vitamin A	Vitamin A is fat-soluble so cook food containing vitamin A with a small amount of oil/fat.
Iron	Iron-rich foods are better absorbed when combined with meat, fish or vitamin-C rich foods.
Protein	Protein from beans is more easily absorbed when they are sprouted or soaked before cooking.
Folate (Vitamin B9)	Folate/vitamin B9 is water soluble. If cooked, use a small amount of water and short cooking time (less than 5 minutes). <i>Note: Do not throw out the water that contains many of the nutrients from the vegetables. Use it in soups or other food preparation.</i>
Iodine	Use small amounts (1 or 2 small pinches) of iodized salt to flavor the dish. <i>Note: Too much salt is harmful and can lead to high blood pressure. Salt should not be added to complementary food given to children under the age of 2. Children in this age range will receive adequate iodine from breastmilk as long as breastfeeding continues and the mother is consuming iodized salt; see <i>Feeding and Nutrition of Infants and Young Children</i> (Michaelsen et al. 2000).</i>

Conclusion

Including a garden in project activities is an opportunity to improve nutrition outcomes. This can be achieved through three main pathways: food production, agricultural income and women’s empowerment. For a stronger impact on nutrition, consider including other activities—such as handwashing, clean water access and improved sanitation—that will address other immediate or underlying causes of malnutrition.

Quiz

1. True or false? Evidence shows that interventions reducing malnutrition make a greater impact on poverty than economic growth on its own.
2. What are the three major pathways along which a garden can improve household nutrition?
3. What are two ways to increase food availability during hunger season(s)?
4. True or false? It is more important to provide recipe books than to conduct cooking demonstrations.

Activity

Using an existing or upcoming project, identify what agriculture–nutrition pathways the project gardens could contribute. Based on the identified pathways, discuss what nutrition or other interventions the project could implement to support gardens in contributing to the selected pathways.

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Chapter 7: Seed

Peter Marks, CEO, Seed Programs International

Contribution from Josh Voges, Impact Investment Specialist, CRS, on private sector

engagement and Alexandra Towns, Senior Technical Advisor, CRS, on indigenous vegetables

Learning objectives

After studying this chapter and its links and resources, you will know how to:

- Choose systems and interventions to help gardeners access seeds.
- Distinguish between different categories of seed including knowing some benefits and uses of each.
- Select seed types and sources that are a good match for your project goals.
- Better understand opportunities to collaborate with commercial (private) seed companies.
- Save, test and store vegetable seed.

Key messages

- **Consider seed availability:** Work to understand whether garden seed is available from and for the community served, and with what range of variety and quality.
- **Address seed access:** If seed is available but not easily accessed, work to understand why. Then design an approach that most directly overcomes barriers to access while not undermining existing commerce or practices.
- **Choose the right seed:** When choosing seed types and sources, consider traditional knowledge, production systems, environment, culture, nutrition, program purpose, and whether the seed source can be sustained over time.

Key questions for decision-making

- What variety of seeds should be promoted?
- What strategy should be used to support access to seed?
- If working with the commercial seed system, what are the implications related to packaging (i.e., size, material and content), distribution channels, affordability and enabling environment?

Seed is important for gardens

For garden projects to successfully increase dietary diversity and commerce, appropriate seed is essential. Furthermore, for gardens to be sustainable, gardeners need to have regular access to seed. Yet seed is an expensive, specialized and perishable input for gardens, so careful choices must be made when choosing seed sources, enabling access, and guiding use.

Sources of seed

There are two main strategies for sourcing seed: 1) encouraging local seed production and trading, and 2) connecting communities with commercial seed suppliers. The costs, benefits and risks of focusing on each of these strategies need to be weighed.

Local seed saving and production

In striving for self-sufficiency at the household or community level, local seed saving and production can be either an initial seed-sourcing strategy or an end goal for seed provision. Know from the start that seed selection, saving and processing techniques across the range of common vegetables can be a lot to master, especially in the humid tropics and during crisis recovery. On the positive side, seed for fresh vegetables tends to be small and therefore easier to store and tuck away from insect pests and other damaging factors.

Effective seed-saving techniques can be learned if training is budgeted and deployed. Saving seed adds labor requirements, so factor in this increase in workload when planning seed-saving projects, especially in crisis situations when gardener resources might already be stretched, or when engaging women and girls. The ease or difficulty of saving seed varies greatly by crop type (Table 1, over the page).

Seed is an expensive, specialized and perishable input for gardens.



Table 1: Ease of saving seed for some vegetable crops

Crop	Ease of saving seed	Instructions for saving seed
Broccoli Cabbage Chinese cabbage	Difficult	Require cold weather conditions to cause plant to flower and produce seed. Some tropical varieties may flower if left to mature completely. If seed production is attempted for cabbage, the head must be cut open carefully to expose the growing point and produce flowers. After flowering, allow the pods to dry and then remove seed.
Carrot Beet	Difficult	Roots need a period of cold weather for growth to stop and for flowering and seed production to start. Not recommended for tropical countries.
Cucumber Gourd	Easy	Allow plants to grow well past normal market stage, when fruit turns a yellowish color and plant is no longer growing. Harvest fruit, extract seed, wash in clean water and dry in shade. If seeds are encased in heavy pulp, fermentation will help separate them.
Lettuce	Moderate	Plants will start flowering under hot conditions, but head lettuce needs to have heads cut open when young to allow flower stalk to grow up. Care is needed when cutting the heads open so the growing point is not damaged. Harvest seed when flowers appear white and fluffy.
Mustard	Easy	Most plants will flower and produce seed. After flowering, allow the pods to dry, then remove seed.
Okra	Easy	Harvest pods when fully mature (brown) but before shattering. Remove seed.
Onion	Difficult	Bulbs need a period of cold weather for growth to stop and for flowering and seed production to start. Not recommended for tropical countries except in high-altitude areas.
Pepper	Easy	Will cross-pollinate in the field if not isolated. Allow plant to grow to full maturity and final color. Cut open fruits, extract seed and dry in shade.
Radish	Easy	Most small red radish varieties will flower easily and produce seeds. When seed pods are dry, remove seed. Some Asian varieties, especially daikon, require cold weather to cause plants to flower. These are difficult to produce in tropical countries.
Regionally important traditional greens	Easy	Food plants such as amaranth, jute and Malabar spinach tend to have short seasons and readily go to seed. Techniques vary with species but are generally easily learned.
Squash Pumpkin	Easy	Allow plants to grow well past normal market stage, when fruit turns a yellowish color and plant is no longer growing. Harvest fruit, extract seed, wash in clean water and dry in shade.
Tomato Eggplant	Difficult Moderate with training	Allow fruits to ripen to full color. Extract seed into a container (drier eggplant may require soaking) and keep in a cool place for 24 to 48 hours for natural fermentation to take place. Wash seed with clean water, strain and dry in shade.
Watermelon	Easy	Allow fruit to mature to full market stage. Open fruit and extract seed. Wash with clean water and dry in shade.

Source: Marks et al. 2014. Thank you to Julian Hoyle for generously sharing most of the material for the above table.

Successful seed saving for a broad mix of garden vegetables can be a complex but worthwhile task. Issues to consider when selecting crops to save seed include isolation distance, production technique and competing priorities.

- 1. Isolation distance:** This term refers to how far plant varieties must be separated in order to guarantee that seed saved from an open-pollinated parent will not have hybridized with another plant. Because certain plants may readily cross between neighbor’s gardens or with wild varieties of the same species, isolation distance is crucial if the intention is to save seed for future use. Table 2 illustrates how widely divergent this distance is among garden vegetables.

Table 2: Isolation distance to ensure seed saved is true to type of parent plant

Vegetable	Isolation distance	Note
Amaranth	1,000 meters	Wind pollination possible across vast distances, even between different <i>Amaranthus</i> species; individual flower heads can be bagged to prevent cross-pollination
Peppers	20 meters	Mostly self-pollinating, but possible for bees to cross pollinate
Yardlong bean	Not necessary	Cross pollination is not likely

Source: Sukprakarn et al. 2005

2. Seed production challenges:

- Some garden crops—like carrots and onions—are biennials, producing seed only in their second year, typically after a cold period.
- Producing seed from plants grown in soil with poor fertility can negatively influence the size and germination percentage of the resulting seed crop (Weller and Simon 2014).
- Some seed, such as tomato, or plants in the wet-seeded squash family (like cucumber) require fermentation to break down the gel around each seed that inhibits germination.

3. Competing priorities: Other seed-saving challenges are due to competing interests between saving seeds and other gardening goals. Saving seeds cannot be done as an afterthought—it requires specific planning and some sacrifice of shorter-term income and nutrition potential. A farmer’s natural inclination may be to harvest the best plants to eat or sell and then save seed from plants that are less appealing on the table or at market. This is the reverse of how improved varieties are maintained (or improved further) over time. “Roguing,” a step in the seed-saving process, removes all plants except those which best represent the desired traits. For example, being slow to bolt (go to seed) is a desirable trait for plants eaten as leaves, such as coriander leaf (cilantro) or lettuce. As soon as seed heads begin to form, plants become more tough and bitter. In the garden, it may seem logical to save seed from the plants that go to seed first and keep eating from the other plants, but over just a few years of this practice, the gardener will have selected an early-to-seed variety which gives a shorter harvest period of leafy green vegetables with each generation of seed saving.

Another natural and logical farmer propensity is to save seed from just one or two plants in order to more quickly reuse the garden space where all the other plants are growing. Again, good seed-saving practice requires the opposite: that within a small garden seed should be saved from as many plants as possible. Saving seed from one or two plants will select random, unwanted traits.

Good seed-saving practices include:

- Isolate seed-producing plants from unwanted pollen if necessary
- Save seed from the plants with the best traits, even if that means not being able to eat or sell those plants
- Save seed from a lot of plants, not just one or two
- Ensure seed is dry and then store saved seed in the lowest humidity and temperature environment possible

Many cultures will have well-established local traditions and experts who save seed for garden vegetables from both cultivated and wild sources. For example, community members, typically female elders, may be accustomed to regularly wild-harvesting seed, particularly for wild leafy vegetables that grow on the margins of fields, riverbeds and in other areas. Ask about this directly in the community if you are not sure.

Even professional seed producers experience a level of error in terms of getting predictable genetic results. The seed that gardeners save will have *mixed results* and unfortunately, in many cases, the negative results do not become apparent until the *end of the next season*. Consider this risk when investing in seed-saving training.

Based on these considerations, the following ideas are suggested:

- If context allows, a few gardeners could save seed and share/sell them. This can be a better path to success in contrast to setting an expectation (through training) that every gardener should save seed.
- A community organization, school, place of worship or program demonstration site may serve as a designated “seed-saving garden,” possibly with labor contributions from the gardeners in exchange for receiving seed, or else as a micro-enterprise. A CRS program in Rwanda took that approach, centralizing seed-saving activity at demonstration sites.
- Consider training staff on the diverse range of native and indigenous vegetables available in the community and on gathering wild seed and identifying these wild vegetables.

Many cultures will have experts who save seed for vegetables from cultivated and wild sources.

Wild-sourced plants and transplants

A CRS Niger project carried out a week-long assessment of indigenous vegetables with agricultural field staff, followed by a two-day training that included interaction with female elders in the surrounding community on gathering wild seed and identifying wild vegetables. The training led to the development of two indigenous vegetable demonstration gardens that included vegetables from wild-sourced plants and wild transplants.



Commercial vegetable seed

Worldwide, commercial vegetable seed supply is narrow, with only a few primary producers servicing a large downstream distribution network. Commercial vegetable seed production is slow to emerge in the developing world, resulting in vegetable seed originating from imported sources. Yet even in remote locations, vegetable seed may be seen in all kinds of small shops and from markets, not just agro-dealers.

Private sector seed supply development strategies dovetail well with other project strategies. For projects that are organizing seed fairs or buying seed for direct distribution, it is wise to help seed providers consider the seed end-user as their primary and eventual customer—not the nongovernmental organization planning the fair or distribution. Over time, smart enterprises can find profitable ways to reach remote and impoverished gardeners with seed, completely apart from NGO intervention. They may even provide training, demonstration and extension on seed. Discuss meeting the vegetable seed needs in remote areas with seed suppliers, and discuss/brainstorm with them ideas and paths for success. When working with commercial seed companies there are five factors around packaging that need to be considered.

Packet types and sizes: Vegetable seeds are sold in various packages, such as small packets, large packets, sacks, cans or bulk containers. Projects designed to support gardens work best when each household receives an amount of seed just right for their own use. For example, a typical small paper packet (8 x 11 cm) contains more than enough seed to grow produce for both home consumption and some surplus for sale. Please note that when small and tiny vegetable seed is distributed to individuals from larger containers, the tendency is to give too much. Plan to provide appropriate voucher values, training and a process/tools to ensure appropriate allocations of household quantities.

Table 3 gives an example of a larger, medium and smaller type of seed, showing the amount typically planted in a garden. The Agromisa publication [The Vegetable Garden in the Tropics](#) includes an expanded variation of this table (Waaijenberg 2003) and a web search will find many U.S.-produced charts of seed weight, plant count and yield per 100 feet of row such as this [chart](#) from Rutgers University (Rabin, Zinati and Nitzsche 2012).

Table 3: Examples of the seed quantity needed for a family of eight

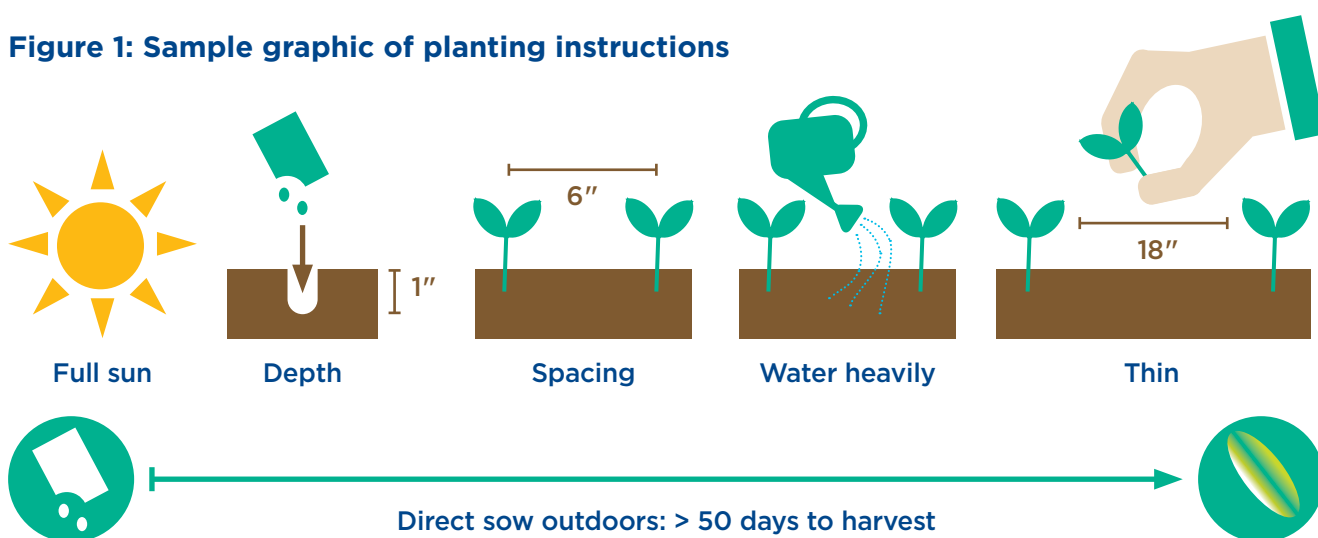
Vegetable	Estimated number of garden plants needed	Weight of seed needed for this count*	Volume of this count
Cowpea	60	15 grams	Small handful
Amaranth	200	0.1 gram	Tiny pinch

* Most gardens won't fit this much, so seed provided on this table is generous and if properly used could be shared with neighbors.

Printed gardening instructions: Seed packets can be a medium for providing gardening advice. Where literacy rates are low and/or training for each individual gardener is not feasible, the project should be certain to use well-understood graphical instructions. Where packets are printed in only one of several languages used in a region, differential access to understandable seed planting instruction can drive unequal success. Consider these notes of caution around information on printed packets:

- Paper vegetable seed packages that reach local shops from other climate regions (e.g., imported from Asia to Africa) may show irrelevant planting calendar information.
- Seed packet instructions that show spacing between rows and spacing between plants are likely written for commercial-scale growers using power equipment. Gardeners working small beds by hand can sow and thin following plant spacing instructions and ignore the row spacing.

Figure 1: Sample graphic of planting instructions



Packet material: Seed packets can be made of varying materials, which can affect the seed being stored and the cost. Consider the climate and setting to determine ideal packet types.

- **Paper:** The traditional glued paper seed packet does very little to prevent moisture vapor transfer. When moisture is combined with heat, it destroys vegetable seed. However, paper packets allow for more information to be shared than foil packets.
- **Plastic:** Plastic bags or sleeves allow some water vapor to pass through, but at around 1% the rate of paper, when thickness is comparable (for polyethylene, the most common bag material—Walters 2007). Therefore, if you receive paper seed packets in a climate-controlled location or during a dry season, it is a good idea to seal them into plastic bags while in those favorable conditions.
- **Foil:** When still sealed, foil seed packets eliminate moisture transfer between the seeds and the outside air. However, many foil packets are not printed with the same amount of information as paper packets and may also drive the price up due to the manufacturing cost.

Seed treatment and safety: The source of the seed often determines whether the seed is treated. Locally produced or farmer-saved vegetable seed is almost never treated. But companies that serve commercial farmers often treat seed. Seed treatment has advanced over the decades from powders to a film coating. The film coating technology results in much less transfer of treatment onto hands or into lungs. In both cases, a colorful dye is added to indicate that a seed has received treatment. Although labeling of treated seed is required by most countries, it is good to ask seed vendors whether the seed to be provided is treated and how this is indicated. If literacy is a concern for the targeted audience, explore with the seed vendor the option of a graphical symbol indicating treatment using a widely understood symbol for poison. For the project, you will need to consider how safety information will be provided to gardeners. For example, will there be verbal announcements at seed fairs?



There are several concerns when using treated seed.

- **Gardeners:** In some cultures, farmers sow seed by mouth, which can transfer chemicals.
- **Animals:** Wild birds or livestock can also be at risk of ingesting chemicals when fed old seed.
- **Children:** The bright colors may be appealing to children so be sure to include child safety messages in training.

The use of treated seeds for gardens will depend on the project goal. For example, if organic methods are a goal, most treatments make this impossible. Otherwise, seed treatments are designed to help plants overcome common challenges. For large seeds like legumes and gourds, common treatments are fungicides and antimicrobials—with the intent of increasing germination by preventing rotting and damping off in wet conditions. For small vegetable seed like tomatoes, peppers or brassicas, treatments are more likely to contain insecticides, including types that have raised concerns about impact on pollinators. Nutrients are mixed into some seed coatings to fertilize the young plant in its first few days.

Printed viability information: When supplying seed for a project or inviting suppliers to sell seed, there is a need to understand what the printed dates on a seed package mean. A printed date on a package may give the date it was packed or the expiration date. Since both systems are common in the seed industry, staff members who are working on selecting seed or discussing with seed vendors need to clearly understand what the date represents. This information also needs to be conveyed to gardeners.

Expiration dates on packages—sometimes labeled as “sow by” dates—are projected from the date of the last successful germination test, not from the date seed was produced. The same bulk lot of seed, grown on the same farm in the same year, may be tested again year-after-year. After each successful test it will be packaged again with a new expiration date, until it is completely sold or its viability shows signs of decline. Conversely, do not assume commercial seed is viable solely because its printed expiration date has not yet been reached. This seed has passed through importers, wholesalers and sat in shops or vendors’ hands in difficult climatic conditions for unknown lengths of time. Dates on package labels assume more controlled conditions. For these reasons, projects may counsel gardeners to do home germination testing on seed they have stored as it approaches planting time.

How to maintain quality of locally and commercially sourced seed

Seed storage

Whether gardeners work with locally produced or commercial seed, they may need to store it for weeks or months. For example, fairs that provide seed of multiple species will not occur just before the planting season for each one. After planting, families may have leftover seed. And, of course, seed savers must preserve the quality of their entire seed harvest until the next planting season comes around. Consider these seed storage ideas to maintain quality:

Seed savers must preserve the quality of their seed harvest until the next planting season.

- **Sealed plastic bag/jar:** On a dry day, use plastic bags or jars to seal seed. Place the seeds in an envelope and then inside the bag or jar. Add loose oven-dried rice or fresh charcoal to absorb moisture. Do not open the bag or jar until close to planting time.
- **Moisture level:** Most commercial seed will have been dried appropriately prior to packaging and sale. If seed is farm-saved, ensure low seed moisture before storage. In tropical conditions, saved seed can be difficult to dry enough to achieve effective seed storage, but this effect varies by species. For example, at average 25° Celsius and 60% humidity, watermelon seed will equalize with its environment to 7.4% moisture, which is reasonable for storage. In the same conditions, pumpkin seed will equalize to 9%, which is too moist to store seed successfully (Roberts 1972). Bioversity International provides a helpful [chart](#) with this data. Farmers can do simple tests of seed dryness. If a larger seed can be easily snapped or bitten in two, it is sufficiently dry. Smaller seeds can be put in a bottle in the sun; if condensation forms, it is not yet dry enough. A seed-drying cabinet or other appropriate technology device can be of great value as a community resource or in the hands of a lead seed saver. The Educational Concerns for Hunger Organization (ECHO) gives technical notes on building a simple seed-drying [cabinet](#) and on modifying a common [bicycle tire pump](#) to create a vacuum-sealed environment in any glass jar of seed with an airtight metal lid (Forst 2002 and Motis 2019).
- **Cool storage:** In hot climates, store seeds in the coolest available location. Identify cool and shaded facilities that could provide a community service for storing vegetable seed. If not available, consider storing sealed seed in an underground pit where the temperature is stable.
- **Rodent-proof containers:** If rats or other rodents are common, consider rodent-proof containers, such as glass jars.
- **Purchase timing:** Hold fairs closer to planting season or make purchases more often so that less storage is needed.

Seed testing

Although the expected viable lifespan of seed can be quite long in ideal conditions (see seed life chart in [Seed Processing and Storage](#), McCormack 2004), in real-world conditions lifespan can be much shorter; therefore, it is necessary to conduct seed germination tests (see box below) for both commercial and locally sourced seed.

For commercial seed, important information regarding crop year, harvest dates and variety name should be available on the package, but for seed from farmers or the informal sector, this information will likely not be included. For that reason, staff or gardeners should be trained to interview the grower or seller carefully to better understand the seed they are buying. The interviewer will need to label the seed they buy with as much information as possible such as: seller, crop year, harvest date and whether/how seed was conditioned (prepared for sale by cleaning, drying, screening, etc.). They should ask whether the seller has germination-tested the seed lot and if so, when and with what result, so this can be recorded with the seed. Record formal or informal variety names and any promised or described characteristics of the vegetable variety. Without such record keeping, it will be difficult to assess later exactly how reliable the seller may be, and equally difficult to request the same seed variety from the same seller again, if desired.

At-home seed germination test

- Count out a round number of seeds such as 100 (ideal), 50 (good), or 10 (okay, if little seed can be spared). If you are sampling seed from a large container, make sure you mix seed well to ensure a truly random sample, since seed in different parts of a canister or bag will experience different levels of heat and moisture.
- Wet a piece of thick paper towel, clean rag or coffee filter. Newsprint paper works as well, but is less preferable because it is harder to see the seeds.
- Space the seeds evenly on half of the material and fold over or roll up carefully and tightly to enclose them.
- Put the material with seed (referred to as “test”) somewhere safe and warm and away from insects.
- Keep moist by spraying or by storing the test in a plastic bag.
- After 3 days, open the test. Count and remove seeds that have sprouted and look similar to all the other seed. Very abnormal seeds would probably not survive in the garden. Close the test again.
- Count again after 7 to 10 days and add this count to the count from Day 3. This is the portion of seed that has sprouted. Divide by the total number of seeds included in the test to calculate germination percentage.
- If you test the seed coming from the same source over time and note that more seed is taking longer to sprout, that is a sign of reduced vigor and impending germination decline.

A simple, illustrated home seed germination testing lesson designed for children is found in Agricorps’ school garden curriculum. A guide with good photographs and some alternative methods is found at the [Southern Exposure Seed Exchange](#).

Ways to increase access to seed

There are several key factors that may reduce access to seed: lack of seed available at a reasonable distance from the target community, lack of affordable seed (especially when income is reduced due to crisis or chronic stress) and gender considerations.

Gendered seed access

- When considering gardeners' access to seed, we need to understand that men and women of varying ages may have different levels of access. Level of control over income to buy seeds, physical and cultural ability to travel to the seed market, freedom to engage and negotiate with male vendors, and control over the seed once home may affect women's seed access. Because vegetable seed is relatively expensive, women with unequal control of household income may not have sufficient funds to buy it. During a crisis, gender roles can further reduce access to garden seed where women's freedom to find resources has been restricted (Harvey et al. 2013).
- Men and women often grow different types of crops and for different purposes; therefore, the seed diversity—staples, legumes and vegetables—and variety available are important influencers on what is sourced. The exit interviews during the USAID Zambia Mawa Project's Diversification for Nutrition and Enhanced Resilience (DiNER) fairs indicated that women and older men purchased seed based on household consumption needs, while men purchased seed based on opportunities for market sales.

Conduct a gender analysis to gather, hear and respond to feedback about gendered differences in seed access. Analyze whether your seed access strategy widens or narrows this gap.

Strategies for supporting seed access

Practitioners and communities have several options for enabling seed access. Each has advantages and disadvantages that need to be considered when designing the approach. Although there are several options, most use more than one access strategy concurrently.

Before designing a seed strategy, a [Seed System Security Assessment \(SSSA\)](#) should be conducted to better understand what seed is available, how seed is currently accessed and constraints to accessing quality seed, which will all guide the seed strategy design. In a recent assessment conducted in Burkina Faso, some of the main constraints identified in the Center-North region included:

- Quality seeds and inputs were not conveniently available to producers in rural locations—seeds were not in the right place, in the right quantity, at the right time
- Seed supply chain actors, such as agro-dealers and rural vendors, had insufficient business management, financial and marketing skills to effectively promote commercial seed and expand sales to new populations
- Farmers demonstrated limited willingness to pay (weak demand) for commercial seeds, and uncoordinated distributions and subsidies by the government and other development actors depressed the market demand for commercial seed

When using the SSSA to guide the seed strategy for gardens, you will need to adapt it to focus on garden crops.

Seed supply development

Often known as a value chain approach, this strategy initiates when the private seed sector is engaged as a partner. Projects can facilitate linkages between gardeners, producer groups, seed retailers (e.g., rural vendors and agro-dealers) and seed companies to reduce identified constraints and increase access to seeds. For example, project teams can collaborate with private seed companies through joint planning to strengthen distribution networks, strengthen business development services to improve the company’s management team capacity and operations, and broker investment from banks or impact investors to help finance the expansion of their business. Depending on the specific circumstances, projects may include other incentives, such as time-bound subsidies (i.e., funding market studies and co-funding marketing activities) or guarantees of certain sales volumes (i.e., resource transfers via seed fairs for the most vulnerable households), provided seed companies adapt their strategies to better serve gardeners with appropriate products and services at the last mile. For additional information and resources about how to collaborate strategically with private companies to achieve program objectives, engage your organization’s impact investing team.

In addition to strategic collaboration directly with seed companies, projects can strengthen the seed system by addressing constraints at other distinct levels, such as providing technical assistance or business development services to agro-dealership managers, recruiting and training last-mile salespeople, and helping producer groups understand the return on investment of small expenditures on quality seed. In situations where there are insufficient quantities of quality seed available in a specific region, seed multipliers could be trained to coordinate with seed companies. When market and policy environments are unfavorable for sustainable seed systems, such as parallel development programs in overlapping regions, the project can help coordinate actors to ensure that development funding is used strategically to reduce market distortions and dependencies and improve the overall ecosystem.

Table 4: Seed supply development as an access strategy

Some advantages	Some cautions
<ul style="list-style-type: none"> ■ Aims to foster a solution that helps everyone’s bottom line, and is therefore self-sustaining without further intervention. ■ Once seed sellers better understand small/remote gardeners’ needs, they may adapt other product lines and sales practices to meet these needs. ■ Private sector actors may share costs related to distribution infrastructure development, training, advertising and others. ■ Seed supply development can be combined with other seed access strategies to help overcome disadvantages. 	<ul style="list-style-type: none"> ■ Gardeners may not initially be motivated to change seed access habits (e.g., paying for seed). ■ Standalone interventions may not adequately address seed affordability. ■ Without project incentives, seed companies may be motivated to reach the easiest first, so most remote gardeners may still struggle to access seeds. ■ Program staff will need specialized skills, including business networking, negotiation, design of incentive programs, etc. ■ May inadvertently hamper competitors.

In Niger, CRS used a supply development approach to improve sustainable supply and access to improved cash crop seeds in the Zinder and Maradi regions. The two major problems identified by CRS Niger were 1) insufficient supply of quality seeds, and 2) beneficiaries largely dependent on free distributions. CRS Niger established a relationship with a local seed company that was already actively producing quality seeds and targeting smallholder farmer clients in the Maradi region. The project team then trained farmers on the benefits of using improved seed varieties (cultivating demand), increased the seed company production capacity by supporting certain farmers to multiply foundation seed (increasing supply), and recruited and trained local agro-dealers and local vendors to support last-mile marketing and service delivery. Due to the project's initial subsidization of the seed company's operations during a proof-of-concept phase, the company realized the profit opportunity of expanding its operations into a new region and, consequently, made investments to improve sustainable access to quality seed for smallholder farmers.

Table 5: Contributions by CRS and seed company to achieve shared value in Niger

	Seed multipliers	Local seed vendors	Farmer groups
CRS	<ul style="list-style-type: none"> Recruit and support multipliers 	<ul style="list-style-type: none"> Recruit and support seed vendors Provide training to managers Share costs of demonstration plots 	<ul style="list-style-type: none"> Increase savings/incomes Train farmers on seed use Cultivate demand for seed
Private seed company	<ul style="list-style-type: none"> Supply foundation seed Provide inputs and training Guarantee purchase of seeds Certify seed for legal sale 	<ul style="list-style-type: none"> Train and monitor seed vendors Prepare small packages of seeds Deliver seeds on consignment Share costs of demonstration plots Pay for radio commercials 	<ul style="list-style-type: none"> Provide free sample packs Host demonstration days Guarantee seed authenticity

While the arrangement in Niger was focused on cash crops, this approach is an effective example of private sector engagement and seed value chain development that can be applied to companies that provide vegetable seeds for gardens.

Another example of a larger-scale seed supply development project comes from the NGO Swisscontact, working in Bangladesh. This multifaceted project, called Katalyst, used several strategies:

- Conducted market research to show unmet small-grower market demand for small seed packets
- Presented this market research to seed companies to motivate investment and action
- Supported mobile seed vendors to enable a distribution network that reached more remote seed users and fosters business success
- Worked with a seed company to incorporate the mobile seed vendors into their distribution channel
- Assisted the private sector in measuring impact and still-unmet potential demand
- Measured and encouraged the spread of new garden practices from lead farmers/early adopters to neighbors

Using these strategies, the Katalyst program increased the number of households using the small packets from 236,000 to 458,000 over three planting seasons in 2012 (Hasan et al. 2015). Although this example focused on helping a large seed company reach small communities, local vendors can be important seed sources as well. Remember, vegetable seed is often imported, even if locally branded, so the widely held belief that buying locally will turn up more locally adapted varieties of vegetable seeds is false.

Training and demonstration

Seed access can be hampered by a lack of knowledge/awareness of the benefits of accessing a better quality or diversity of seed. This strategy works with lead farmers who demonstrate the benefits accrued or by providing direct training via project staff on the benefits of improved or quality seed.

Table 6: Training and demonstration as a seed access strategy

Advantages	Cautions
<ul style="list-style-type: none"> ■ Less invasive strategy than organizing fairs or distributing seed. ■ If knowledge alone boosts interest in seed access, gardeners may use existing resources and commercial networks to find seed. ■ Training could be structured to include cross-cutting goals beyond seed access, related to food utilization, marketing, nutrition, etc. ■ Training can engage private seed companies, public extension and/or local lead farmers, building a stronger resource network for gardeners. 	<ul style="list-style-type: none"> ■ Knowledge alone may still leave the least-resourced, most remote or least-empowered members of the community without seed access. ■ Works best in combination with other strategies. ■ If based on a phased approach that expands from early adopters to a larger set of gardeners, this strategy may require longer project timelines to achieve results.

The Centre Technique Agroécologique du Sud (CTAS) and Professionals for Fair Development (GRET) are working together in Southern Madagascar to offer an interesting marriage of lead-farmer training and voucher programming. CTAS established a network of 80 small seed and farm supply shops throughout the region while lead farmers were positioned and developed as trainers in agricultural best practices related to specific crops. For each training the lead farmer delivered, they received both cash and a voucher redeemable for any kind of seed in the shops. Upon receiving training, other farmers received a voucher from the lead farmer that was redeemable in the shops for a specific type of seed related to the training content delivered (Lheriteau and Rakotondramanana Ratrimo 2014).

Seed vouchers

In this strategy, people needing seed access support are given vouchers, preferably in a range of denominations, which are used to buy seed at a fair organized within a reasonable walking distance for participants. Fair vendors are recruited and reimbursed by the project based on vouchers collected. An alternative strategy engages with designated local shops accessible to beneficiaries. Vouchers are redeemable in these shops, which are in turn reimbursed for their value.



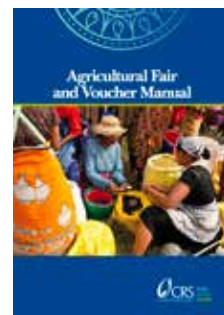
DiNER fair in Madagascar. Photo by Heidi Yanulis for CRS

Table 7: Vouchers as a seed access strategy

Vouchers and fairs: Advantages	Vouchers and fairs: Cautions
<ul style="list-style-type: none"> ■ Implemented close to beneficiaries' homes where markets do not exist ■ Can provide a mix of seed vendors including local/informal seed suppliers, small to large enterprises, agro-dealers and government seed banks ■ Possible to bring other crop inputs, tools or even livestock to the same site ■ Often stiff competition between vendors ■ Mainly limited to beneficiaries ■ Opportunity for social mobilization ■ Participants can use cash to buy items that exceed voucher amount or type ■ Added income for storeowners can help them maintain increased and diversified stock 	<ul style="list-style-type: none"> ■ Could set up parallel market system that can displace sales from existing market actors ■ May be labor-intensive and expensive to organize ■ Supplier relationships established for the fair do not imply sustainable engagement with these communities' post-fair; continued advocacy and support is needed ■ Creates a more artificial economy in which non-beneficiaries are left out ■ Beneficiaries only have one day to use vouchers, and preferred goods may run out ■ Possibility of collusion between vendors and beneficiaries and other types of unintended use of the system
Vouchers and shops: Advantages	Vouchers and shops: Cautions
<ul style="list-style-type: none"> ■ Shops are typically open 6 to 7 days a week ■ Beneficiaries can shop in their own time, thereby reducing crowds and security risks ■ Uses existing market structures ■ Goods can be stored in the shop ■ Easy for NGOs to collect vouchers from the shop ■ New products brought into the shop can also be accessed at a reasonable price by non-beneficiaries ■ Added income for storeowners can help them maintain increased and diversified stock 	<ul style="list-style-type: none"> ■ May only have a few vendors near the location ■ Some shop-owners may feel that the effort of working with alternative payment systems is not worth the benefit of additional sales ■ Shops may be far from beneficiaries, particularly women, if mobility constraints exist ■ Compared to the seed fair approach, may exclude small vendors or producers as well as indigenous and wild-sourced seeds ■ Possibility of collusion between vendors and beneficiaries and other types of unintended use of the system

Source: Some content is quoted or paraphrased from CRS Emergency Capacity Strengthening Catalogue, Section 4.1: [Designing Cash and Voucher Programs](#).

The central advantage of a voucher model is the deliberate exposure of the gardening population to potential new suppliers and new varieties. The approach aims to increase/combine availability and access. Very specific vendors or specialized local informal producers (perhaps growing traditional crops) can be recruited to a fair or to supply a shop-based voucher program. Resources exist that give guidance on how to organize and manage seed fair and voucher programs, such as the CRS [Agricultural Fair and Voucher Manual](#) (2017), which incorporates the model known as DiNER fairs.



Ledgers

ASO-Ixil, a community-based NGO in Guatemala, used a ledger system instead of a voucher system for a shop-based seed access program. The shop owner was given a list of all beneficiaries indicating which had qualified for a 25%, 50% or 75% subsidy for seed. Beneficiaries paid cash in the shop or purchased on credit if available. Project staff paid out the difference to the shop based on proof of sales. Extension visits to each garden confirmed that payments resulted in actual provision of seed. As with the DiNER fairs, seeds newly available in the shop could also be purchased by non-beneficiaries, should they choose to pay the full price. One issue with this shop-based seed access program was that women did not (traditionally) enter such a shop alone, which was an issue for the many widows participating in the gardening interventions. While the storeowner was typically required to record a signature (or thumbprint) attesting to the identity of the subsidy-user in relation to the ledger, exceptions were made for the widows in the program, who were able to accept delivery of seed by project staff or certain relatives.

Direct seed distribution

Sometimes a program acquires seed and distributes it to selected audiences. When considering direct seed distribution (DSD), first assess whether seed availability is actually an issue by conducting an [SSSA](#). For example, ask: Are there potential vendors of garden seed material? If vendors do exist, can other access strategies be employed to assist in reaching gardeners with seeds? An example is a transport subsidy to help farmers lower their costs in reaching seed sellers.

Table 8: Direct distribution as a seed access strategy

Advantages	Disadvantages
<ul style="list-style-type: none"> ■ If the program is designed to reach specific people with specific seeds, this can be the easiest method. ■ In cultures where women are not allowed to participate in commerce or attend a public event without men, direct distribution can reach them. ■ Can be a quicker method of seed distribution when gardening is part of a fast-moving crisis response. 	<ul style="list-style-type: none"> ■ A direct material aid mechanism that does not suggest an exit strategy to self-sustained local supply and does not accustom people to spending on seed. ■ Potential to cause dependency rather than self-sufficiency. ■ Requires care in program design to not disrupt local commerce or informal seed systems. ■ Does not typically allow each gardener any choice of vendor, brand of seed, or choice of seed. ■ Indigenous and wild-sourced seeds are typically not included.

Direct seed distribution has at times been combined with other approaches like seed fairs. For example, CRS' Eastern Chad Horticultural Program (2008–2009) was a response to a complex humanitarian emergency that employed both tactics, because garden seeds could not be available everywhere due to distance or unavailability. Some 2,250 people received—via direct distribution—turnip, tomato, beet, onion and hot pepper seed along with garlic planting material. The same population, along with 750 other participants, was invited to seed fairs. Seed that vendors provided at fairs was entirely different from what was distributed: peanut, beans, watermelon, okra, millet, sorghum and sesame (CRS 2009).

A modified form of direct seed distribution (DSD) is possible by deploying seed through established groups rather than to individuals, such as savings/investment groups, agricultural cooperatives for other crops (e.g., coffee, tree fruits or livestock), designated management groups for water resources, etc. DSD to a group can be set up as a one-time investment. The idea is to spark experimentation and innovation in gardens, with the expectation that they work together to pool resources to access seed via normal supply chains in the future. However, as with any group approach, internal dynamics that affect who receives the seed need be considered (e.g., male, female, elderly, young, wealthy, powerful and more vulnerable).

Motivation is an important factor to consider when directly distributing seed. Free seed distribution risks wasting program resources or causing widespread resale of seed to those with less need. Avoid this by assessing the interest, time and aptitude of seed recipients or by placing conditions on the access. For example, CRS Afghanistan employed a conditional seed distribution strategy that provided households with seed once it was verified that the household had built a garden.

What are the different seed variety types?

A packet or handful of seed has a whole “family tree” of ancestral seed that came before it—and the genetic makeup of every vegetable seed (aside from those gathered from a wild population each time it is planted) has been heavily selected and determined by human choices. There are five different systems that can be used either by commercial breeders or traditional farming cultures (see box below).

***Different types of seed variety serve different purposes.
Match the types of vegetable varieties offered to
the goals of the project.***

Types of vegetable seed varieties—definitions/examples

Open-pollinated (OP) seed: Open-pollinated seed breeds when pollen is naturally transferred by insect, bird, wind, etc. It can produce new seed similar to the original plants if it is done with care as described in the “Local Seed Saving and Production” section above.

Hybrid: Hybrids in a general sense are created in nature or by humans when two unlike types of a plant species successfully mate. Commercial F1 hybrid seed results when two highly inbred lines are deliberately crossed to give predictable results in offspring. Seed saved from a hybrid plant will not have predictable results, so hybrid seed cannot be saved and needs to be purchased every season.

Wild-sourced seed: Seeds from wild sources are unlike other vegetable seeds since they grow spontaneously in self-maintaining populations in natural ecosystems and have not been domesticated by humans. However, many wild vegetables, such as leafy greens that thrive in disturbed areas close to human settlements, can more accurately be considered semi-domesticated, because humans have been interacting with them and influencing their growth over time (Heywood 1999).

Landrace: Unlike hybrid and OP varieties, which by design grow fairly uniform plants, a landrace is a diverse population of plants. Landraces result when farmers or researchers select seed to save that represents a variety of a vegetable’s desirable forms, tastes, uses and/or types of stress resistance. Learn more about landraces in [Resource Book for Preparation of National Conservation Plans for Crop Wild Relatives and Landraces](#) (Maxted et al. 2013).

Genetically modified organism: Commercialization of genetically modified varieties is extremely limited for common and traditional garden vegetables. A few genetically modified summer squash varieties have been commercially available since 1995 for their virus-resistant qualities. But, as of this writing, those seeking vegetable seed sources for gardening are unlikely to encounter this seed.

Seed saving: Where seed saving by gardeners is a goal, OP or landrace seed is required. Assuming plants are not allowed to cross-pollinate with other cultivars in the garden or with wild relatives of the garden plants, offspring will be genetically similar to parent plants. But the very controlled seed-saving conditions required to succeed with some species are often not possible. See the seed-saving section for more information.

Reliable production during the first season: Seed cannot be saved with predictable results from hybrid plants, but if a project’s main concern is reliable production in the first season, hybrids may be a superior choice. Some hybrids are bred for higher yield or more marketable product in conditions of ideal water and soil nutrition, but may not do well when conditions are less than ideal. Other hybrids are bred specifically to perform in stress conditions such as drought. Hybrids bred to slow specific diseases or resist pests may not display that resistance if the plant is under high stress. Know and teach others that well-chosen hybrid seed may go a long way to solving some garden problems, but just the fact of a seed’s hybridity does not in itself automatically make a better plant for the exact conditions, particularly since the gardener will need to buy them every year.

Seed cost: Whether staff members are buying seed within a budget for distribution, or vouchers are deployed, seed cost can be a major project concern. Hybrid seed is much more expensive than open-pollinated seed due to the laborious work of crossing the parent plants. For horticultural garden vegetables, hybrids typically range from 300 to 1,000% more expensive than OP varieties. One of the key benefits of wild-sourced vegetables is that they are free.

Cultural context: Projects that strongly value cultural context must consider that landrace, wild and open-pollinated seeds are often closely tied to the history, ecology, celebrations, language and food preferences of people and places. Informal, locally sustained seed systems are founded on these seed types and are potentially threatened by hybrid seed, even in those cases when hybrid seed has the potential to make gardens more productive and reliable. When local gardener-saved vegetable seed is sold at a fair side-by-side with hybrid seed, the hybrid seed vendor may present more enticing, eye-catching and well-funded marketing. The tension between these two models deserves consideration by all garden project designers.

Transport and storage: Finally, a major goal of vegetable breeding in the last century has been to develop hybrid types that hold up well in transport and storage to accommodate large-scale commerce. Gardeners with a goal to sell vegetables may therefore benefit from these same traits, such as harvests that are more uniform for easy marketing; fruit that transports more easily due to tough skin, firm flesh or size; plants that hold ripeness longer; etc. If immediate fresh eating is the sole goal, then some of these same advantages from hybrid seeds may become disadvantages.

Indigenous vegetable seed

Indigenous vegetables fall under the umbrella of neglected and underutilized foods, since they have typically received less investment by agricultural research centers and less attention from nutrition and food security programming than globally recognized vegetables, such as tomatoes, carrots and lettuce. This underinvestment has resulted in local communities becoming the custodians of the genetic diversity of indigenous vegetables, particularly the seeds, resulting in informal yet well-established systems of seed saving and varietal improvement. Many communities source both indigenous vegetables and their seeds directly from the wild, and scatter them closer to the home in fields or gardens. But gardeners are also often quite resourceful in maintaining access to seed material for indigenous vegetables, whether through careful home seed saving, informal market connection, highly specialized local seed producers, or by requesting seed material from plant gene banks via government extension offices. Communities displaced from a familiar home ecosystem may have special interest in bringing into the garden traditional plants, such as foods gathered from forests from which they are now displaced (Samberg 2016). For example, in its assessment of indigenous vegetables, CRS Uganda found that refugees from South Sudan brought several species of indigenous vegetable seed with them when they fled their homes, but due to restricted land availability in refugee settlements, they were unable to grow the vegetables.

If a garden project seeks to promote indigenous vegetable seed and gardening, it is important to first define the term within the project setting and then seek seed sources locally (or commercially, depending on your definition). Creative garden project design and community-based investigation can result in traditional seed materials being included in seed fairs, microenterprise-level supply-chain development or direct seed distribution. The global seed trade is aware of the growing interest in the indigenous vegetables of Africa and Asia. Such seeds are accessible from dealers and in shops in some places, but building commercial trade capacity to serve this interest is gradual work.

The [World Vegetable Center](#) and [Bioversity International](#) are two of the international research centers leading research and promotion efforts of indigenous vegetables. [African Indigenous Vegetables in Urban Agriculture](#) (Shackleton et al. 2009) is a useful resource for learning more about indigenous vegetable seeds.

Nutrition and seed

When considering the use of gardens for nutrition, it is important to understand that who is contracted to sell seed could affect what seed is available for planting, and thereby positively or negatively influence the project's potential impact on nutritional outcomes. Some strategies to use to support the nutritional aspects of gardens through seed are:

- **Maturity time:** Projects can make available varieties with short days to maturity that allow repeat planting even within a single growing season. The shorter growing time decreases production risk from uneven rainfall and other factors. Also, vegetables that are quicker to harvest are suitable for women who have unequal access to labor-saving tools and/or whose overall workload is too heavy. Examples are shown in Table 9 on how this strategy varies among vegetable crops.
- **Plant varieties with different harvest times:** Provide gardeners access to early and late-harvest varieties of the same vegetable to continue to provide a diverse diet for a longer time period. Gardeners will sell and trade, so the strategy still works even if different varieties are selected by different growers.
- **Ripening:** Making available select varieties that tend to stagger ripening, and/or varieties that are edible in the ripe stage for a longer period of time, will maintain or increase food variety over a longer time period and reduce the postharvest storage burden for the gardener. Vegetables that can be eaten ripe or unripe have much more nutrition when ripe, but the tradeoff is that they may perish much more quickly.
- **Preservation:** The project could help ensure there are varieties available suited to drying or other traditional preservation methods so the nutritious foods are available in times when they are normally limited (see Chapter 11 on Postharvest Handling).



CRS supported nutrition through increasing access to nutrient-rich vegetable seed in the Philippines after Typhoon Haiyan. *Photo by Jennifer Hardy/CRS*

Table 9: Examples of quick-growing vegetables

Type	Note
Malabar spinach	Can be replanted from cuttings: self-generated replanting without waiting for seed production cycle.
Cowpea	Example of a vegetable providing edible leaves quickly and additional food in later growing cycle.
Beet	Example of a vegetable providing edible leaves quickly and additional food (roots) in later growing cycle.

Conclusion

Vegetable seeds are an essential element of the garden and it is easy to assume they are one step toward supporting a gardening intervention. But always tread carefully as humanitarian aid efforts can do harm as well as good. If seed is offered repeatedly, at no cost or with incentives, this can pull farmers away from their own self-insurance strategies and make them vulnerable to crisis. If seed is offered at the beginning but no sustainable seed system is available to gardeners, then the gardens will not be sustainable. Our ultimate goal is for gardeners to have the knowledge, motivation, capacity and authority to either produce seed reliably or find it affordably in the marketplace.

Always tread carefully as humanitarian aid efforts can do harm as well as good.

Quiz

- Which of these is a good seed-saving practice?
 - Save seed from only one plant
 - Seed should be wet when it is put into storage
 - Save seed from the plants with the best traits, even if that means not being able to eat or sell those plants
 - It is best to save seed from hybrid varieties
- True or false: A small handful of seed is about the right amount for each gardener to receive of any vegetable.
- Be cautious in designing any project involving direct distribution of seed to gardeners, to ensure that your program:
 - Does not undermine local commerce, either current or potential
 - Does not cause dependency on free materials among gardeners
 - Does not disrupt traditional food or seed-saving/sharing practices
 - All of the above
- True or false: Seed purchased from a local agro-dealer will always be better adapted than seed purchased from a company farther away.

Activity

Identify how an existing or upcoming project will help gardeners access seed.

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Chapter 8:

Integrated Soil Health Management

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Learning objectives

After studying this chapter and its links and resources, you will know:

- How to use multiple tests to understand the health of the soil
- Approaches for improving soil health

Key messages

- **Healthy soils = healthy plants = healthy people:** Feed the soil, let the soil feed the plants and the plants will feed the family.
- **Do no harm—minimize soil disturbance:** The top layer of soil is alive. When soil is treated as a lifeless, passive mass to be dug up and tilled often, and when agro-chemicals are applied frequently, much of the underground life and benefits are destroyed.
- **Cover and protect the soil:** Protect the soil all year round with a living cover crop or layers of mulch from dead plant matter to prevent the loss of valuable topsoil due to wind or rain. Mulch and cover crops feed soil organisms that transform dead plant material into nutrients for growing plants. Mulch also controls the loss of soil moisture from evaporation.
- **Land management:** When land is left alone, natural systems, such as forests and drylands, improve the soil. When people poorly manage the land, it degrades. Gardeners who manage the soil to imitate nature can restore poor soil to grow vegetables, fruit and flowers year after year.

Key questions for decision-making

- What soil tests will the project use?
- What strategies will the project promote or provide training on to improve soil quality in the gardens of target audience(s)?

Soil health is important for gardens

If a soil is healthy, it will feed the plants, and the plants will feed the family. If soil nutrients are used by each new set of growing crops without being replaced, the soil will be degraded and no longer support plants or produce food. At the other extreme, applying too many nutrients, often with commercial fertilizers, damages the soil, reduces yields and contaminates soil and water. The key is balance.

If a soil is healthy, it will feed the plants, and the plants will feed the family.

Soil knowledge needed to grow a successful garden

Gardeners need to know what soil is, what it is made of, its unique properties in their own gardens, and how to manage it to grow healthy vegetables and fruit in spite of moderate weather problems.

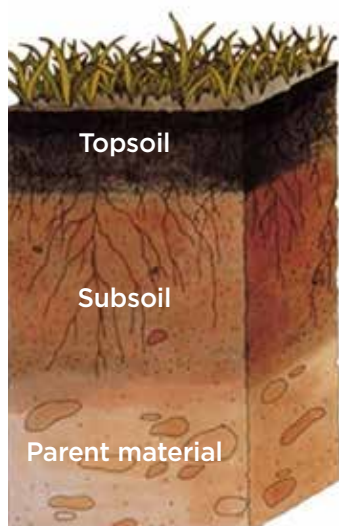
Soil is a complete environment that is hidden right under our feet. Dig down a meter or so and you are likely to see two or three layers of soil with different colors and textures. The top layer, referred to as “topsoil,” is the most important for gardeners and farmers.

Topsoil is alive and is where most of the organic matter and much of the soil's life can be found. It is where most of the plant roots are growing and where much of the plant nutrition is stored. It is usually a thin layer of organic matter and very small rock particles (minerals). It is often between 5 and 20 centimeters (2-8 inches) deep. The best gardens have at least 10 centimeters of topsoil. It is darker than the layer below. Soils that are on slopes or that have suffered losses from too much wind, heavy rain, frequent burning, or tillage may have very little or no topsoil.

Subsoil is a layer with clay that has accumulated from the topsoil above. In soils of the tropics, subsoil often has iron and aluminum in it.

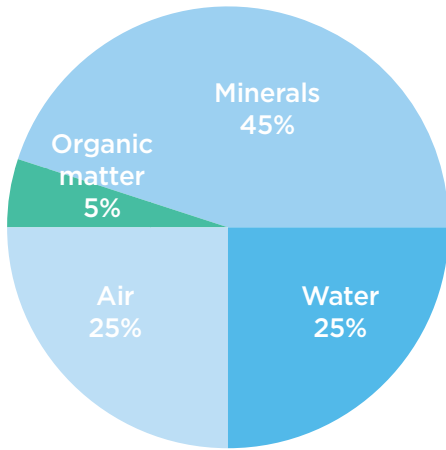
Parent material is partially broken rock material from which the upper layers have developed. Not shown here is bedrock which lies under the parent material. This is a hard layer that is not soil.

Figure 1: Soil profile



Although many people think soil is nothing more than a mass of very small pieces of rock, the rock particles make up less than half of the soil. Air, water, organic matter and living organisms make up the rest. A healthy soil has a good mix of the nutrients that plants need, a balance of different sizes of tiny rock particles, many living creatures and a somewhat loose structure that allows roots to grow and support the plant.

Figure 2: Soil ingredients



Minerals: There are three types of rock particles that make up soil texture—*sand, silt and clay*. These particles are identified by their size. Sand is the largest of these very small rock particles and clay is the smallest. The proportion of each of three minerals in the soil determines the soil’s texture and influences properties that are important to plants. When there is a lot of sand, the texture is described as a sandy soil. Water drains quickly and the soil is not very fertile. A clay soil is more fertile than a sandy soil but may not drain water well. Silt is made up of mid-size particles.

Water: In good garden soil, half of the soil is made up of open spaces between soil particles. These “pore” spaces are filled with water or air. Small pores hold water and plant nutrients dissolved in water.

Air is held in the large soil pores. Plant roots and many microorganisms that break down dead plant material into nutrients need air. These decomposers cannot live without oxygen.

Organic matter is material that was once living. It is fresh or partially rotted (decomposed) plant and animal residue such as leaves, roots and manure. *Living organisms* in the soil that are large enough to see are *macro-organisms* while those that can only be seen with a microscope are *micro-organisms*. Together they break down organic matter and help it decay into plant nutrients. Over time, decomposition produces a rich, dark substance called *humus* which decomposes no further. Humus provides many nutrients needed by plants, holds water well, and produces toxins that reduce weeds and plant disease.

- **Macro-organisms** include millipedes, beetles and earthworms. Most types of millipedes break down dead plant tissue into organic matter for micro-organisms to break down further. Ground beetles eat harmful insects such as cutworms and slugs. Earthworms tunnel through the soil making it easier for air and water to move. They fertilize the soil with their droppings (castings) that are rich in nutrients.

Living organisms in the soil break down organic matter and help it decay into plant nutrients.



- **Micro-organisms** are the bacteria, fungi and nematodes that help decay plant material into humus. Nematodes are very small worms that also reduce diseases in the soil. Almost all nematodes improve the soil, but there are also a few harmful ones. For example, gardeners struggle with root knot nematodes that produce a growth on the root that reduces its ability to absorb water and nutrients (see Chapter 9 on Pest and Disease Management for more information).

Getting to know your garden's soil

Healthy plants depend on healthy soil, and soils differ from garden to garden. For this reason, practices that improve the soil in one garden may be useless or may even do harm in another. Although it is possible to have a productive garden without ever testing the soil, when gardeners understand a few basics about soil and know their own soil well, they are more likely to manage it in ways that nourish plants and resist weeds, harmful insects and brief storms or dry spells.

There are a few observations and simple tests that gardeners can use to identify which practices will make their garden soil healthier. When a garden is new or is planted in a new area, knowing the soil becomes especially important. It is rare that a garden has no soil problems. The five tests that follow can be done by the gardener.

Simple do-it-yourself soil tests

You can learn a lot about a soil through observation and experience working in the garden. Although soils can be tested in a laboratory, the results may be difficult to understand, they are costly for most gardeners and the laboratory is often located far away. The following tests can be done by gardeners themselves at a low or no cost:

1. Soil texture and structure
2. Drainage
3. Depth of topsoil
4. Earthworms (to indicate soil quality)
5. Soil pH (acidity or alkalinity)

Texture and structure test

Soil texture refers to the amounts of sand, clay and silt in the soil. When you know the texture of a soil, you have a pretty good idea of how well it drains water, holds water in dry spells, and whether it is apt to be more or less fertile. You can also recommend crops that do well in local soils.

- **Sandy soil** has large pore spaces between particles that do not stick together well. It also drains water well so usually has few nutrients. However, they do have good air flow for roots and soil organisms to “breathe” and grow.
- **Clay soil** has mineral particles that are attracted to each other when wet, and hold water and nutrients well. But too much clay causes poor drainage. Clay soil can also form a hard layer which blocks the flow of water and the growth of roots. When heavy clay soil is saturated, roots and soil organisms lack the air they need to survive.

- **Silt soil** is made up of mid-sized particles. Like clay soil, it can retain too much water in rainy weather and cause drainage problems that lead to root disease. Silt soil tends to be somewhat fertile.
- **Loam soil** is ideal for gardening. It is a blend of the above three soil types with additions of organic matter. The blend consists of 40% sand, 20% clay and 40% silt.

Soil structure is the way that particles and groups of particles are arranged together to form both soil pores and soil clumps (aggregates). Good soil structure helps with drainage and aeration. Structure can be formed by plant roots, worms or additions of organic matter:

- When plant roots die, they leave an open space where the root was growing for air and water.
- Earthworms move through the soil leaving channels for roots, air and water.
- Humus and organic matter have different sizes of particles and pore spaces, so the more organic matter in the soil, the better the soil structure.

It is easy to destroy the structure by walking on or digging silt or clay soils when they are wet.

The **squeeze-and-feel test** can be used to test soil structure. Two or three days after a good rain, when the soil is still damp but not wet, take a loose ball of soil from the surface about the size of a table tennis ball (about 4 centimeters or 1.5 inches in diameter). Squeeze the ball in your hand and then let go.

- If the soil does not form anything like a ball, it is sand. If it feels gritty, it has a lot of sand or gravel. If you cannot see the particles easily, it is sandy. If there are small pebbles, it is gravelly.
- If the soil crumbles, it has fairly good texture and is loam.
- If it holds its shape and feels sticky, it is likely to have a good amount of clay.
- If you can roll the ball into a fat snake, it has too much clay.
- If the soil feels soapy, slimy or greasy, it contains silt.

For more accurate estimates of texture, there are two other simple tests that can be used: the ribbon test and the jar test. To learn more about these two tests, visit:

- **Ribbon test:** [Guide to texture by feel](#) (USDA n.d)
- **Jar test:** [How to evaluate your soil type](#)

Soil drainage test

Drainage is the movement of water through soil. It is affected by soil texture, soil structure and soil management. A soil that drains too fast is likely to have a lot of sand and does not hold water between rainfalls. This is a problem because water travels so quickly down through a sandy soil that it is lost to plants. Often this soil cannot hold nutrients and they are washed away with rain. Soils that drain too slowly, puddle, or turn into mud have few pore spaces or poor structure. They are likely to be a silty or clay soil. They hold water well but lack air space, may be hard to work, and nutrients may be locked up and hard for plants to access.

To improve soil drainage for sandy and clay soil, add lots of organic matter before planting. When a soil is very hard, it may be necessary to dig and turn it over before the gardener can produce and apply enough organic matter to make it hospitable for young plants.

To conduct a soil drainage test, dig a hole that is 30 centimeters (12 inches) in diameter and 30 cm deep. Place a marking stake or straight tree branch into the hole. Fill the hole with water and mark the top of the water line on the stake or branch. Use a watch or timer on your phone to track time.

- Ideal drainage: 2.5–5 cm (1–2 inches) per hour
- Rapid drainage: More than 5 cm (2 inches) per hour
- Poor drainage: Less than 2.5 cm (1 inch) per hour

Topsoil depth

A dark, crumbly topsoil layer is ideal for gardening and represents a good mix of minerals and organic matter with a good balance of pore space. Also, evidence of animals and soil organisms is a good sign.

To conduct this test, dig holes in three different locations. Each hole should be 30 centimeters (12 inches) in diameter and 30 cm deep. Place the soil from each hole into a bucket or on light-colored cloth/paper.

- If it is difficult to dig, comes out in clumps or is grey, then it is more of a clay soil
- If it is easy to dig, and
 - is light brown, it is more of a sandy soil
 - is dark brown and clumps fall apart easier, it is more of a loam soil

Earthworm count

A healthy soil has many small, visible insects and animals, such as earthworms, living and working beneath the surface. Earthworms eat, break up and decompose plant litter (the leaves, stems and roots of plants). They ingest partially rotted compost and animal manure and leave behind excrement (castings) that enrich the soil. These castings can contain many times the amount of nutrients of the original plant matter. They contain nitrogen, phosphorus and potassium, the main nutrients found in bags of commercial fertilizer. Earthworms act as natural tillers that mix soil minerals with organic matter; they contribute to soil structure by burrowing deep and opening the soil to create air space, pathways for roots and drainage channels. They increase soil water-holding capacity and reduce erosion because their tunnels help water soak into the soil, rather than wash it away. In many cases, the number of earthworms provides the easiest and quickest way of assessing soil health.

The number of earthworms in a soil can provide the easiest and quickest way of assessing soil health.

If the soil has been tilled frequently, has received heavy fertilizer or agrochemical applications, is rocky, eroded, lacks topsoil, or is very poor (infertile, very acid, has a hard layer, is a heavy clay, extremely sandy or very salty), it is unlikely you will find earthworms near the surface because there is little or no organic matter. Under these conditions, earthworms may have burrowed deep into the soil or moved to another area to avoid these stresses.

In the dry tropics where earthworms are less likely to be found, termites can indicate soil quality. Termite mounds increase the fertility of nearby soils, and like earthworms, termites increase the soil's pore space, water infiltration and water retention.

The **earthworm count test** should be done several times during the growing season when soil is moist but not saturated or bone dry. After collecting two or three samples across the garden, take the average of the counts to get an estimate of the earthworm population.

1. Dig a hole that is 20 to 25 centimeters (8-10 inches) deep and 30 centimeters (12 inches) in diameter.
2. Count the earthworms in the soil. It helps to place the soil on light-colored cloth.
3. Interpret test results.

Table 1: Interpreting the earthworm test

Earthworms in sample (average)	Soil health
10 or more	Very healthy soil
6-9	Fairly healthy soil
5 or less	Possible problem soil: very acid or alkaline, little organic matter, heavy soil (poor drainage), over-application of chemicals, over-tilled, too hot

Instructions on how to increase live insect counts

- Make the garden a no-till (zero tillage) or low-till zone to increase plant residue, improve soil structure and reduce soil temperature.
- Apply rotted manure and organic matter to the soil. If the soil is very poor, dig this into the soil before making the garden a no-till zone.
- Rotate crops—plant different vegetables in a different area of the garden each year.
- Plant legumes (beans, groundnuts, etc.). Earthworms prefer legume plant residue.
- If there is space, plant cover crops between rows of vegetables. Plant drought-resistant cover crops between vegetable rows before the end of the rainy season. They will grow into the dry season, die back and provide earthworm food and mulch cover when the rain drops off.
- If there is a pasture, grassy area or forested area nearby where the soil has lots of worms, dig up a few large chunks of soil and work them into the garden soil to reintroduce worms.
- If the soil is very acid or alkaline, make the pH more neutral.
- Be patient. Commercial fertilizer repels earthworms. It takes longer for earthworms to return to areas where chemical fertilizers have been consistently applied.

Soil pH test and what pH tells you

The pH is a measure of the concentration of hydrogen ions in soil water. The pH scale ranges from 0 (most acid) to 14 (most alkaline). Soil pH indicates whether a soil is acid (pH less than 7), alkaline (pH greater than 7), or neutral (pH of 7). Many tropical soils are very acidic (pH below 4.5). The soil's pH influences whether plants can absorb nutrients through their roots, whether soil bacteria can decompose organic matter, and whether there are toxins in the soil. Most plants will grow in a range of pH levels but prefer a soil between a somewhat acid soil (5.5 pH) and neutral (7 pH). Below a pH of 5.5, aluminum levels in the soil can become toxic enough to limit or stop root growth. As a result, plants are unable to absorb water and nutrients, especially phosphorus. Plants become stunted and yields drop.¹² Remember that an acid-loving plant will not grow well in an alkaline soil and vice versa.

Table 2: The best pH for some common garden crops

	Crop	Preferred pH
Root crops	Carrot	5.8 – 6.5
	Cassava	5.0 – 8.0
Legume crops	Chickpeas	6.0 – 9.0
	Cowpea	5.5 – 7.0
	Groundnut (peanut)	6.0 – 6.5
Leafy crops	Cabbage, kale	6.5 – 6.8
	Amaranth leaves	5.5 – 7.5
	Sweet potato leaves	4.5 – 7.5
Fruit crops	Guava	4.5 – 8.2
	Papaya	5.5 – 6.6
	Lime, lemon, orange	5.0 – 7.0
	Avocado	5.5 – 7.0
Other	Cashew	5.5 – 7.0

For a general indication of pH and whether soil amendments are needed, gardeners can test their soil with the supplies listed in Table 3. This must be done with distilled water, which does not change the pH of the soil you are testing. If the products are not available, rely on extensionists or farmers who already know whether local soils tend to be acid, neutral or alkaline. Large towns, cities or district capitals are likely to have these supplies.

¹² Phosphorus is one of three macronutrients (nitrogen, phosphorus and potassium) that plants need in large amounts. Both acid and alkaline soils have the potential to cause deficiencies in soil phosphorus.

Table 3: Supplies for soil pH test

Item	Alternative item	Where to find item
Glass /ceramic cup	Hard plastic cup	
Measuring cup	Small cup marked for quarter cup or 2 ounces or 60 ml	<ul style="list-style-type: none"> ■ Supermarket in baking section
Distilled water (the pH is close to 7 so it will not change the pH of the soil)		<ul style="list-style-type: none"> ■ Supermarket or pharmacy ■ Auto repair store or gas/petrol station (distilled water is used to fill batteries) ■ Beverage manufacturer or beer producer
Baking soda or sodium bicarbonate or bicarbonate of soda (all the same)	Do not use baking powder	<ul style="list-style-type: none"> ■ Supermarket in baking section ■ Pharmacy
White vinegar	Other vinegar	<ul style="list-style-type: none"> ■ Supermarket
Clean spoon for stirring and spade for digging (or machete, cutlass, shovel)		

Adapted from Coronado 2017

Table 4: Test to determine soil pH level

Process for testing for acidity	Process for testing for alkalinity
Dig a quarter cup of soil (equivalent of 2 ounces or 60 ml) from the surface of the garden	Dig a quarter cup of soil (equivalent of 2 ounces or 60 ml) from the surface of the garden
Mix soil with distilled water to make a muddy liquid	Mix soil with distilled water to make a muddy liquid
Sprinkle baking soda on top of the liquid	Pour a quarter cup of distilled vinegar over the top of the soil liquid
If it bubbles up, the soil is acidic	If the mixture bubbles up, the soil is alkaline

Source: Coronado. 2017

Improving garden soil

The soil problems that gardeners already know about, or discover during do-it-yourself tests, include few or no soil animals—indicating poor soil fertility; too much or too little sand, clay or silt; no topsoil; soil that is too acidic or alkaline for garden crops; and drainage problems. Gardeners may also describe too many rocks. Almost all of these problems can be improved or resolved, but it may take two or more growing seasons to see changes. In dry areas, it will take even longer. In areas with frequent burning or where animals graze the garden, the soil is likely to degrade further.

Improving the soil with the Rule of 3. Gardeners can transform poor soil into rich productive soil by 1) engaging in minimum tillage, 2) adding organic matter, and 3) diversifying and rotating crops.

Rule of 3
Gardeners can transform poor soil by engaging in minimum tillage, adding organic matter, and diversifying and rotating crops.

Preparing the soil: To till or not to till

Many gardeners start a garden by digging the soil and turning it over. Some use a mechanical tiller to do the work. Gardeners may have to do this in the first year to break up hard layers of soil, but for most soils it should not become common practice each season.

Too much tilling harms the soil, reduces organic matter, kills beneficial soil organisms and multiplies weeds. Tilling a heavy clay or silt soil that is too wet or too dry destroys it. When very wet, these soils can form large chunks that dry into a hard mass without pores to hold air and water. Rain runs off the soil without soaking in and roots are unable to grow. Soils tilled when they are very dry can form a fine dust with no pore space. So, pick up a ball of wet soil and squeeze it. If it makes a muddy ball it is too wet to dig. If it crumbles into smaller light pieces but does not crumble into dust, it can be planted or tilled lightly.

Overall advice: Avoid tilling the soil.

Feeding the soil: Adding organic matter

Organic matter can be added to your garden through compost, green manure/cover crops (gm/ccs), mulch and animal manure. Adding organic matter to a garden can keep it fertile, as long as enough is added each year. If the garden is smaller than a quarter hectare, compost is the best source of organic matter. For larger gardens, gm/ccs are best, because less labor is needed.

Compost

Adding compost is one of the best ways to make sure that garden soil is healthy and produces vegetables that are healthy and rich in nutrients. Compost is especially important for poor soils and gardens that must produce well every single growing season. It strengthens plants so they can resist poor weather and pests (see Chapter 9 on Pest and Disease Management).

Compost is a blend of organic materials mixed together and allowed to decompose into rich, dark humus (“gardener’s gold”). Compost is made up of materials that are rich in the nutrient carbon—which soil organisms use for energy—and nitrogen and are used to build protein in the organisms that decompose plant material and release nutrients to plants. The best mix of carbon and nitrogen in compost is 25 to 30 parts carbon for every part of nitrogen. All plants contain carbon, and different individual plants have different ratios of the two elements. For example, beans have more nitrogen and thus a lower carbon-to-nitrogen ratio than rice or maize.

One way to think of compost ingredients is to divide them into the “greens” that tend to be rich in nitrogen, and the “browns” which have lots of carbon (these rules don’t always apply but are helpful when you first make compost). Below is a description of the inputs used to make compost:

- The “browns” (high in carbon) include dried leaves and grasses, straw, dead plants, crop residue (rice, maize, sorghum or millet stalks), pine needles and plain cardboard (no labels or paint).

- The “greens” (high in nitrogen) include vegetable peelings; fruit skins; leaves and pods from beans, peas and peanuts/groundnuts; coffee grounds; tea leaves; leaves of leguminous trees that produce nitrogen, such as *Gliricidia* (Mother of Cacao), *Acacia*, *Leucaena*; or green manure crops, such as jack bean (*Canavalia* species), velvet bean (*Mucuna* species), *nyama* (*Piliostigma reticulatum*), sunnhemp (*Crotalaria ochroleuca*) and lablab bean (*Dolichos lablab*). Other products that are high in nitrogen are hair or animal fur, and manure from animals that do not eat meat, such as poultry, cows, horses, sheep, goats and rabbits. The manure does not have to be aged first because the composting process will age it. To be clear, fresh animal manure should never be applied to plants as it will “burn” the plants and transfer bacteria or parasites to humans. Compost manure first or let it age before adding it to garden beds.

**Not all
“greens”
are green
in color.**

Where to source “greens”

If “greens” are hard to access and the community members are near a town, community/field agents could potentially negotiate with juice bars or restaurants for the collection of fruit and vegetable peels for use in compost.

- Egg shells can be crushed into small pieces to add calcium, which is good for acid soils. Ash and charcoal are also good for acidic soils.
- To help keep rats and animals away from the compost, do not add meat, bones, dairy products (milk, cheese, yogurt, cream or butter), or anything containing fat or oil.

Instructions for producing compost

- Near the kitchen or garden, gardeners should dig a hole that is at least 1 meter deep and 1 meter wide. Set the top layer of soil aside.
- Spread a layer at least 5 cm thick of dry, coarse browns, such as leaves and grasses.
- Add a layer of greens. To start, try to add about 1 part greens to 2 parts browns. With 5 cm of browns, the layer of greens would be 2–3 cm thick. This will vary based on the type of greens and browns you are using, because different soils and plant types contain different amounts of nutrients. Gardeners can experiment to find what works best in their garden.
- Add a thin layer of the topsoil previously set aside.
- Apply just enough water to dampen the layers. The soil should be moist, not drenched.
- Repeat these layers as more greens and browns are collected.
- Use a shovel or garden fork to turn the pile over every three or four days and at least once a week. Move the center of the pile to the edges and the edges of the pile to the center. If you want to compost faster, then turn the pile more often.
- Keep the soil slightly wet.
- When the center of the pile becomes dark and crumbly and smells sweet, this is humus. When there is enough humus to add to the garden, transfer it. Leave the part of the pile that is not fully decomposed to start the process again for a second round of compost.
- If animals—such as dogs or goats—roam free, they may dig into the pile and gardeners will need to fence it off with thorny bushes or other means.

When there is enough compost ready, add 5 centimeters (2 inches) to the topsoil all across the garden and mix in lightly with a machete, cutlass or rake. Otherwise, if sufficient compost is not available, use a combination of compost with gm/ccs, aged animal manure and mulch to enrich the soil. Plants need more nitrogen, phosphorus and potassium than other nutrients,¹³ so a good mix of items with these nutrients should be added to the compost. These nutrients can be found in the following input:

- Animal manure contains nitrogen, phosphorus and potassium
- Legume residue (beans, chickpeas, pigeon peas, lentils, etc.) contains mainly nitrogen but often all three nutrients
- Banana peels contain potassium and phosphorus if grown in soils with these nutrients
- Avocado, papaya, melons and mango contain potassium
- Squash, sunflower and sesame residue contains phosphorus

Notes of caution

1. Ash from a wood fire is very alkaline and improves acid soils. However, be careful to add only very small amounts to a compost pile and monitor changes in the garden before adding more. Too much ash will slow or stop the activity of soil microorganisms. If the garden soil is already alkaline (above a pH of 7), do not put wood ash in the compost.
2. Avoid handling manure with bare hands. Wash hands and clothing after applying manure, because pathogens from soil and animal manure can cause illness. Make sure the compost smells like fresh earth with no odor of manure before applying it to the garden.
3. If the compost pile smells bad, there may be too much water in the pile and too little air flow. Dig and turn the pile over. Move new material from the edges to the center of the pile and move the center to the edges.
4. Another cause of a bad smell is too much “green” or nitrogen (fresh kitchen peelings or manure) and the pile needs more “brown” (dead leaves or other browns). To help mitigate the bad smell, the gardener can turn the compost over more often and add carbon products, such as leaves and straw.
5. If the pile decomposes slowly, there is not enough nitrogen for microorganism populations to increase and do the decomposing work, so add more “green.”

Green manure/cover crops

Green manure and cover crops are those that are grown before the garden is planted or between rows; gm/ccs offer several benefits, such as:

- Improving soil structure damaged by too much tillage, by increasing aeration and buffering pH.
- Increasing fertility by adding organic matter; on acid soils, gm/ccs can increase the availability of soil nutrients up to five times.
- Reducing harmful insect pests and supporting beneficial insects.
- Increasing the drought resistance of plants and increasing the soil’s ability to capture more rain and hold water longer.
- Controlling weeds.
- Providing additional protein-rich food for human and animal consumption.

13. In addition to the three main plant nutrients (nitrogen, potassium and phosphorus), compost, mulch, composted manure, and gm/ccs can improve deficiencies of nutrients such as boron, sulfur, manganese and iron.

In many parts of the tropics, soils are so degraded that the preferred cover crops are green manures, the legumes that transform (“fix”) nitrogen from the air into the legume’s plant tissue (and into the soil in a form that other plants can use). Legumes are high in protein and nitrogen, the most important plant nutrients. Beans, pigeon peas, lentils, chickpeas, cowpeas and peanuts (groundnuts) are all legumes. Trees like *Leucaena*, *Gliricidia* and *Acacia* are also legumes and are used as gm/ccs to improve soil and provide shade, livestock feed, cooking fuel, etc. Benefits may take a while to emerge, so rotted animal manure can be applied to a degraded soil at first to speed improvements.

Traditionally, green manure crops were grown alone across an entire field and tilled into the soil at maturity, adding green plant manure in the same way that animal manure is added before planting. However, gardeners can grow the gm/ccs with vegetables and grains together at the same time or a bit later. Each cover crop has different characteristics and requires different types of management. Find out what the local innovators are using and learn from those who are already planting green manures.

Traditional cover-cropping systems

Examples of traditional cover-cropping systems are maize, beans and squash (Latin America); sorghum and groundnuts (Africa); millet, cowpea and cassava (Africa); and rice with soybeans (Asia).

The basic management process for gm/ccs is:

1. Plant drought-resistant gm/ccs at the end of the rainy season to provide cover during the dry season.
2. Grow them for a full season before the garden is started to improve degraded soil enough to produce a crop.
3. Leave gm/ccs on the surface to die back and form a protective mulch or cut them back before they go to seed and reproduce.
4. If cut, dig them into the topsoil before planting garden crops to provide organic matter and nutrients. Several weeks of decomposition is needed before vegetable germination.

Notes on green manures and cover crops.

1. **Local problems:** Gm/ccs often produce their organic matter at the end of the rainy season or continue growing into the dry season when animals, termites, dry weather and fire can destroy them. It is important that you identify local gardening problems before advising gardeners on selecting gm/ccs that resolve local problems. For example, jack bean (*Canavalia ensiformis*) grows on very poor soils in hot, dry weather. See also [Restoring the Soil](#) (Bunch 2012).
2. **Availability:** Seeds may not be available locally. Check first with local farmers and training centers for local supplies either from innovative farmers and gardeners, an agricultural university, technical school or training center. Starter sets of cover crop seeds in small amounts can sometimes be ordered.¹⁴ In West Africa, you can access cover crop seeds from Dr. Kofi Boa’s [Centre for No-Till Agriculture](#) in Amanchia, Ghana.

14. [ECHO Development Network](#) has a wealth of information on tropical gm/ccs that can be used to decide which ones to test locally.

- 3. Competition for garden crops:** Some cover crops are aggressive and hard to eradicate if allowed to set seed, such as *Mucuna* (velvet bean), which is usually cut back at flowering before it can produce seed.
- 4. Commercial fertilizer:** In soils where commercial fertilizers have been frequently applied, the soil and nearby water sources may have excess nutrients, such as nitrogen, potassium and phosphorus. If this is a problem, it is wise to use gm/ccs in the garden rather than animal manure. This is because the nitrogen and other nutrients in the manure can move easily with water and will continue to pollute when it rains. On the other hand, the gm/cc provides nutrients as organic matter when its roots and leaves decompose. Organic matter holds nutrients until plant roots need it and is not easily washed away. However, many gardeners have too little animal manure, so a combination of gm/cc, compost, mulch and animal manure is most practical.

Mulch

Mulch is fresh or dead plant matter (leaves, stems, straw, rice hulls, maize husks and sorghum stalks). It is placed on top of the soil to decompose. Earthworms feed on mulch and incorporate the organic matter into the soil where microorganisms transform it into plant nutrients.

Rotted animal manure

Animal manure is often rotted with straw or other livestock bedding. It is mixed into the top layer of soil. Fresh animal manure is so strong that it will burn plants, so it needs to be aged (“cured”) first. To do so, place manure mixed with straw in a hole where it ages for one to two months, and until it no longer has a strong smell. Gardeners can also place manure into a hole with a layer of plant residue or straw on top. Manure must be composted before being applied to the garden.

Manure must be composted before being applied to the garden.

Commercial (inorganic) fertilizer

You may need to use commercial fertilizer to start a garden, especially when there is no compost or animal manure, and the soil is so degraded that it cannot produce. After the first harvest, use the mulch or compost to begin the process of soil restoration or plant a mix of hardy green manures with aged manure or commercial fertilizer.

Although commercial fertilizers provide immediate improvements to growing plants, they depend on soil tests to determine type and amounts needed and are expensive for many gardeners. Commercial fertilizers cause environmental problems if overused or used incorrectly, and can damage or kill soil organisms. If chemical fertilizers are needed, use a formulation prepared for horticulture that contains the right mix of nutrients for good fruit or vegetable production. An imbalance can lead to poor flowering and fruit production.

Garden crop rotation

Planting vegetables in a new spot in the garden each season reduces damage from disease and insect pests and keeps the garden fertile. Most root crops and herbs are light users of soil nutrients, but cabbage, tomatoes and maize are heavy users of nitrogen and phosphorus. To avoid depleting nutrients in one area of the garden plot, change the location of crops to renew soil fertility. Nitrogen-loving plants (the users) can be preceded or followed by legumes (beans, groundnuts, etc.) or green manure (the producers). Both legumes and green manures add nitrogen to the soil. See table below on crop rotation guidelines.

Table 5: Crop rotation guidelines

Plant group	Crop rotation
Onions, garlic	Rotate with legumes (producers); avoid planting with undecomposed organic matter.
Carrots, parsley, coriander (cilantro), parsnip	Add compost to soil before planting. These moderate feeders can come after any other plant group. Follow with legumes.
Cabbage, radish, broccoli, leafy vegetables	Plant legumes the season before. These vegetables are heavy users, so apply compost or aged manure to the soil before planting.
Melons, squash, pumpkin, cucumber	Follow with legumes or plant green manure between the vegetable rows.
Beans, peas, cowpea, pigeon pea, green manures	Alternate these producers with all other garden crops where possible.
Maize, millet, sorghum	Plant grains before tomato, melon or squash to control weeds and retain water.
Tomatoes, peppers, aubergine (eggplant), Irish potato	These are heavy users of nutrients and are susceptible to fungal problems. Plant grains or cover crops beforehand and legumes (producers) after.

Adapted from Rodale 2017

Simple improvements for problem soils

Extremely degraded or infertile soils: In areas where soils are so poor that most leguminous cover crops will not grow well, the gardener can plant jack bean (*Canavalia ensiformis*), *Tephrosia* (any of the species), or both *Canavalia* and *Tephrosia* for one to three years until the soil is improved enough to support other gm/ccs. Gardeners can accelerate the timeframe by working rotted manure or compost into the soil before planting gm/cc seeds.

Soils with acidity or alkalinity problems: Most vegetables do best in soils that are slightly acid, with a pH between 5.5 and 6.5. Compost is the best way for most resource-poor gardeners to raise the pH of an acid soil. But when compost is not available and when soil pH is below 5.5, gardeners can apply small amounts of lime¹⁵ by digging it into the soil near the plant's root zone. This will neutralize soil acidity enough to allow vegetables to grow at first. Lime can be expensive, so applying it near the root zone of a plant, rather than throughout the garden helps. Also, increasing the levels of

15. Lime is either calcium carbonate or a mix of calcium carbonate and magnesium carbonate (dolomitic lime). Dolomitic lime is used on soils that have low pH and low levels of magnesium, an important nutrient for plants.

organic matter in the soil requires smaller amounts of lime. The exact amount needed will depend on the current pH of the garden, soil texture, and the needs of the crop. If there is an agricultural supply store nearby, a soil pH test strip and distilled water can be used to identify the pH numerically.¹⁶ This determines the amount of lime to raise the pH to a less damaging level. Also, the amount of lime changes with soil texture. Lime will improve root growth, make soil nutrients available (especially phosphorus), and increase beneficial soil organisms. For acid soils, dolomitic lime is usually best. If topsoil is alkaline, add *rotted* manure or pine needles to make it more acidic.

Gardens on slopes: Protect the garden from erosion by using live barriers (plant deep-rooted grasses or bushes along the contour, i.e. across the slope, not up and down the slope) or live barriers of trees that are pruned before the rains and mark the garden borders. If the land is rocky, use rocks to build a wall on the contour, or make a small terrace into the slope. Plant vegetables in rows that run across the slope (along the contour). Infiltration ditches and bunds are also helpful. For more information, see Chapter 10 on Water Resources in this guide, and read more in [Preparing Smallholder Farm Families to Adapt to Climate Change, Pocket Guide 3: Managing Water Resources](#) (Burpee et al. 2015).



Make sure that sloped gardens have something planted on them all the time. If the dry season is so long that plants will die, use gm/ccs that resist dry spells and that will provide a mulch of leaves and stems when they die. Or plant dispersed legume trees that can be pruned back just before the rainy season and used to form a mulch before planting the garden.

Gardens with heavy clay soil and lots of rain: Raised beds can be used to improve drainage for crops such as tomatoes and greens that are sensitive to wet soil. Gardeners can also mound soil into a small hill for planting or construct permanent raised beds with local materials.

Conclusion

This chapter introduced soil and its types, how different soil attributes affect plant growth, and how soil quality is affected by the vegetation it supports. When a gardener understands the basics of their own garden soil and something about its physical, biological and chemical properties, management decisions become easier. Simple tests to monitor soil properties help point the way to practices that will build and maintain soil health for a productive garden.

¹⁶ Soil pH test strips can be purchased online or at hardware and gardening stores (in the U.S.). However, pH strips are not available to most gardeners except during a formal development project, so the tests above give a general indication of pH.

Quiz

1. What is soil made of? Check all that apply.
 - a. Water
 - b. Organic matter
 - c. Minerals
 - d. Air
2. True or false: Land should be tilled every time crops are planted.
3. The three main practices for restoring soil health are (check all that apply):
 - a. Minimum tillage
 - b. Adding organic matter
 - c. Applying chemical fertilizer
 - d. Crop diversification and rotation

Activity

Using an existing or upcoming project, identify what soil health practices you think gardeners will find most useful.

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Chapter 9:

Pest and Disease Management

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Learning objectives

After studying this chapter and its links and resources, you will know:

- Common practices of integrated pest management (IPM) for gardening.
- Key pests and diseases that can cause serious damage.
- Some strategies to prevent and/or control pests and disease.
- Key beneficial insects that help to protect the garden.

Key messages

- IPM combines multiple control strategies including cultural, biological, mechanical and chemical methods.
- IPM depends on scouting the garden to identify pests and differentiating between pests and beneficial insects, and tolerable or unacceptable damage/ plant injury.
- IPM aims to control pest populations at a tolerable level.

Key questions for decision-making

- What pest management strategies will the project promote?
- What disease management strategies will the project promote?

Pest and disease management is important for gardens

Pests and disease can affect any garden, resulting in the loss of a harvest. This means less food to eat in the household and fewer opportunities to sell the crop for income. It also means a risk of exposure to dangerous chemicals, such as pesticides.

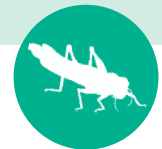
Defining integrated pest management

IPM is a broad crop management approach that stresses the importance of monitoring and correct pest or disease identification. The approach integrates cultural, biological, mechanical/or physical control and chemical practices to control pest populations below established thresholds. The main steps in this approach include 1) preventing, 2) monitoring, 3) identifying, 4) assessing, 5) taking action, and 6) evaluating results.

Step 1: Start with prevention

Pest and disease management starts with prevention. An important prevention practice is sanitation. For disease- and pest-free plants, start with clean planting material and planting media that will help to avoid infection from viruses and soil-borne diseases. Tools and stakes should be sanitized if reused, to avoid spread of disease. Gardeners should follow good agricultural practices related to soil fertility and water management because healthy, vigorous plants will be better able to withstand pest and disease damage. For more information on good agricultural practices, refer to Chapter 8 on Integrated Soil Health Management, and Chapter 10 on Water Resources.

Pest and disease management starts with prevention.



Other prevention practices include:

- Applying mulch to suppress weeds and minimize splashing, which can spread disease like early blight.
- Trellising tomatoes and cucumbers to increase air flow, making a less conducive environment for disease.
- Avoiding over-application of nitrogen, which can attract some pests.
- Avoiding over-watering, which can create a conducive environment for the spread of disease.
- Removing plants that may provide habitat for pests or disease agents.
- Removing weeds before they reproduce (Malinoski et al. 2003; Meadows 2015; North Carolina State Extension 2018).

Step 2: Monitor to know what is present

Monitoring the garden and searching for pests is called scouting. This should be done at least twice a week to identify what pests are in the garden and if they are a problem. The best time to search for pests is very early in the morning, especially on the underside of leaves.

For this step, it is also important to learn what types of beneficial or non-harmful insects may be present in the garden as well as what other crops are present. Beneficial insects can help with pollination and fruit production as well as insect pest control. Some plants may also serve as alternative habitats or hosts of unwanted pests and disease agents or can help repel pests.

Since it is often difficult to spot or count insects using only visual inspection, yellow sticky traps and pheromone traps can be useful tools for detecting when pests arrive and assessing infestation levels (below). There are a number of do-it-yourself traps as well (Arthurs and Hunsberger n.d.).



Yellow sticky traps are a useful tool for monitoring pest levels. *Photo by Sarah Page/CRS*

Step 3: Identify pests and disease

Proper pest and disease identification enable the gardener to choose the most appropriate treatment. Pests or disease can be observed directly on crops or by the evidence they leave behind. Common disease-causing agents including fungi, bacteria, nematodes, viruses and parasitic plants, among others, which can be identified based on tell-tale **signs** and **symptoms**.

- **Signs** include physical evidence of the disease agent or its products such as fungal vegetative growth structures like mycelium and fruiting bodies (mushrooms); powder on leaves or the hardened masses of some fungi; spores; bacterial ooze; or nematode eggs.
- **Symptoms** are the visible changes that the disease agent causes and can include changes in leaf or plant color or shape, wilting, spots or browning, lesions, or light-colored halos on leaves (Isleib 2012).

Table 1: Signs and symptoms of plant diseases and nematodes*

Disease Type	Signs	Symptoms
Fungal diseases: Rusts, powdery mildew, white mold, early and late blight	Leaf or stem rust, powdery substance on leaves and stem, sclerotinia	Yellowing of leaves (chlorosis), damping off or collar rot of seedlings, leaf spots, birds-eye spot
Bacterial diseases: Bacterial leaf spot, bacterial wilt, black rot	Bacterial ooze or streaming from stem when cut stem is placed in water, lesions	Yellow halo around leaf spot, cankers, galls including crown gall, fruit spot
Viral disease: Tobacco, cucumber, African cassava mosaic virus; potato virus X and Y, tomato yellow leaf curl	None—too small to see	Stunted, curled leaves, mosaic pattern on leaves, yellowing of leaves (chlorosis)
Nematodes: Cyst, Root-knot	Nematodes or eggs (need a microscope)	Below ground: galls (i.e., swelling) or knots on roots Above ground: wilting even with moist soils, patches of affected plants surrounded by healthy plants, stunting, symptoms of nutrient deficiencies

* For illustrations of these signs and symptoms, visit [this link](#) for a list of online resources.

Damage caused by insect pests varies depending on the type of mouthparts they have. Knowing the damage characteristic of each type of mouthpart can help to identify the pest culprit (see Table 2). Common damage or symptoms of insect pests include defoliation of leaves; leaf curling, bunching and yellowing; and indirect symptoms caused by transmission of viruses or increased susceptibility to fungal or bacterial disease agents.

Table 2. Common insect pests by mouthpart type and the damage they cause*

Mouthpart	Insect pests	Damage/Symptoms
Piercing-sucking	White flies Aphids Mealy bugs Squash bugs, stink bugs, and other true bugs	Feeding can cause leaf curl or bunching, damage to flower buds, yellowing of leaves and stunting. Production of “honeydew” can lead to sooty mold growth. White flies can vector serious viral diseases such as tomato yellow leaf curl virus.
Rasping-sucking	Thrips Spider and broad mites (non-insect)	These tiny pests scrape the leaf surface resulting in silvery-colored leaves. Thrips cause indirect damage by vectoring plant viruses or making plants more susceptible to fungal and bacterial disease agents. Mites are common in the dry season or dry climates.
Chewing	Beetles Caterpillars / larvae of moths and butterflies Grasshoppers Locusts Termites	Insects with chewing mouthparts cause holes or jagged edges on leaves and stems, and defoliation or “skeletonizing.” The larvae of the tomato leafminer (<i>Tuta absoluta</i>) burrows in leaves and stems and can damage buds and fruit.

* For illustrations of these pests, visit [this link](#) for a list of online resources.

When identifying pests and disease there are two more considerations: insect life stage and abiotic problems.

- **Insect life stages:** Insect pests often do not look the same throughout their life, and they may be capable of more damage at certain growth stages. Therefore, it is important to become familiar with the form of common insect pests at different lifecycle stages. That way you may detect pests early and introduce control measures before they become a threat or when they are most vulnerable.
- **Abiotic problems:** Sometimes plant injury caused by abiotic factors, such as nutrient deficiencies, chemical injury, drought stress, etc., can look similar to pest damage or disease. Some simple ways to distinguish between biotic (caused by pests or disease agents) and abiotic plant damage is that the latter will often affect many species across plant families, and symptoms do not spread across plants as they would for plant disease.

Step 4: Assess damage and decide when to act

Once a pest or disease agent is identified, the gardener will need to decide whether it is necessary to act. In many cases, mild damage to plants, meaning 20% to 30% defoliation, does not lead to major loss in yield and does not necessitate control measures (Malinoski et al. 2003). A gardener should determine threshold levels for acting, which may be based on the percentage of damage to a crop or the number of insect pests found. Threshold levels will differ depending on the growth stage of a plant. For example, mature, healthy plants can tolerate more damage than seedlings or transplants; therefore, action thresholds may be lower for young plants. Thresholds for action in a garden will also depend on the relative importance of that crop to household food security and income generation.

Step 5: Implement pest- and disease-control strategies

IPM promotes four strategies for managing pests and disease: 1) cultural control, 2) biological control, 3) mechanical or physical control, and 4) chemical control. The following section provides examples of these approaches.

Cultural control

Cultural control methods can be made before the pest and disease outbreak occurs as part of prevention. Some cultural approaches that can be adapted to local conditions include sanitation, crop and variety selection, crop spacing, companion and border planting, and crop rotation.

Sanitation: Gardeners can prevent pest and disease from the start by adhering to the following good practices:

- Avoid planting in previously diseased or pest-infected areas.
- Always use clean tools to avoid spreading disease throughout the garden.
- When using saved seed, make certain the seed has come from healthy plants.
- Be careful when using “volunteer seedlings” because they can contain disease.

Crop selection: Gardeners should plant crops and varieties that are adapted to the local climate and soil. Healthy, more vigorous plants will be better able to withstand pest and disease damage. Crop selection should also be based on the prevalence of known pests and diseases, and gardeners may want to choose varieties that are resistant or more tolerant to common pests and disease, if available. Additionally, gardeners can plant early-season, late-season, short-season or early maturing varieties to either avoid times of the year where there is higher prevalence of pests and disease or to ensure that plants are well-established and thus more tolerant to pest attacks.

The gardener's first line of defense should be prevention.

Crop spacing: Crop spacing can also affect the spread of pests and disease and plant's ability to tolerate damage. Gardeners should use recommended spacing to promote healthy, high-yielding crops with the idea that they will be better able to withstand pests and disease and that high yields can offset loss from damage. Next, gardeners should consider spacing that will make a less conducive environment for the spread of pests and disease. This consideration is more complicated and requires a strong understanding of the pest or disease agents' biology and feeding preferences (Hill 1989). For example, widely spaced rows may help prevent the spread of bacterial or fungal pathogens but may also make a crop more susceptible to insect pests (Langston et al. 2013).

Companion planting and border planting: In the context of IPM, companion planting or border planting can be used to attract beneficial pests or natural enemies that can control other pests, repel pests with certain scents or toxic compounds, or be used to attract and "trap" pests away from target crops (Kuepper et al. 2016). A "trap" crop can be a plant that the pest prefers over the target crop, or the same crop planted at a different time so that it reaches a more desirable growth stage and is preferred over the main planting of the target crop. Planting trap crops also helps concentrate pest populations so that they may be more easily treated.

A "trap" crop is a plant that the pest prefers over the target crop.

Flowering plants interplanted with crops or planted on garden borders can attract predators and parasitoids of insect pests and provide alternative habitats to ensure a consistent, high population of natural enemies (Rodriguez-Saoana et al. 2012). Similarly, live barriers or fences that aid in animal exclusion can also provide refuge for beneficial insects.

There are a number of useful plants for the control of pest and disease.

- Flowers that attract natural enemies of insect pests:
 - Members of the carrot family (dill, coriander, fennel), aster family (coneflower, cosmos, sunflower), legumes (alfalfa, sweet clover, hairy vetch), brassicas (mustards, alyssum) and other species such as buckwheat and cinquefoil (Altieri 2005).
 - For example, plant marigolds, zinnias or sunflowers to attract aphid-eating green lacewings (Winski 2013).
- Plants whose odor repels pest:
 - Garlic, basil, marigold, leek, tobacco, ginger, mint, onion, hot pepper.
 - For example, plant garlic to repel Japanese beetles, spider mites and aphids (Ray and Zehnder 2019).
- Plants that repel soil pests:
 - Marigold and brassicas, such as turnip and cabbage.
 - For example, plant brassicas and mustard for control of fungal disease (SARE 2012).
- Trap crops (for different target crop):
 - Collards (cabbage), cherry peppers (green peppers) and sunflower (tomato) (Boucher and Durgy 2012).
 - For example, blue hubbard squash can be used as a trap crop for squash vine borers, squash bugs and cucumber beetles (Pinero 2017).

These examples may be used within a companion planting system or planted around the garden in areas such as the borders or margins. For more information on beneficial insects, see the section below on biological control. Use of border plantings or companion plants may not be sufficient to maintain pests at tolerable levels and, thus, may need to be combined with other strategies.

Crop rotation: Rotating crops from different crop families can help manage and prevent the build-up of certain pests and disease. Crops in the same plant family are also vulnerable to the same types of pests and diseases, and when they are grown in the same location each season it “provides a reliable food source for the pest and disease-causing organism with a continual source of host plants that they can infect” (Higgins and Krokowski 2012). Crop rotation can disrupt this constant food source.

For pest management, crop rotation is most effective if the pest has limited mobility and has a “restricted range of host plants,” however, many pests fall outside of these two criteria (Stoner 2009). For disease management with crop rotation, the gardener needs information on: 1) how long the pathogen can survive in the soil, 2) which additional plant species (including weeds and cover crops) it can infect or survive on, 3) other ways it can survive between susceptible crops, 4) how it can be spread or reintroduced into a field, and 5) methods for managing other pathogen sources. For example, a pathogen that can survive in the soil but can also disperse by wind may not be successfully managed by rotation if an infected planting occurs nearby or the spores can disperse over long distances (McGrath 2009). For more information on crop rotation, see Chapter 8 on Integrated Soil Health Management.

Biological control

Biological pest control involves the use of natural enemies, including predators, parasites, parasitoids and pathogens that attack harmful insects, mites and other pests (Dreistadt 2014). In addition to beneficial insects, including predators and parasitoids, other biological control agents include pathogens like the bacterium, *Bacillus thuringiensis*, better known as Bt, and beneficial nematodes. Bt is used to control caterpillar pests and beneficial nematodes for soil-dwelling pests.

Below is a list of beneficial insects, a brief description of each, and the pests they prey on. If there are beneficial insects in the garden, it may be wise to avoid the use of chemical insecticides, since spraying will kill beneficial insects as well as harmful ones.

For more information on beneficial insects, see the section below on biological control.

Table 3: List of beneficial insects*

Beneficial insect and description	Prey
Ladybird beetles or “lady bugs”. Very beneficial in the garden. They can prey on aphids, spider mites, and other pests. The adults are easily recognizable, but the larva, or immature stage can consume the largest number of aphids.	Whiteflies, aphids, spider mites
Praying mantis An insect that is easy to identify because it holds its “hands” in a position of prayer. In addition to eating pests, it can also feed on beneficial insects like ladybugs (www.gardeninsects.com).	Aphids, moths, flies, mosquitoes
Assassin bug Searches for insects that it can eat.	Almost any pest
Green lacewing Has a number of stages that will hunt several pests. The adults are the most visible, but it is the larvae that have the largest appetites, capable of eating 60 aphids per hour.	Whiteflies, aphids
Miniature pirate bug Very small.	Whiteflies, thrips, spider mites, various insect eggs, aphids
Robber fly Very strong and fast. It can search throughout the garden for its prey. Its immature stage is capable of eating the most aphids.	Aphids
Syrphid fly Beneficial in two ways: First, it flies into flowers and helps with pollination. Then, the larvae also eat several pests, such as aphids. In some countries this insect is cultivated and sold as a biological control agent.	Aphids
Spiders A general predator, but they are very susceptible to pesticides.	
Parasitoid wasps There are many families and species of wasp and they are one of the most important biological control agents. Adults lay eggs on top of or inside of larvae, eggs, or pupae of pests, and the larvae then consume the host insect.	Aphids, caterpillars, sawflies, beetles, leafhoppers, truebugs, thrips, psyllids, flies

* For illustrations of these signs and systems, visit [this link](#) for a list of online resources.

Mechanical or physical control

Mechanical control of pests involves the physical removal, trapping or exclusion of pests or diseased plants to prevent damage from occurring or spreading in the garden. Sometimes handpicking or physically removing the insects or diseased plants is the most effective way to control damage. Handpicking is best when the insects are slow moving and do not sting, bite or pinch. The best example is caterpillars, but some beetles may also be easily handpicked. Once removed from plants, insects may be placed in a small cup with soapy water to kill them quickly. The dead insects can be used to make a biopesticide.

For some pests, it may be necessary to construct a physical barrier around the garden or around some plants or fruit to prevent entry. This is especially effective in the nursery stage of seedling production, when the plants are very small and especially vulnerable to attack. Barriers can be made from a fine mesh net and can include a floating row cover or low tunnels, net houses, and bags to protect fruit. Metal or paper collars at the base of transplants can be used to exclude cutworms and armyworms (Kansas State University Agricultural Experiment Station and Cooperative Extension Service 2016).

Chemical control

If cultural and physical measures fail to control a specific pest, then gardeners may wish to explore chemical control or the use of pesticides. In IPM, chemical control is the method of last resort and should always be used in conjunction with other control methods. Pesticides can be harmful to human and animal health as well as soil and water quality; therefore, any use of pesticides should be done with caution, following proper scouting, and after determining that pest damage is not tolerable.

Small-scale farmers are increasingly using agrochemicals including pesticides in horticultural production; thus, project implementers should be prepared to guide farmers to resources that can support them to apply these products correctly and safely. This is especially important because in many areas of the world, there is limited understanding of human safety and environmental risks associated with pesticide use. As a first step, project implementers should consult country-level or regional programmatic Pesticide Evaluation Reports and Safer Use Action Plans (PERSUAP), which can provide helpful information on what pests are common in the geographic target area, standard recommended practice for (non-chemical) control, and approved pesticides (both formulations and trade names available in the marketplace).

Pesticides—the general term for various agrochemicals used to control specific pests—come in many forms and levels of toxicity. This section will cover basic information on all pesticides, including synthetic pesticides, but will mainly focus on biopesticides. While not without risk, biopesticides are generally less harmful to humans and the environment.

Pesticides are composed of active ingredients (National Pesticide Information Center 2018) and other ingredients. Active ingredients are the chemicals in [pesticide products](#) that kill, control or repel pests. Often, the active ingredients make up a small portion of the whole product. A product [label](#) includes the name of each active ingredient and its concentration in the product. A single active ingredient may be found in hundreds of pesticide products with different names. Products with similar brand names may have different active ingredients with varying concentrations. Some active ingredients work on a broad spectrum of pests. Others are more targeted, killing only certain types. There are families of active ingredients that work in the same basic way. Using active ingredients from different chemical families can slow the development of pesticide resistance.

Pesticide concepts

Below is a brief overview of pesticide-related concepts. However, when using pesticides or giving advice to others, we recommend that you seek out more detailed information.



Guide farmers to apply pesticides correctly and safely

Types of pesticides:

- **Insecticides** are used against harmful insects only when they are causing economic levels of damage to the crop. Insecticides are the most poisonous of all agro-chemicals and must be handled with great care using all appropriate safety equipment. In many cases, they can also be harmful to beneficial insects.
- **Nematicides** are also highly toxic chemicals used to control nematodes in infected soils. Most gardeners only use nematicides in plant nurseries.
- **Herbicides** are used against weeds that cannot be controlled using physical methods like hoeing and hand removal. Usually gardens are small enough to allow weeds to be controlled using physical methods.
- **Fungicides** are used on molds and fungal attacks. They are often used at the postharvest stage.
- **Synthetic versus biopesticides:** Synthetic pesticides are produced artificially whereas biopesticides are “derived from such natural materials as animals, plants, bacteria and certain minerals” (EPA n.d.). Biopesticides are often but not always less toxic than synthetic pesticides.
- **Broad spectrum versus selective:** Pesticides can be classified into two categories: broad-spectrum or selective. Broad spectrum pesticides can be used to control a wide range of pests, whereas selective pesticides will target a specific pest. IPM encourages the use of narrow-spectrum or specific pesticides that are less likely to target beneficial insects and other, non-target animals (including humans).

Mode of action: The mode of action is the specific way that the pesticide causes harm to the pest. For example, some pesticides work by interfering with nerve functioning and others by targeting the hard, outer layer of an insect’s body. Using the same mode of action over a long period of time can sometimes lead to resistance in pest populations, so it is important to rotate products that work via different modes of action.

Contact versus systemic application: Some pesticides must be applied directly to the pest to harm it; these are called *contact* pesticides. An example of these are pyrethrins. Others can be applied to a plant and will harm the pest once it ingests the plant material. These are called *systemic* pesticides.

Short-term versus residual: Some *short-term* products break down very quickly and no longer pose a threat to pests or humans. Other products are designed to last for longer periods of time, providing longer-term control of pests. Some products that are now banned in many countries can persist in the soil and water for many years. Although banned in some countries, many of these products can still be found in developing countries (WHO 2018). Pesticide residues can also remain on fruit and vegetables long after a product has been sprayed and pose health risks when consumed by humans or animals.

Re-entry periods: Related to residual pesticides is the concept of re-entry periods. The re-entry period for a specific product is the amount of time following an application after which it is safe to enter the garden or field. Keep in mind that in places where people often go barefoot or wear shorts, the re-entry period may be longer (Oregon State University n.d.).

Signal words and toxicity: Signal words are often included on pesticide labels to indicate the level of immediate toxicity of a product. Signal words for less toxic to more toxic products are as follows: **Caution** (slightly toxic), **Warning** (moderately toxic), **Danger and Danger-Poison** (Highly toxic) (National Pesticide Information Center 2008). It is important to keep in mind that the risk posed by these products is a combination of the level of toxicity and the level of exposure as:

$$\text{Risk} = \text{Exposure} \times \text{Toxicity}$$

Thus, even slightly toxic products can pose a high risk to those exposed to a large amount. It may be best to avoid the use of any pesticides as **zero exposure = zero risk**.

**Risk =
Exposure x
Toxicity**

Other safety precautions

- **Proper mixing and application:** The toxicity of a pesticide depends on its concentration. Therefore, it is important to follow guidance on proper mixing and application of pesticides.
- **Use of safety equipment:** Protective equipment should be worn when applying pesticides to minimize exposure to harmful chemicals. Pesticides can cause harm via contact with skin or eyes, ingestion or inhalation.
- **Storage and triple-washing:** Always store pesticides in designated containers that cannot be easily confused for something else, and place them out of the reach of children. When cleaning an empty pesticide container, triple rinse the container and *do not reuse it*.
- **Counterfeit and poor-quality products:** Fake, counterfeit and ineffective products are common in the marketplace because of a lack of proper storage and poor regulations and oversight. Project staff should consult with or collaborate with trusted agro-dealers to learn how to spot counterfeit and poor-quality goods.

Biopesticides

Some biopesticides can be made at home using available materials; others are more specialized and need to be purchased from a commercial agro-dealer. Some specialized biopesticides may be difficult to find in rural areas; however, there are several that a gardener can prepare using ingredients commonly found around the household. Examples of biopesticides include:¹⁷

- Pyrethrins are broad-spectrum insecticides derived from chrysanthemum and often mixed with other compounds for garden use. They are used to control aphids, beetles, cabbage loopers, leafhoppers, mealy bugs, moths, stinkbugs, thrips, white flies and mites, among others (Missouri Botanical Garden n.d.).



Pyrethrins are insecticides that can be harmful to honey bees.

17. This list is intended for information purposes only and not as a recommendation. Always consult technical project staff and/or local agricultural extensionists for advice on the best products to use.

- Bt, or *Bacillus thuringiensis*, is a microbial pest control agent that can be bought in various forms including, “wettable powders, spray concentrates, liquid concentrates, dusts, baits and time-release rings” (University of California San Diego n.d.). Different strains of Bt are used to control specific pests such as caterpillars, moth larvae and some beetles. By using a pest-specific strain, you can avoid harming beneficial insects. It is important to note that Bt must be ingested by the pest to be effective, and it does not work well for adult insects (University of California San Diego n.d.).
- In many countries, homemade biopesticides made with everyday ingredients like garlic, chili, ash and tobacco are common. The use of tobacco oil has been shown to kill potato beetles and limit growth of some bacteria and fungi (American Chemical Society 2010). However, these homemade mixtures may only work to varying degrees.
- Horticultural oils are used to control insects such as scales, aphids, whiteflies and thrips, among others, and fungal pests such as downy, powdery mildew and rust (Pundt 2000). Many horticultural oils are plant-based, but some commercial oils are petroleum-based. Horticultural oils must completely cover insect eggs or the insect body to be effective and work best on soft-bodied or immature insects and eggs (Pundt 2000). Neem oil is a common type of horticultural oil.

Preparation of neem leaves

Neem oil is very difficult to produce at home, so a preparation of neem leaves is a good alternative. Neem comes from the Neem tree *Azadirachta indica*. The leaves of the neem tree have properties that deter pests such as aphids, beetles, thrips and whiteflies (Pundt 2000). A preparation of neem leaves should be applied in advance of an outbreak because it prevents pests.

Typically, the neem leaves are dried and mixed with grain to protect harvested crops, or the leaves can be cut and mixed with water and used as a spray in the field. To make a neem-based pesticide spray:¹⁸

- Pick leaves off the branch and cut them into fine pieces.
- Mix 1 kilogram of leaves with 5 liters of water.
- Leave the water and leaf mixture for one day.
- Filter out the particles and use the liquid that results.

Insecticidal soaps

Insecticidal soaps are not considered biopesticides, but they are low in toxins and a useful tool to combat soft-bodied insects such as spider mites, aphids and white flies, and even the early life stages of fall armyworm. There are a variety of pre-made insecticidal soaps with different trade names that contain the active ingredient potassium salt of fatty acids (Cranshaw 2008). These may not be available in many rural areas in the developing world, so gardeners may also make their own by mixing a small amount of simple soap (1 tablespoon) with water (1 liter).

18. Recipe can be found at <http://scripts.farmradio.fm/radio-resource-packs/package-31/the-comeback-of-quinoa/>

Keep in mind the following when using or making your own insecticidal soap (Trinklein 2016):

- Use simple soaps that do not contain bleach.
- Test the insecticidal soap on a small area of the plant to make sure the mixture does not harm the plant.
- Spray the entire insect. To find the insect, identify where the insects feed and spray that area.
- Apply when it is cooler to avoid burning the plants—either morning or late afternoon.

Step 6: Evaluate results

The final step in IPM is to evaluate the effectiveness of the selected control measures. Gardeners should keep records if possible on what problems they encountered, actions they took, and how well those worked. This will help them improve their IPM strategy in future growing seasons.

Conclusion

IPM depends on multiple strategies to control pests and disease to a manageable level. Combining strategies ensures that chemicals, which are expensive and can be dangerous to humans, are used only as a last resort. The broad concepts within the chapter will help support pest and disease management. Regional resources are available for support in applying these concepts and practices to the local context, such as:

- [*Integrated Pest Management in Vegetable Production: A Guide for Extension Workers in West Africa*](#) (James et al. 2010).
- [*Field Guide: Insect Pests of Selected Vegetables in Tropical and Subtropical Asia*](#). (Parker et al. 1995)

When there is less reliance on chemicals in the garden—whether it be fertilizer or pesticides—the garden can benefit humans by producing a crop that is healthier and more resilient to environmental shocks.

IPM checklist for project designers

- Understand key pest and disease challenges to inform the design of a garden intervention.
- If necessary, budget for disease-resistant varieties and materials for exclusion structures, such as a floating row cover. Identify sources to procure those items.
- Budget for training private sector partners in pesticide application, and for application and protective equipment.
- Ensure that any use or promotion of chemical pesticides will be permitted by donor regulations. Determine if a PERSUAP should be prepared as part of the Initial Environmental Examination (IEE).

IPM checklist for implementers

- Learn what pests and diseases are common.
- Identify key control methods.
- Know what additional resources exist in the project area for IPM support.
- Communicate with local environmental compliance officers regarding any planned use of agro-chemicals.
- Ensure that any project activities, especially those related to use or promotion of chemical pesticides, comply with donor regulations and the approved PERSUAP.

Quiz

1. What are the control mechanisms of integrated pest management?
 - a. Cultural, biological, mechanical and chemical
 - b. Fungicide, insecticide and herbicide
 - c. Knowing the right amount of pesticide to use
 - d. Relying on the grace of God
2. What is a good way to get beneficial insects in your garden?
 - a. Spray a sugar solution
 - b. Plant flowers that attract insects
 - c. Make a living fence
 - d. Avoid the use of insecticides
 - e. All of the above except "a"
3. Insecticides may only be purchased at the store and may never be made in the home.
 - a. True
 - b. False

Activity

Using an existing or upcoming project, identify the common pests and diseases that could affect garden crops to be promoted. Identify ways to support gardeners in preventing these common pests and diseases.

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Chapter 10: Water Resources

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Learning objectives

After studying this chapter and its resources, you will know how to:

- Better manage water resources for garden planning and implementation.
- Design gardens that address the level of water availability.
- Select crops based on the access and availability to water resources.

Key messages

- Water is a critical element in designing and sustaining any garden.
- Crops' water needs are based on climate, growth stage and crop type.
- Water availability and accessibility influence what crops gardeners can plant and when.
- Garden type affects water retention.
- There are several low-cost approaches for watering gardens.

Key questions for decision-making

- What water management strategies will the project promote for its garden intervention?
- What strategies will the project use to ensure equitable participation of men and women in community-level water decisions that affect gardens?

Water resources are critical for gardening

Water is a required and essential element in gardening, and lack of access to water is a common barrier to successful gardens. Therefore, water availability must be considered when designing a garden and selecting the appropriate garden type, location and diverse/nutritious crops to plant. Improved water resource management can dramatically increase production of the garden. With climate change significantly impacting water resources spatially (*where* rain falls) and temporally (*when* rain falls), gardeners need to adapt to these changing rainfall patterns to ensure water is available and accessible to their gardens.

Lack of access to water is a common barrier to successful gardens.



Sources of water for gardens

The creation of a garden is possible when water resources are available and accessible near the household. While rainfall is often the primary source of water, close proximity to other water resources allows for easier water collection and transport to the gardens when supplemental water is needed. There are several sources of water for gardens: rainwater, groundwater, surface water and reclaimed water (CDC 2016).

- **Rainwater** is precipitation that falls from clouds and infiltrates the ground, evaporates or runs off the soil into a water body (e.g., stream, lake or ocean). Most gardeners rely on rainwater for crop watering.
- **Groundwater** is the water found underground. Depending on the type of underground formation, groundwater can be accessed with a well or collected at a spring.
- **Surface water** is water on the surface of the planet such as in streams, rivers, lakes, wetlands and oceans.
- **Reclaimed water** is recycled water converted from wastewater into water that can be reused for other purposes.

Approaches for accessing water

There are many ways gardeners can access water to support their gardens, such as wells, rainwater catchment systems, protective berm and swale systems, and greywater use. If there is a drinking water system but not a crop-watering system in the community, some of this water may be diverted to crop production and reduce what is available to meet homestead domestic needs. In cases where this drinking water is treated (e.g., with chlorine), the treatment itself can have an adverse effect on the gardens. Conversely, if there is not a drinking water supply, water for crop watering is sometimes used for drinking. Unless treated, these sources of water may cause illness if consumed.

Wells

Wells are shafts that penetrate the ground to access groundwater. There are two types: small diameter and large diameter.

- Small diameter wells—also called tube wells, bore wells or boreholes—are generally 15 to 30 centimeters (6–12 inches) in diameter. They are usually machine-drilled or hand-augured. The practical maximum depth for accessing water (without a motorized pump) is 150 meters (500 feet), because pumping by hand is very difficult at this depth. The borehole is usually cased with polyvinyl chloride (PVC) piping to prevent collapsing (Uhl 2009).

Wells are shafts that penetrate the ground to access groundwater.



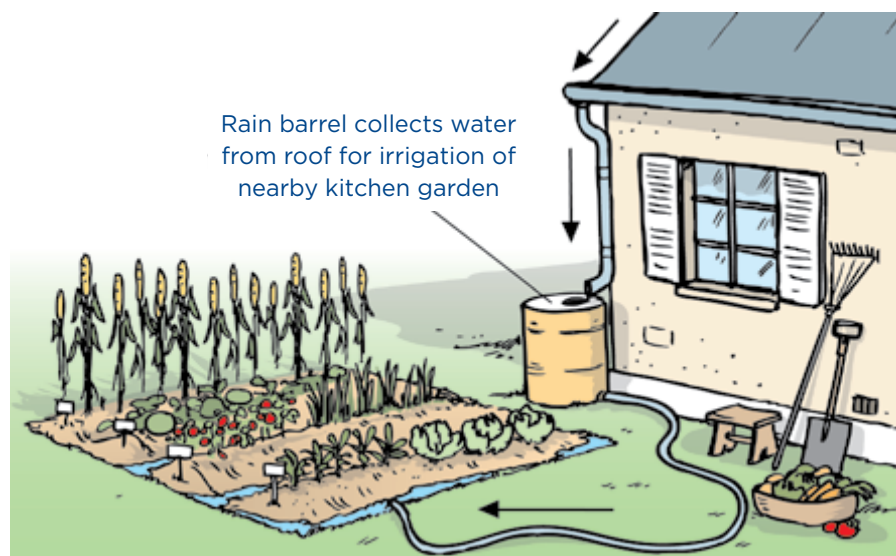
- Large diameter wells are typically 1 to 3 meters (3-10 feet) in diameter, can be up to 60 meters (200 feet) in depth, and are usually dug by hand. In soft soils, they should be lined with stones, brick or concrete rings to prevent collapsing. No lining is needed in strong soils or rock (Uhl 2009).

All wells should be covered, to prevent surface contamination from entering the well, and fitted with a pump to extract the water. Pumps can be powered by hand, foot, suction, wind or motor. Electricity can come from a generator, electric power lines or solar-powered collection systems. Buckets or other such containers lowered by rope are typically used to collect water from open hand-dug wells and these can increase the chance of groundwater contamination if not properly stored between uses (Uhl 2009). Boreholes are typically fitted with a pump. An apron and spillway should be constructed around the well to carry wastewater (i.e., water on the apron from splashing, washing containers or any other water that is discarded) away from site. This wastewater could be channeled to a garden area if chemicals or fresh manure are not in the wastewater. To learn more, read CRS' [Groundwater Development: Basic Concepts for Expanding CRS Water Programs](#).

Rainwater catchment systems

Rainwater can be captured off of an impermeable surface, such as the ground, through a natural drainage channel or paved surface, or rooftop where corrugated iron is used. Ground catchment systems are relatively larger in space and typically use in-ground ponds or reservoirs to store water, which are generally not near homesteads. For the purposes of this guidance document, rooftop rainwater collection systems (Figure 1) are more practical for gardening since the gardens are likely to be constructed close to homes.

Figure 1: Example of a rooftop rainwater catchment system



Source: (Burpee et al. 2015)

A rooftop rainwater harvesting system consists of three basic elements:

1. Collection area
2. Conveyance system
3. Storage facilities

The collection area is usually the roof of a house or building. The roofing material affects the efficiency of water collection (i.e., the amount of rainwater lost through bouncing off the catchment surface) as well as water quality. Nontoxic material should be used. Vegetation should not hang over the roof as it prevents rainwater from falling on the roof (Caldwell 2017).

After rainwater is collected on the roof, it drains into a gutter system, which directs the water to a storage tank typically made of or lined with concrete or plastic. The storage tank is constructed either above or below ground, and must be covered to avoid contamination and prevent the creation of mosquito breeding grounds. The storage volume is dependent on the water supply (i.e., amount of rainfall expected and collection area size) and the water demand (i.e., water uses). In above-ground tanks, a faucet can be installed just above the base of the storage tank for filling watering containers or other devices.

A well-engineered rainwater harvesting system will be sized to meet the water demands of the dry season when rainfall is not sufficient to meet the crops' growing needs. The storage tank should be checked periodically to ensure there is no build-up of debris, including algal growth. For more information on rainwater catchment systems, read CRS' [Best Practices in Water and Sanitation](#) guidance document, and [Preparing Smallholder Farm Families to Adapt to Climate Change: Pocket Guide 3; Managing Water Resources](#).

Protective berm and swale system

Swales and berms have been used for centuries to control the flow of water across land. Together they form a system to capture, divert and store excess water, during periods when rain falls too quickly, for later use. Berms are raised mounds used to redirect water. Swales are shallow channels in the ground designed to encourage the accumulation of rainwater during storms and hold it for a few hours or days to let it infiltrate the soil. Larger swales are ideally tree-lined and store water for the immediate landscape as well as help cleanse the water as it percolates into the ground. Swales can be installed separately or as part of a larger rainwater ground catchment system including cisterns, water smart agricultural techniques (i.e., planting techniques aimed at increasing soil moisture by causing water to infiltrate and remain in soil) and underground dams. Swales and berms are some of the least expensive and easiest water control and storage methods and can be installed almost anywhere; on their own, however, they may be insufficient to soften the impact of storms and protect crops from the full force of flooding. When installing berms and swales, be sure to comply with any environmental regulations and approvals from the donor.

Greywater

Greywater is relatively clean wastewater produced from bathing, cooking and clothes-washing that is not contaminated with feces. While cleaning products containing ammonia are safe to use (plants can extract the nitrogen), greywater containing other toxic materials such as bleaches, bath (sodium) salts, artificial dyes, chlorine-based cleansers, strong acids or solvents cannot be used.

Some guidance on using and maintaining greywater that is drawn from [Greywater Action](#) is listed below.

1. Use simple systems that do not use pumps or filters.
2. Given pathogens in greywater, do not let it touch a person's skin. Hands should be washed after applying greywater.
3. Because diapers contain feces, water used to wash them should not be used as greywater.
4. Apply greywater to the soil and not directly on plants to avoid contamination of leaves, vegetables and/or fruit that will be consumed.
5. Pour the greywater instead of spraying to avoid inhaling contaminants.
6. Pour sufficient greywater to water plants but do not let water pool or run off.
7. Do not store greywater for more than 24 hours or it will start to smell
8. Although greywater is safe to use following these recommendations, it is important to understand any taboos that may impede its use for gardening by your target audience.

More information about greywater reuse is available from [Greywater Action](#).

Soil moisture management

Soil moisture, critical to plant growth and survival, can be managed in several ways. These include the type of garden constructed, and the soil and water conservation activities practiced at farm scale. To learn more about soil and water conservation, see Chapter 8 on Integrated Soil Health Management.

Garden types and water efficiency

Keyhole and vertical gardens are two types of gardens that are designed for the easy application of water and efficient water use. The permagarden is another garden type that conserves water. As described in Chapter 3, it uses swales and berms to manage rainwater in the garden. The berms stop or slow the rainwater and allow it to collect in the swales, allowing the formerly uncontrolled runoff to slowly sink into the subsoil. The recharging of the subsoil moisture then moves back into the root zone during the subsequent dry season. The topsoil may appear dry, but digging 30 centimeters (12 inches) down will reveal a deeply moist layer.

Soil moisture management in the face of climate change

The various land-use practices aimed at managing water resources and improving and maintaining soil moisture assist gardeners to adapt to the effects of climate change. For instance, in wet areas, use of raised beds and drainage channels can alleviate the saturation of soils (e.g., overwatering) when there is too much rain. When there is little or no rain, mulching, cover crops, minimum tillage and soil fertility management can increase the infiltration of rainfall into the soil. Mulching and cover crops increase the soil's capacity to hold moisture in the topsoil and decrease water loss from the soil surface through evaporation. Minimum tillage techniques, which minimize the disruption of the soil structure, and the use of the aforementioned drip irrigation systems and household greywater, help to conserve overall water resources.

More detail on soil moisture management can be found in Chapter 8 on Integrated Soil Health Management and Chapter 3 in [Pocket Guide 3: Managing Water Resources](#) (Burpee et al. 2015).

Selecting crops to align with water availability

The amount of water required for gardens varies as a function of crop and soil type, seasonality and the climate where the crops are grown (Spuhler and Carle 2018). When the correct crop is selected for the given soil conditions and climate, yields may be optimized and water requirements minimized. The main three factors that define crop water needs are:

- 1. Climate:** The amount of water crops need depends on the climate (i.e., temperature patterns, precipitation and humidity). In a cloudy and cool climate, crops need less water each day than in a sunny and hot climate (Table 1).

Table 1. Effect of major climatic factors on crop water needs

Climatic factor	Crop water need	
	High	Low
Sunshine	Sunny (no clouds)	Cloudy (no sun)
Temperature	Hot	Cool
Humidity	Low (dry)	High (humid)
Wind speed	Windy	Little wind

Source: Brouwer and Heibloem 1986

- 2. Crop type:** The amount of water needed varies depending on the crop. Some crops, such as tomatoes, need more water than other crops, such as beans. The approximate amount of seasonal crop water needed is shown in Table 2. It is important to administer the proper amount of water per crop since either over- or underwatering can damage the plant, making it more susceptible to disease.

Table 2. Average water needs for selected crops

Crop	Crop water need (mm/ total growing period)	Crop	Crop water need (mm/ total growing period)
Alfalfa	800-1600	Banana	1,200-2,200
Barley/Oats/Wheat	450-650	Bean	300-500
Cabbage	350-500	Citrus	900-1,200
Cotton	700-1,300	Maize	500-800
Melon	400-600	Onion	350-550
Peanut	500-700	Pea	350-500
Pepper	600-900	Potato	500-700
Rice	450-700	Sorghum	450-650
Soybean	450-700	Sugarcane	1,500-2,500
Sunflower	600-1,000	Tomato	400-800

Source: Brouwer and Heibloem 1986

For more information on crop type, read:

- [Crop Selection](#) (Spuhler and Carle 2004)
- [A Manual for the Design and Construction of Water Harvesting Schemes for Plant Production](#) (FAO 1991)

3. Growth stage: During each growth stage, a plant needs different amounts of water. From the crop development stage, the water requirement gradually increases until the end of the crop development stage (Spuhler and Carle 2018). Typically, 50% of the water is needed when the crop is flowering and beginning to fruit. Fresh-harvested crops, such as lettuce and cabbage, need the same amount of water during the late season stage as during the mid-season stage. See Table 3 for details on critical growth stages for certain crops and signs of water stress.

Table 3: Critical growth stages for major crops

Crop	Critical period	Water stress symptoms	Other considerations
Beans	Flowering through pod formation	Wilting	Yields are reduced if water is insufficient at bloom or fruit-set stages; sensitive to over-irrigation
Corn	Tasseling, silk stage until kernels become firm	Leaves curl by mid-morning, darkening color	Needs adequate water from germination to dent stage for maximum production
Sugar beets	Post-thinning	Leaves wilt during heat of the day	Excessive full irrigation lowers sugar content
Potatoes	Tuber formation to harvest	Wilting during the heat of the day	Water stress during critical period may cause cracking of tubers
Onions	Bulb formation	Wilting	Keep soil wet during bulb formation and dry near harvest
Tomatoes	After fruit set	Wilting	Wilt and leaf rolling can be caused by disease
Fruit trees	Any point during growing season	Dulling of leaf color and drooping of growing points	Stone fruits are sensitive to water stress during last two weeks prior to harvest

This table is a compilation of information from two sources: Al-Kaisi et al. 2014 and USDA 1997.

Watering your garden

Various watering or irrigating technologies can be used in gardens. The most cost-appropriate, durable and easy-to-use technologies are hand watering, clay pot/pitcher irrigation, bottle irrigation, and drip irrigation kits.

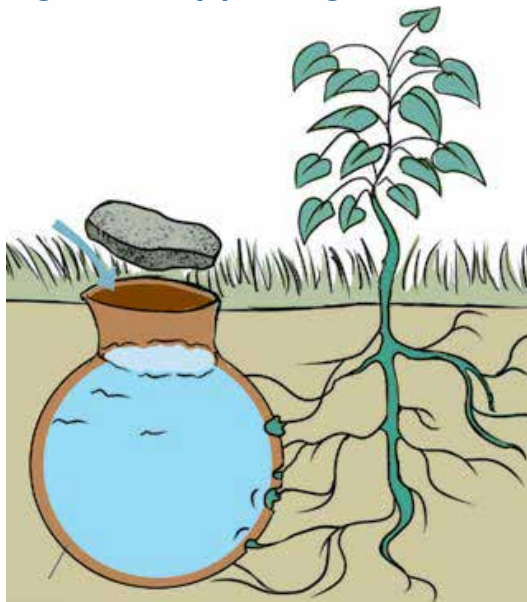


Hand watering in Sierra Leone.
Photo by Eric Clayton/CRS

Hand watering: Hand watering is performed by filling a container with water and gently pouring it at the base of the crops. The container can be a bucket, a watering can with sprinkler head, a plastic bottle with holes in the lid, or other similar containers that can hold water and be easily poured.

Clay pot irrigation: In dry areas, locally made, unglazed porous clay pots can be buried in the garden to help irrigate the crops. The pot is buried up to its neck, filled with water and covered to prevent evaporation. When the crop needs water, its roots suck water from the pot. The clay pot can water crops that are 45 centimeters (18 inches) from the pot. For most crops, a clay pot that is 10 inches in diameter is sufficient, but for crops that are heavy water users, larger clay pots are needed. Check the clay pot regularly for water; when it is half-empty, refill it to avoid calcification.

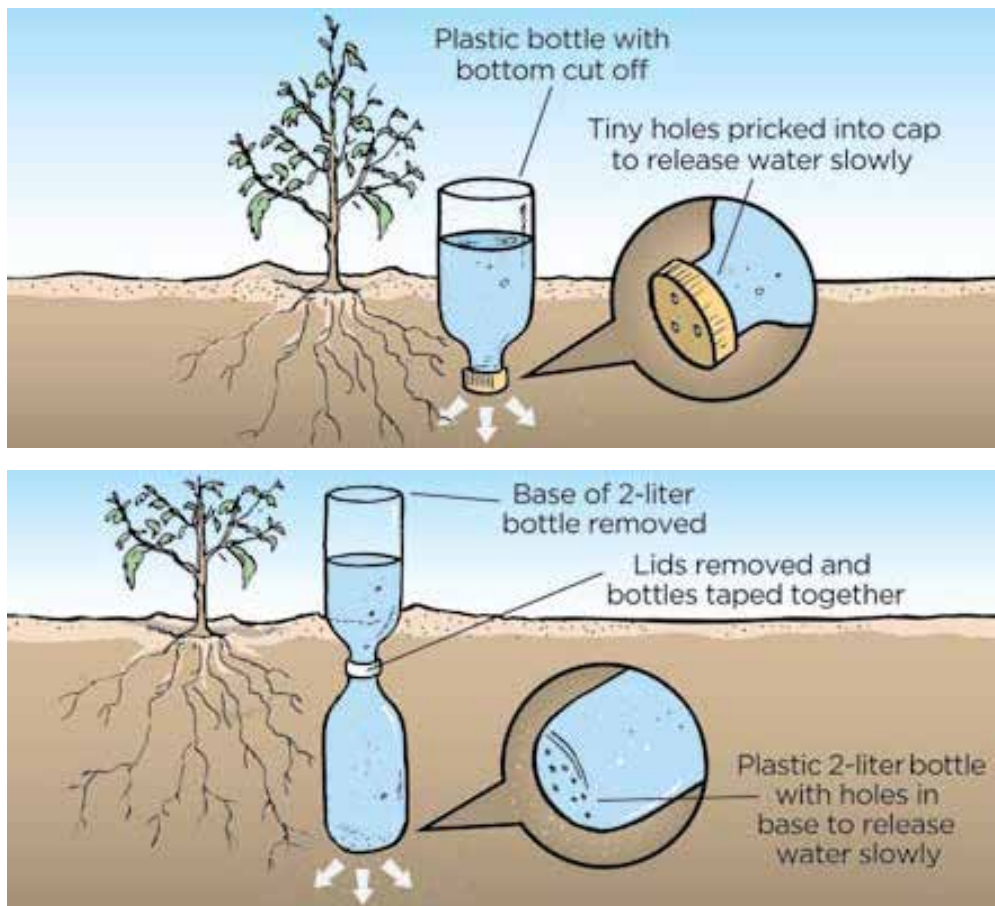
Figure 2: Clay pot irrigation



Source: Burpee et al. 2015

Bottle irrigation: This is a similar technique. A plastic bottle (with a cap in which small holes have been punched) is filled with water. Insert the bottle into the ground at an angle. Refill as needed. To learn more about clay pots and bottle feeding see [Review Paper on 'Garden Kits' in Africa](#) (Merrey and Langan 2014) and the CRS' [Pocket Guide 3; Managing Water Resources](#) (Burpee et al. 2015).

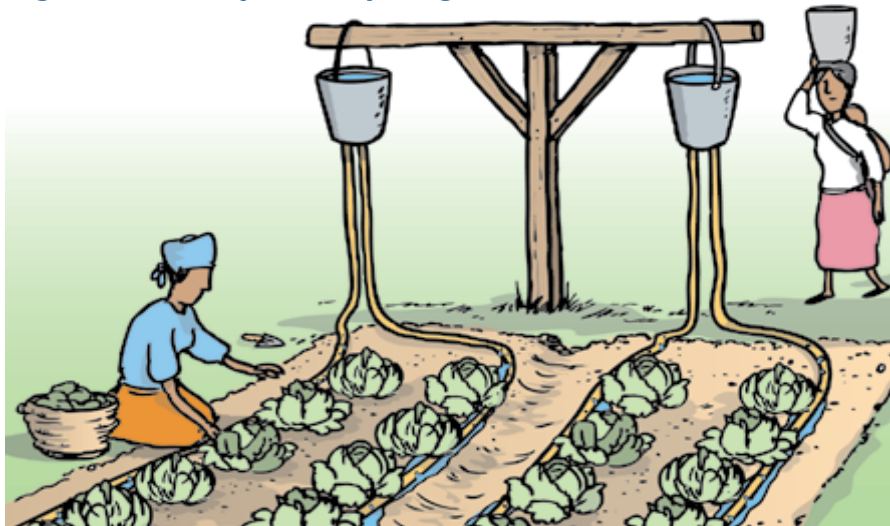
Figure 3: Bottle irrigation



Source: Burpee et al. 2015

Low-cost drip irrigation kits: These irrigation kits use hoses or other material with holes to provide water directly to plant roots (see the CRS [Pocket Guide 3: Managing Water Resources](#)). The lines are laid on the ground near the plants and water seeps through the holes. Drip Irrigation increases soil moisture while decreasing evaporation. There are several simple, low-cost drip-irrigation kits for gardens. The gravity-fed kits have water stored above the area that needs to be irrigated. Gravity rather than electric pumps pulls the water down to the garden (Figure 4).

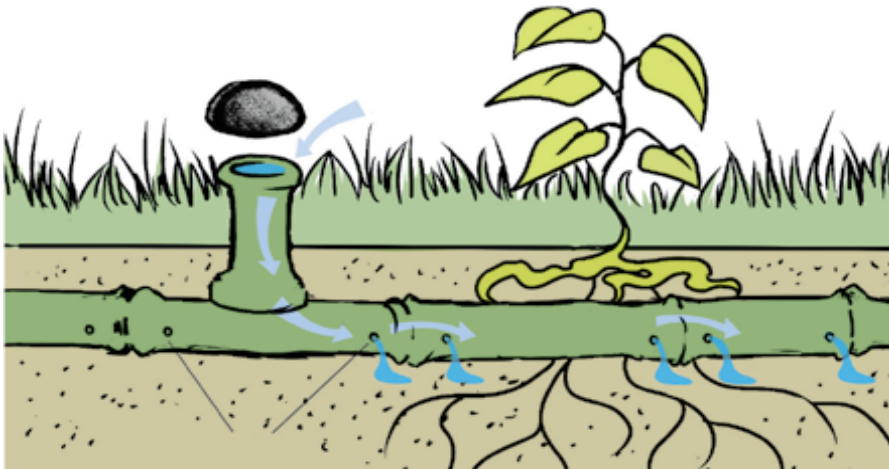
Figure 4: Gravity-fed drip irrigation



Source: Burpee et al. 2015

Bamboo irrigation uses buried bamboo sticks that have small holes punched into them.

Figure 5: Bamboo irrigation system



Source: Burpee et al. 2015

Although drip irrigation kits are efficient at applying water and are easy to use, they may be high-maintenance: the drip holes can clog easily with minerals or debris in the water, plastic left in the sun will weaken over time and become brittle, and the hoses become susceptible to cracking and often require replacement each season. If drip irrigation systems are to be employed, ensure that spare parts are locally available and affordable.

For more information on drip irrigation, read the following technical references:

- [Pocket Guide 3: Managing Water Resources](#) (Burpee et al. 2015)
- [Review Paper on 'Garden Kits' in Africa](#) (Merrey and Langan 2014)
- [Drip Irrigation](#) (Stauffer 2018)
- [Water harvesting and conservation Volume 1](#) (Denison 2011a) and [Volume 2](#) (Denison et al. 2011b)
- [More Crop Per Drop—Using Simple Drip Irrigation Systems for Small-scale Vegetable Production](#) (Palada et al. 2011)

Gender and cultural issues around water resources management

In most developing countries, men make most decisions about water resources management at both local and national levels (UNDP et al. 2006). Although water is typically a public commodity, its use is often associated with land ownership, permits, concessions or other systems of tenure. Women are often disadvantaged if they do not own land. They may work on the farm and may help manage it, but they do not have legal or de facto ownership of it or over other natural resources on it, including water. While women and girls are responsible for collecting and using water for household purposes, most women are rarely in charge of managing water resources or having influence on household financial and community decisions, which impacts access to infrastructure and services that women would benefit from in accessing and delivering water. These types of access and ownership issues related to land need to be better recognized by all stakeholders when considering systems for accessing water.

When considering the community management of their water supply system (i.e., drinking water or irrigation), there should be equal male and female representation on water management committees, with women holding key decision-making positions. This empowers women, and allows for more equitable water-user perspectives to be considered and more equitable access/management of water resources, economic development and environmental sustainability.

Water supply projects often bring new resources (e.g., training, tools and technology), but without specific attention to gender issues, they can reinforce inequalities between women and men and even increase gender disparities. With respect to gardens, projects need to understand gender power dynamics and enable both women and men to benefit equally from water initiatives.

The United Nations Development Programme ([UNDP et al. 2006](#)) suggests four key components for operationalizing gender mainstreaming within water resources for gardening:

1. Gender-differentiated access to resources, labor, water uses, water rights, benefits and production
2. Gender relations including differences, inequalities and power imbalances between and among women and men as it relates to water resources
3. Gender dimensions of institutions relevant to water resources
4. Gender dynamics influence how people respond as individuals and groups as they face different obstacles and have access to different resources

To learn more about water and gender, see Chapter 5 on Gender Integration and read the following resources:

- [Resource Guide: Mainstreaming Gender in Water Management](#) (UNDP, GWA, IRC, Cap-Net and GWP 2006)
- [Passport to Mainstreaming Gender in Water Programmes: Key Questions for Interventions in the Agricultural Sector](#) (FAO 2012)

Conclusion

Gardens will likely thrive if water resources are well managed. Applying certain effective water management technologies and practices as mentioned in this chapter—greywater, rainfall and effective irrigation systems—can make key improvements to crop production at the homestead level. To have a sustainable and effective garden, crop selection must align with water availability and water needs, which are determined by climate, growth stage and crop type. Gardeners in low-resource settings can be affected by global climate change and lack of water for irrigation. We need to prepare gardeners with certain practices that can be used to adapt to the dry seasons and climate change.

Quiz

1. Name three ways for a gardener to water their crops.
2. True or false: For each growth stage a plant needs the same amount of water.
3. What factors influence the amount of water required for a healthy garden?
 - a. Crop type
 - b. Soil type
 - c. Seasonality
 - d. Climate
 - e. All the above

Activity

Using an existing or upcoming project, outline what water strategies should be considered and why? What additional information do we need in order to refine the water strategies for this project zone?

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Chapter 11: Postharvest Handling

Lisa Kitinoja, President, Postharvest Education Foundation

Learning objectives

After studying this chapter and its resources, you will know how to:

- Identify each of the links in the postharvest chain as vegetables move from the garden to storage, consumption, processing and/or the market.
- Identify the major causes and sources of postharvest losses for vegetables produced in gardens.
- Understand some of the best practices recommended for harvesting, postharvest handling, curing and/or cooling vegetable crops.
- Understand the options that are available for home storage and/or processing vegetables.

Key messages

- **Vegetables are not all the same:** Vegetables come in a wide variety of types, including leaves, stems, roots, tubers and bulbs (onions), immature flowers (cauliflower), immature fruits (cucumbers and green peppers) or mature fruits (tomatoes and pumpkins).
- **Vegetable quality is best at harvest time:** Postharvest practices or home storage cannot improve vegetable quality, so crops must be harvested at the proper stage for optimum quality, shelf life and good nutritional value.
- **Postharvest handling can be simple and inexpensive:** Low-cost, simple postharvest handling practices can be used by gardeners to maintain quality, freshness and market value.
- **Storage and home-scale processing can be simple and inexpensive:** There are simple, low-cost storage options and/or home-scale processing methods that gardeners can use to preserve vegetables, extend shelf life and maintain nutritional value.
- **Gardeners' capacity:** Postharvest practices and technologies must be better understood by gardeners so they can be used properly to reduce food losses and ensure safe food.

Key questions for decision-making

- What postharvest practices will be promoted?
- How will the project support the selected postharvest practices?
- How will the project address gender issues related to postharvest handling, such as workload and access to technologies and resources?

Postharvest handling is important for gardens

The postharvest chain for vegetables is composed of many components, each of which may experience postharvest losses. Therefore, effective management during the postharvest period is important for:

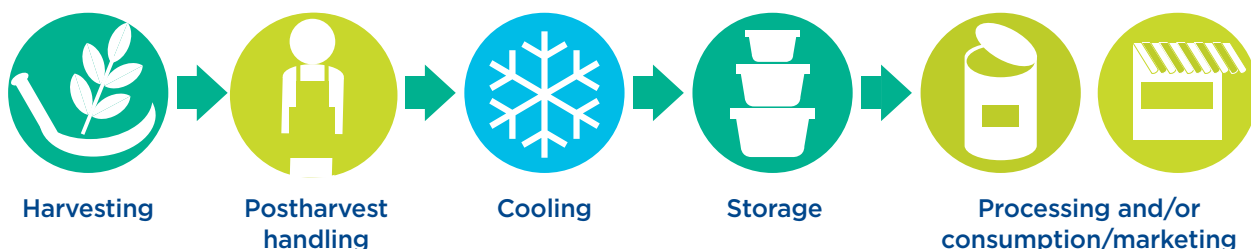
1. Maintaining quality (appearance, texture, flavor and nutritive value)
2. Ensuring food safety
3. Reducing postharvest losses between harvest and consumption
4. Increasing storage life
5. Maintaining and/or adding market value

Although gardeners and small-scale vegetable handlers face many constraints—such as the use of manual labor; lack of credit for investments in postharvest tools and supplies; unreliable or expensive electric power supply; and lack of transport options, storage facilities and/or packaging materials—there is a wide range of simple postharvest handling practices and inexpensive technologies that have successfully been used to reduce losses and maintain the quality of vegetable crops in various parts of the world.

Postharvest chain

The steps or links in a postharvest chain for the gardener include harvesting, postharvest handling, cooling, storage and/or processing and consumption or marketing. This chapter provides detailed information specific to vegetable crops for each of these links, to help get the best results.

Figure 1: Key links in the postharvest chain

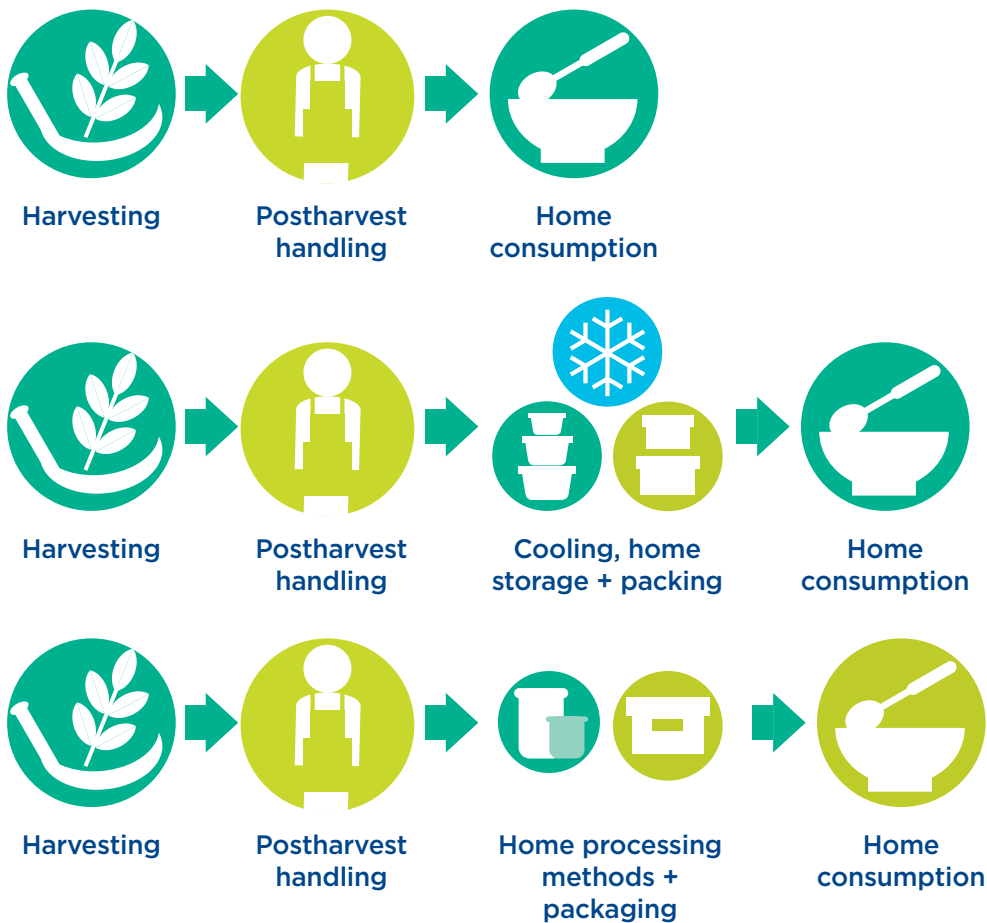


Management considerations around the postharvest chain

Gardeners have many options for the use or destination of their harvested vegetables, so it is good to understand the management considerations for these different options. One option is to consume the vegetables immediately after harvesting. This may be the case for many seasonal vegetables that are a regular part of the local cuisine. Examples include leafy greens, okra and tomatoes. The second option is to store vegetables for later consumption. This may be the case when regularly consumed vegetables have a short harvest window (they mature all at once), a relatively long shelf life, and can be kept safely in cool storage. Examples are carrots, onions, pumpkins and potatoes. A third option is to process vegetables for later consumption. When vegetables are very delicate or have a very short shelf life and/or there is surplus produce being harvested, the extra produce can be dried or otherwise processed to store as a shelf-stable food product for later home consumption. Examples include higher-value produce such as green beans, peas and any fruit grown in gardens (i.e. berries, mangos and papaya).

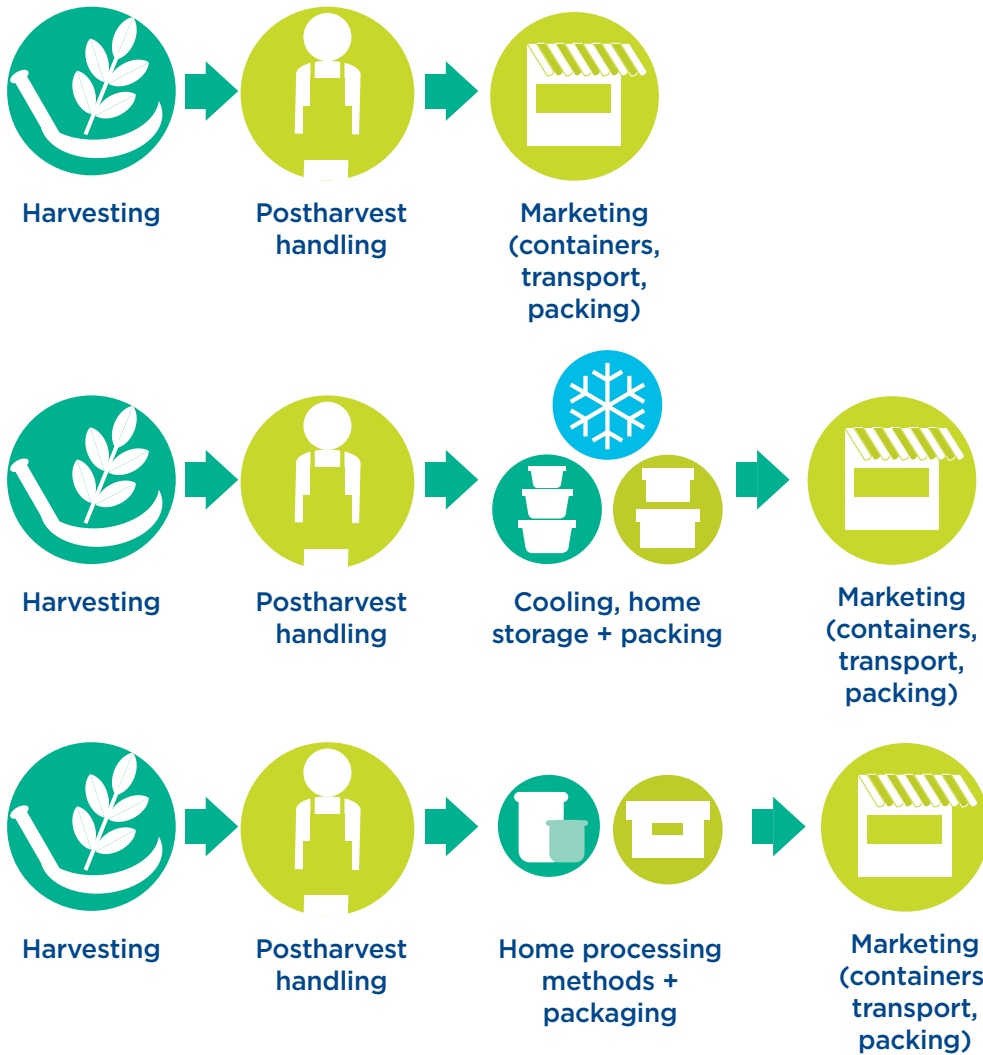
Figures 2 and 3 illustrate the management considerations for home consumption versus selling vegetables in the market respectively. When gardeners produce vegetables only for home use and consumption, they can eat directly from the garden (shown in the top level of Figure 2), or they can store their fresh vegetables (middle level) or preserve their vegetables (bottom level) by processing and packaging the food products for later consumption.

Figure 2: Management considerations in the garden-to-home-consumption postharvest chain



When gardeners produce vegetables only for sale to others, they can market directly from the garden (shown in the top level of Figure 3), or they can harvest and store their fresh vegetables (middle level), or preserve their vegetables (bottom level) by processing and packaging the food products for later sale.

Figure 3: Management considerations in the garden-to-market postharvest chain



Gardeners need to plan ahead when deciding what and how much produce to grow each season for home consumption and market sales. The extra vegetables grown for sale should be those that are in demand from potential customers at least at the local market.

Causes and sources of postharvest losses

There are many different types of postharvest problems that occur in vegetables, all of which lead to losses (Table 1). The most commonly experienced problems can be readily observed when looking at the vegetables. These include **water loss** (due to handling or storage at too high temperatures or in low relative humidity environments), **mechanical damage** (caused by rough handling) and **physical damage** (from attacks by pests and physiological disorders). Most of these can be managed or eliminated by using proper postharvest practices. Other problems are hidden, such as nutritional losses, but they also will be minimized by proper postharvest handling and cool storage.

Table 1: Ten types of postharvest problems that contribute to food losses in vegetables

Postharvest problem	Description
Water loss (weight loss)	Shriveling or wilting of vegetables
Water loss (loss of textural quality)	Softening, limpness, loss of crispiness or juiciness
Mechanical damage	Bruises, cuts, surface abrasions or crushing
Physical losses due to pests	Fungal and bacterial diseases, insect attack
Contamination	Soil, pathogenic bacteria (soil-borne disease), pesticide and chemical residues
Losses from physiological disorders due to temperature	Chilling injury, freezing injury, heat injury, sunburn
Losses from physiological disorders due to nutrient imbalances	Calcium deficiency (blossom end rot), boron toxicity
Losses from physiological disorders due to atmospheric gases	Damage from ethylene (russet spotting, softening, induced browning), low oxygen, high carbon dioxide, or refrigerant gas leaks (ammonia)
Losses due to continued growth and development after harvest	Rooting, sprouting, shoot development, elongation and curvature of asparagus, greening of potatoes, fiber development, compositional changes (loss of color, flavor, firmness)
Nutritional losses	Loss of stored carbohydrates and vitamin C

Source: Kitinoja and Kader 2015.

Different types of vegetables experience different kinds of postharvest losses. The major causes of losses are listed for each type of vegetable in Table 2. For root, tuber and bulb vegetables, the primary cause of postharvest losses and poor quality are rough harvest practices that damage the vegetables during digging. For leafy vegetables, the primary cause of postharvest losses is water loss, which leads to wilting. Over-maturity, as listed below, could result from women having to delay the harvesting of their garden because of workload or other commitments to their male partner's fields.

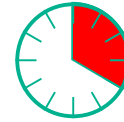
Table 2: Major causes and sources of postharvest losses and poor quality, by vegetable type

Group	Examples	Causes (in order of importance)		
Root, tuber and bulb vegetables	Carrots Beets Onions Garlic Cassava Cocoyam Yam Potato Sweet potato Taro	Mechanical injuries		
		Improper curing		
		Sprouting and rooting		
		Water loss (shriveling)		
		Decay		
		Chilling injury (subtropical and tropical root crops)		
		Leafy vegetables	Lettuce Chard Spinach Amaranth Cabbage Green onions Jute mallow Spider plant	Water loss (wilting)
				Loss of green color (yellowing)
Mechanical injuries				
Relatively high respiration rates				
Decay				
Flower vegetables	Artichokes Broccoli Cauliflower			Mechanical injuries
				Yellowing and other discolorations
		Shedding of florets		
		Decay		
Immature-fruit vegetables	Cucumbers Squash Eggplant Peppers Okra Snap beans	Over-maturity at harvest		
		Water loss (shriveling)		
		Bruising and other mechanical injuries		
		Chilling injury		
		Decay		
Mature-fruit vegetables	Tomato Melons Pumpkins	Bruising		
		Overripening and excessive softening at harvest		
		Water loss		
		Chilling injury (chilling sensitive fruits)		
		Compositional changes		
		Decay		

Source: Modified from Kitinoja and Kader 2015.

Women’s time burden and postharvest losses

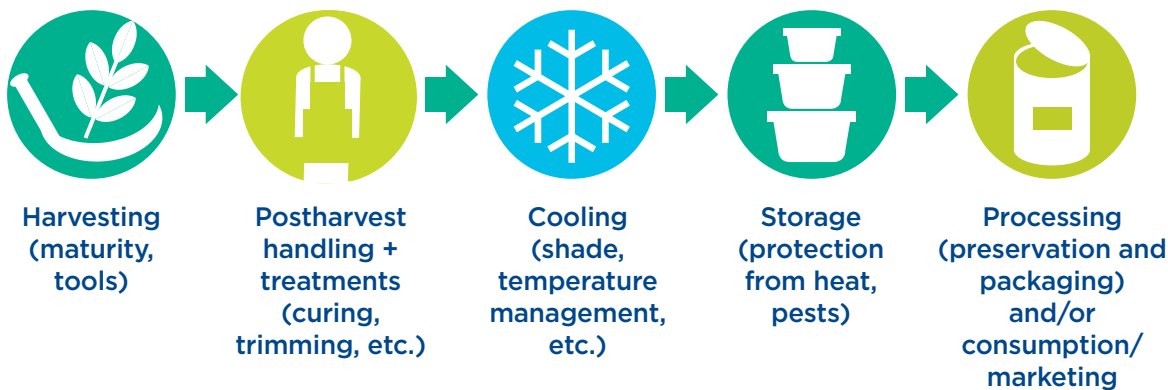
Women are often responsible for postharvest work, particularly for the foods that their family eats from a garden. Postharvest handling work is often time- and labor-intensive, particularly when done manually. Women’s childcare responsibilities have been shown to contribute to postharvest losses of perishables because women have less control over the time when they can harvest fruit and vegetables due to their household demands (World Bank et al. 2009). Access to technologies, such as shelling machines, could reduce their workload. While these machines are often too expensive for individual households to own, farmers’ groups or other associations could buy the machines collectively and make them accessible to the community. Measures need to be put in place to ensure they have ready access and can maintain control over the technology so that it is not taken over by others in the household with greater bargaining power.



Recommended postharvest practices for gardeners

The following section provides examples of harvesting and postharvest handling, cooling, storage and processing practices that will help gardeners protect quality, minimize losses and increase the shelf life of their vegetables. Postharvest handling includes activities or best practices, such as the use of shade, clean sturdy containers and other postharvest treatments (Figure 4).

Figure 4: Activities in the postharvest chain



Harvesting

Determining appropriate maturity for ensuring quality and shelf life

The decision of when to harvest often depends on whether the vegetable crop is being grown for immediate home consumption, for processing or for sale. Vegetables are also harvested over a wide range of maturities, depending on the part of the plant used as food. Vegetables show specific signs of maturity, indicating they are ready to be harvested. Some vegetables continue to ripen after harvest (e.g., tomatoes and cucumbers), while others become dormant and can be stored for long periods (e.g., potatoes and onions). Generally, if everything is harvested at once, there will be many items that are either under-mature or over-mature. Harvesting vegetables **too early** will provide edible food, but the crop will be smaller in size, lower in weight and more perishable (e.g., green beans, peas, okra and carrots). Harvesting **too late** will provide edible food, but the vegetables may be large and pithy (fibrous), less flavorful (e.g., sweet corn), or too full of seeds for good eating quality (e.g., cucumbers, summer squash, eggplant and okra). Using a maturity index as a standard for the best time to harvest will greatly improve quality and can reduce losses (Table 3).



Example of different harvest times for the same vegetable

Tomatoes grown for home consumption or processing can be harvested at the red ripe stage, when they are soft, flavorful and ready to eat. However, if tomatoes are being grown to sell at a local market, they should be harvested a few days before they are fully ripe. And if they are being grown to sell at a distant market, they should be harvested much earlier, when they are just starting to show color and up until they are light pink. These tomatoes will be firm to the touch, but they will slowly continue to ripen during the transport and marketing period and will become fully red ripe by the time they reach the consumer’s home.

Table 3: Examples of maturity indices of select vegetable crops

If the vegetable you are growing is not listed, find more information in the [USDA Agriculture Handbook 66](#) and on the University of California, Davis [Postharvest Center](#) website (available in English, Spanish, French and Arabic).

Vegetable crop	Maturity index
Root, bulb and tuber crops	
Radish and carrot	Large enough* and crispy
Potato, onion and garlic	Tops beginning to dry out and topple down
Yam, bean and ginger	Large enough
Green onion	Leaves at their broadest and longest
Cowpea, yard-long bean, snap bean, sweet pea and winged bean	Well-filled pods that snap readily
Lima bean and pigeon pea	Well-filled pods that are beginning to lose their greenness
Fruit vegetables	
Okra	Desirable size reached and tips can be easily snapped
Snake gourd and dishrag gourd	Desirable size reached and thumbnail can penetrate flesh readily
Eggplant, bitter melon, chayote or slicing cucumber	Desirable size reached but still tender
Sweet corn	Exudes milky sap from kernel if cut
Tomato	Seeds slip when mature green fruit is cut, or green skin color turns pink
Sweet pepper	Deep green color turns dull or red
Muskmelon	Easily separated from vine with a slight twist, leaving clean stem cavity
Honeydew melon	Change in fruit color from a slight greenish-white to cream, aroma noticeable
Watermelon	Color of lower part turns creamy yellow, dull hollow sound when thumped
Flower vegetables	
Cauliflower	Curd compact
Broccoli	Bud cluster compact
Leafy vegetables	
Lettuce	Big enough before flowering
Cabbage	Head compact
Celery	Big enough before it becomes pithy
Spinach***	Rosette with 5 or 6 leaves

* Cultural differences, options for uses (in fresh salads versus cooked foods), and consumer preferences will guide the decision of when a vegetable is large enough to harvest.
 ** Modified from Bautista and Mabesa 1977
 *** Grant 2018

Harvesting practices

Best practices for harvesting vegetables from the garden include:

- Harvesting early in the morning when it is cooler
- Letting dew dry off in the morning before harvesting if crops are susceptible to fungal diseases (e.g., green beans and peppers)
- Using sharp, clean tools for harvest and trimming processes
- Removing any vegetables that are diseased or damaged and disposing of them away from the garden site
- Using a wearable picking bag or harvesting sack to reduce the damage to fresh vegetables during the harvest

Wearable picking bags

These harvesting aids can be made by sewing bags with openings on both ends and adding shoulder straps, fitting fabric over the open bottom of a ready-made bucket, fitting bags with adjustable harnesses, or by simply adding an open pouch to an apron. Picking bags should be kept clean and washed between uses.

Right: Wearable picking bags being demonstrated in Tanzania.

Photo courtesy of Lisa Kitinoja/Postharvest Education Foundation



Postharvest

During the postharvest phase, there are several practices and treatments that can be used to minimize postharvest losses.

Postharvest handling in the field

Best practices include:

- Handling vegetables **gently** and never dropping, throwing or dumping roughly from one container into another. Rough handling increases bruising and mechanical damage, and leads to rapid deterioration and loss of quality and shelf life.
- Providing **shade** (protection from the sun) in the field after harvest to help keep the harvested vegetables cool.

Curing practices

The simple, low-cost method of curing can reduce decay, water loss and weight loss of root, tuber and bulb crops. There are two types of curing, since curing practices differ for bulb crops (onions and garlic) and for root/tuber crops (beets, carrots, potatoes and sweet potatoes).

Onions and garlic: Curing, when used for onions and garlic, refers to the practice directly following harvest of allowing the external layers of skin and neck tissue to dry out prior to handling and storage. If local weather conditions permit, these crops can be undercut¹⁹ in the field, windrowed (piled in a row) and left there to dry naturally for 5 to 10 days. The dried tops of the plants can be arranged to cover and shade the bulbs during the curing process, protecting the produce from excess heat and sunburn. If it is humid or rainy, they can be removed from the field after harvest and dried under a simple tarpaulin or shed cover. The dried layers of skin then protect the produce from further water loss during home storage or marketing.



Onion showing a tight, closed, dry neck after curing is complete.
Photo courtesy of Lisa Kitinoja/Postharvest Education Foundation

Roots and tuber crops: Curing root and tuber crops such as sweet potatoes and potatoes is an important practice if these are to be stored for any length of time. Curing is accomplished by holding the produce at high temperature and high relative humidity (RH) for several days while harvesting wounds heal and a new, protective layer of cells form. Typically, this is done by leaving the crop in a small pile in the field and covering it first with dry plant materials (straw or dried leaves) and then with a large cloth (made of burlap or jute, never plastic). While curing can initially be costly if it is necessary to use added heat, the long extension of storage life makes the practice economically worthwhile. The best conditions for curing vary by crop as shown in Table 4.

Table 4: Conditions for curing selected crops

Vegetable crop	Temperature		Relative humidity	Days of curing
	°C	°F		
Cassava	30-40	86-104	90-95	2-5
Potato	15-20	59-68	90-95	5-10
Sweet potato	30-32	86-90	85-90	4-7
Yams (igname)	32-40	90-104	90-100	1-4

19. Undercutting is when the portion of the onion that remains beneath the soil is lifted above the soil surface.

Cooling and storage

Crop perishability and shelf life

Each type of vegetable in its freshly harvested state has a typical shelf life, based on its type and postharvest conditions. Some vegetables are very perishable and naturally have a short shelf life of less than two weeks, while others are not as perishable so can be stored for a long time. Table 5 provides guidance on storage potential for common garden crops under different conditions while Table 6 classifies fresh vegetable crops according to their relative perishability and potential storage life. Since most vegetables stored in developing countries are not being kept at the lowest safe temperature, the actual shelf life will be much shorter than the potential shelf life (Table 5). Handling fresh vegetables gently during and after the harvest and keeping them cool will help increase their shelf life. Lowering the storage temperature of fresh vegetables by 10 °C will double or even triple their shelf life. Also remember that for vegetables grown for home consumption, staggered planting can help prevent an overabundance of perishable vegetables at harvest time. Program managers should consider the perishability of crops being promoted before deciding *what* and *how* to promote (small production versus large production), particularly for crops that are grown for sale. Also, it is important to consider what additional support may be needed if more perishable vegetables are being promoted. Gardeners may need assistance accessing needed tools, construction materials and training.

Lowering the storage temperature of fresh vegetables by 10°C will double or even triple their shelf life.



Table 5: Maximum shelf life under recommended (optimum cold) conditions and at ambient temperatures as experienced in many developing countries

Crop	Storage potential			
	Optimum cold storage temperature	Optimum temperature + 10°C	Optimum temperature + 20°C	Optimum temperature + 30°C
Fresh green vegetables (cabbage, broccoli, peas)	1 month at 0°C	2 weeks at 10°C	1 week at 20°C	Less than 2 days at 30°C
Leafy greens	2 weeks at 0°C	1 week at 10°C	3 days at 20°C	Less than 1 day at 30°C
Green beans (French beans)	2 weeks at 7°C	1 week at 17°C	3 days at 27°C	1 day at 37°C
Tomatoes (breaker or turning)	2 weeks at 18°C	1 week at 28°C	3 days at 38°C	
Tomatoes (red ripe)	1 week at 18°C	3 days at 28°C	1 day at 38°C	
Fruit vegetables (eggplant, cucumber, summer squash)	2 weeks at 15°C	1 week at 25°C	3 days at 35°C	
Potatoes	5–6 months at 4 to 12 °C	Less than 2 months at 22°C	Less than 1 month at 32°C	Less than 2 weeks at 42°C
Onions	6 months at 0°C	3 months at 10°C	6 weeks at 20°C	Less than 3 weeks at 30°C

Source: Based on author’s calculations using the Q10 or respiratory quotient for each crop, which increases as temperature increases (Source: [USDA Agriculture Handbook 66](#)).

Table 6: Classification of fresh vegetable crops according to their relative perishability and potential storage life in air at near optimum temperature and relative humidity

Relative perishability	Potential storage life (weeks)	Vegetable crops
Very high	<2	Asparagus, bean sprouts, broccoli, cauliflower, green onion, leaf lettuce, mushroom, muskmelon, pea, spinach, sweet corn, tomato (ripe)
High	2–4	Melons (honeydew, crenshaw, Persian), artichoke, green beans, brussels sprouts, cabbage, celery, eggplant, head lettuce, okra, pepper, summer squash, tomato (partially ripe)
Moderate	4–8	Table beet, carrot, radish, potato (immature)
Low	8–16	Potato (mature), dry onion, garlic, pumpkin, winter squash, sweet potato, taro, yam
Very low	>16	Tree nuts, dried vegetables

Source: Kader 1993

Storage practices

Vegetables that are put into storage must be kept cool and protected from damage. Some best practices are:

- Use high-quality vegetables if storage is intended.
- Keep vegetables cool after the harvest to maintain quality and extend shelf life. Simple cooling methods include the use of shade, ice, or sprinkling with clean water.
- Sort before storing, as vegetables should not be stored with damaged or diseased produce.
- Use well-ventilated containers that can withstand stacking (e.g., vented crates).

In general, proper storage practices include:

- Temperature control
- Relative humidity control—keep onions/garlic at low RH (60–70%) and other vegetables at high RH (85–95%)
- Adequate ventilation and air circulation by maintenance of space between containers
- Avoidance of incompatible product mixes (e.g., storing ripe fruits in the same room as green vegetables)

Crops stored together should tolerate the same temperature, RH and ethylene level in the storage environment. Onions/garlic can be kept dry by providing a storage environment with good ventilation and air circulation. Other fruits and vegetables can be kept in a high RH (95–99%) storage environment by wetting the floor, covering the containers with a wet cloth, or sprinkling the vegetables with clean water.

High ethylene producers—such as ripe bananas, mangoes, cantaloupe or tomatoes—can stimulate physiological changes in ethylene-sensitive commodities, such as leafy greens, cucumbers, carrots, potatoes and sweet potatoes, leading to undesirable color, flavor and texture changes. Chapter 7 of [Small-scale Postharvest Practices: A Manual for Horticultural Crops, 5th Edition](#) (Kitinoja and Kader 2015) provides guidance on the proper storage environment for hundreds of different vegetable crops.

Simple cool storage structures for fresh vegetables

Evaporative cooling systems (ECS) can provide a cooler environment for storage of most fresh vegetable crops, but they should not be used for storage of onions or garlic. They work best in regions where the RH is low or in warm/hot climates during the dry season. Examples of simple ECS include the pot-in-pot, zero-energy cool chamber and the desert cooler storage cabinet.

A desert cooler is simply a cabinet of shelves, covered with wet burlap or jute cloth, made in any size with local materials, such as bamboo or wood that has been oiled to prevent mold (below). A pot-in-pot storage system uses two clay pots and sand to create a cool storage environment. You can learn how to make one by viewing the garden toolkit lesson plan on post-harvest practices or visiting wikiHow's [How to make a pot in a pot refrigerator](#).



Desert cooler storage cabinet with shelves and a wet burlap cover.
Photo by Esa Abiso for CRS



Improved zero-energy cool chamber (ZECC) with water supply and shade cover in Arusha, Tanzania. *Photo courtesy of Lisa Kitinoja/Postharvest Education Foundation*

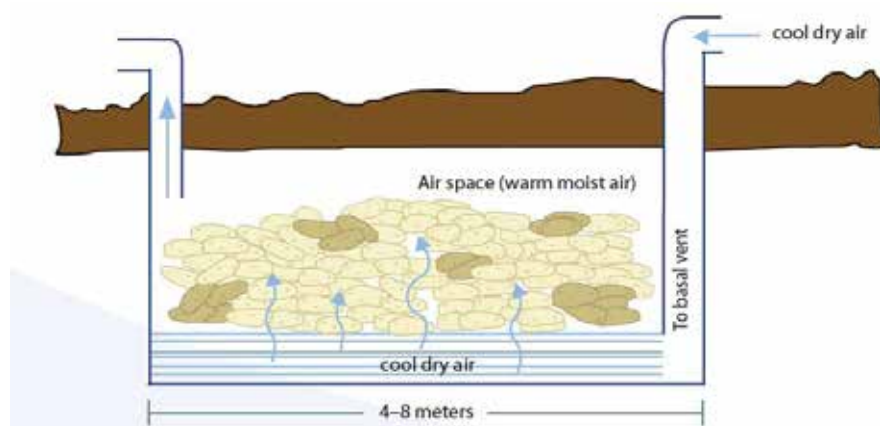
The low-cost [zero energy cooling chamber](#) is constructed from loosely stacked, porous bricks. The cavity between the double brick walls is filled with sand, and the bricks and sand are kept saturated with water. Vegetables are loaded into the chamber, and the entire chamber is covered with a rush mat, which is also kept moist. The evaporation of water keeps the temperature inside the chamber cool. The chamber can be made in any size needed. During the hot summer months in India, this chamber can maintain an inside temperature between 15 and 18 °C (59 and 65 °F) and a RH of about 95%. Eventually, the bricks in the chamber become mineralized, but they can then be dried and reused for normal construction purposes. The chamber may be more appropriate for gardeners coming together as a group than for each individual to construct one for their household.

CRS has shown that communal pit storage in cold climates is a successful method for storage of seed potatoes (CRS 2014). When compared with traditional storage structures, the improved, ventilated pit storage reduced losses from 20-35%, down to an average of 5%. The cost is estimated at only US\$22 per pit, which holds two to three metric tonnes (MT). Farmers should receive training on five key topics: 1) timely cessation of irrigation and dehaulming (cutting back the stem) preharvest, 2) rigorous sorting at harvest, 3) gentle handling, loading the pit and curing, 4) ventilation management, and 5) opening the pit and seed preparation.



To learn more about the ventilated pit, watch this CRS YouTube video: [Low-cost potato storage technology has big impact in Afghanistan's Central Highlands.](#)

Seed potato pit storage



Source: CRS 2014

Chapter 7 of *Small-scale Postharvest Practices: A Manual for Horticultural Crops, 5th Edition* (Kitinoya and Kader 2015) on small-scale storage structures and management practices provides additional options and detailed information on underground storage, root clamps, roots cellars, night air ventilation, high altitude storage and much more.

Small-scale food processing

If vegetables need to be stored for longer periods, beyond their natural storage potential (Table 6), then processing into more stable forms is required. Rapid handling after harvest and minimal delays while processing (i.e., quickly performing the steps of preservation) generally result in better retention of nutrients and higher nutritional value.

Simple methods for home processing of vegetables include 1) drying (via shade, solar, electric or fossil fuel heat sources), 2) canning (in whole form or chopping/pureeing/juicing), and 3) fermenting, pickling, or preserving in sugar (jams, jellies and candies). Each of these methods could fill an entire manual so a few websites and references are provided here and at the end of this chapter for further information, instructions and recipes.

- Tomatoes: *Complete guide to home canning: Guide 3: Selecting, preparing, and canning tomatoes and tomato products* (USDA 2015) http://nchfp.uga.edu/publications/usda/GUIDE03_HomeCan_rev0715.pdf
- Vegetables: *Complete guide to home canning: Guide 4: Selecting, preparing, and canning vegetables and vegetable products* (USDA 2015) http://nchfp.uga.edu/publications/usda/GUIDE04_HomeCan_rev0715.pdf
- Jams/jellies: *Complete guide to home canning: Guide 7: Preparing and canning jams and jellies* (USDA 2015) http://nchfp.uga.edu/publications/usda/GUIDE07_HomeCan_rev0715.pdf
- Fermented foods/pickles: *Complete guide to home canning: Guide 6: Preparing and canning fermented foods and pickled vegetables* (USDA 2015) http://nchfp.uga.edu/publications/usda/GUIDE06_HomeCan_rev0715.pdf

Of the three types of preservation, drying foods is typically the cheapest form and is promoted in many developing countries. Chapter 10 of [Small-scale Postharvest Practices: A Manual for Horticultural Crops, 5th Edition](#) (Kitinoja and Kader 2015) on small-scale food processing includes information on preparing food for drying, time required for drying each type of vegetable, and packaging options. Simple solar drying can be done by laying sliced produce on a tray and exposing it to the sun. Better quality (color and nutritional value) can be achieved if the produce is shaded by using a lightweight cloth or placing the tray under natural shade (a tree or other vegetation). There are many types of solar dryers and they come in all shapes and sizes. The two basic designs are either **direct** (where the sun shines on the produce) or **indirect** (where the produce is kept protected inside a cabinet (See photos below). Solar drying has been widely studied and there are many open-source designs available (Tiwari 2016). Purdue University and the University of Davis have also developed solar dryers.

Although canning and bottling are good forms of preservation, they require time, labor, equipment, supplies, fuel and safe-handling practices. Most importantly, they require clean water; without clean water, canning should not be promoted. See USDA's [Complete Guide to Home Canning](#) (2015) for details on canning practices and altitude adjustments.



A direct model solar dryer (holds six trays), and protects drying vegetables from insects, dust and rain.
Photos courtesy of Lisa Kitinoja

The third method of processing includes fermentation, acidification and sugar preservation. Fermentation is when lactic acid bacteria in foods convert carbohydrates to lactic acid resulting in low pH, leading to preserved food. Kimchi (cabbage) and *tempeh* (soybeans) are two examples of the thousands of fermented foods made around the world. For more information and recipes, see *Keeping the harvest* (Chioffi and Mead 1991). Acidification—also known as pickling—is a simple processing method that can be used with many types of fruits and vegetables. Brine solution (9 parts cider or white vinegar, 1 part non-iodized salt, 9 parts water, plus flavorings and spices) is poured over the product into glass canning jars (leaving a half-inch or 6-centimeter headspace). Brined pickles are sealed and left at ambient temperature for three or more weeks.

The general process for making jams is to combine 3 parts chopped produce with 2 parts sugar, then cook on medium heat for about 30 minutes until thickened. Use 3 grams of ascorbic acid for each batch of 300 gram of jam to help to preserve color. Jams are heat processed in pre-sterilized jars for 5 to 10 minutes, depending upon altitude. A simple recipe for preserving homegrown fruit or vegetables, such as peppers or tomatoes, in sugar is provided at wikiHow's [How to make mango jam](#).

Processed vegetables must be packaged and stored properly in order to achieve their potential shelf life of up to one year. Dried products must be packaged in air-tight containers (e.g., glass or plastic bottles or sealed food-grade plastic bags). Canned and bottled products must be properly heat-processed using high-quality food-grade containers (e.g., glass jars or high-grade plastic jars) that provide good seals. Dried and canned or bottled products are best stored in a cool, dark place. Various types of improved packaging materials and storage containers are shown here.



Plastic buckets, glass and plastic jars, metal foil packaging and zip-lock plastic food storage bags. Source: ULINE.com

Opportunities in food processing

In Tanzania, postharvest training programs have provided information and access to food processing recipes, tools and supplies for many women's groups located in and near the city of Arusha. The Arusha Widow's Association is making solar dried vegetables, and selling them at an organic farmer's market operated by the Italian NGO, OIKOS.



A solar drier in use in Tanzania (a direct model). *Photo courtesy of Lisa Kitinoja/ Postharvest Education Foundation*

Another of the groups is processing their home garden-grown fruit and vegetable crops, mostly into jams and marmalades, and selling them to local shops.



A home gardener selling organic dried vegetables in Arusha farmers' market (left). Jams made by an Arusha women's group in Tanzania (right) on sale in a local shop. *Photos by Odette Ngulu and Radegunda Kessy for CRS*

Food safety practices

The typical causes and sources of food safety problems during production and postharvest handling fall into the following three major categories: physical hazards, chemical hazards and human pathogens.

Physical hazards may become embedded in produce during production handling or storage:

- Fasteners (e.g., staples, nails, screws and bolts)
- Pieces of glass
- Wood splinters

Chemical hazards that may contaminate produce during production handling or storage include:

- Pesticides, fungicides, herbicides and rodenticides
- Heavy metals (lead, mercury and arsenic)
- Industrial toxins
- Compounds used to clean and sanitize equipment

Human pathogens that are associated with fresh produce include:

- Soil-associated pathogenic bacteria (e.g., *Clostridium botulinum* and *Listeria monocytogenes*)
- Feces-associated pathogenic bacteria (e.g., *Salmonella spp.*, *Shigella spp.*, *E.coli* O157:H7 and others)
- Pathogenic parasites (e.g., *Cryptosporidium* and *Cyclospora*)
- Pathogenic viruses (e.g., hepatitis and enterovirus)

Many of these pathogens are spread via a human or domestic animal to food to human transmission route. Handling of vegetables by infected gardeners, cross contamination, use of contaminated irrigation water, use of inadequately composted manure, or contact with contaminated soil are just a few of the ways that transmission of human pathogens to food can occur. Keeping animals out of the vegetable garden can help reduce exposure to pathogens.

While vegetable quality can be judged by outward appearance on such criteria as color, turgidity and aroma—food safety cannot. Casual inspection of produce cannot determine whether it is safe and wholesome to consume. Management of growing and postharvest handling conditions is the only way to prevent the contamination of fresh produce by physical hazards, harmful chemicals and human pathogens.

Casual inspection of produce cannot determine whether it is safe and wholesome to consume.

There are four principles that encourage food safety: 1) clean soil, 2) clean water, 3) clean surfaces, and 4) clean hands. Within these four principles there are groups of practices that can reduce the risk that produce may become contaminated in the home garden (Cornell University GAPs Program 2000)

Clean soil

- Avoid the improper use of manure (see Chapter 8).
- Compost manure completely to kill pathogens and incorporate it into the soil at least two weeks prior to planting.
- Keep domestic and wild animals out of fields to reduce the risk of fecal contamination.
- Work with WASH colleagues who are promoting communities free from open defecation.
- Prevent run-off or drift from animal operations from entering gardens.
- If the manure was not cured, do NOT harvest produce within 120 days of a manure application.

Clean water

- Water teams can regularly test surface water that is used for irrigation for fecal pathogens, especially if water passes close to a sewage treatment or livestock area.
- Keep livestock and chemicals away from the active recharge area for well-water that will be used for irrigation.
- For watershed-based projects, use filtering or settling ponds to improve water quality.
- Where feasible, use drip irrigation to reduce crop wetting and minimize risk. Otherwise, whenever possible, irrigate soil around plants, rather than foliage or fruit.
- Use integrated pest management practices to minimize chemical pesticide use (See Chapter 9).

Clean surfaces

- Tools and field containers must be kept clean. Wash and sanitize these items before each use. It is sufficient to wash tools and containers with soap, rinse with clean water and then air dry. You can also heat tools to sterilize them.

Clean hands

- Anyone who harvests produce must wash their hands after using the toilet.
- Provide soap and clean water using tippy taps in the field and insist that all harvesters wash their hands before handling produce.

Conclusion

This chapter provided the basic framework for using best practices for postharvest handling by identifying each of the links in the postharvest chain as vegetables move from the garden to home storage, consumption, processing and/or the market. Gardeners who can identify the major causes and sources of postharvest losses for vegetables they produce and understand some of the best practices recommended for harvesting, postharvest handling, and cooling of vegetable crops will be able to protect their crops better from damage and losses. By understanding the options that are available for home storage and/or processing of vegetables, gardeners will be able to maintain the quality and nutritional value, and extend shelf life of their vegetables, whether they produce for home consumption or for sale in the market.

Anyone who harvests produce must wash their hands after using the toilet.



Quiz

1. True or false? Gardeners can improve the quality of their fresh vegetables after harvest.
2. Multiple choice. How does evaporative cooling work to keep vegetables cool in storage?
 - a. Cold water is used to wet the vegetables
 - b. When water evaporates from the storage chamber walls, it takes heat away from the vegetables stored inside the chamber
 - c. Wind dries the vegetables
3. True or false. Solar drying, pickling and canning are three options for home processing of vegetables.
4. Multiple choice. What is the most important practice a gardener can use to prevent food safety problems?
 - a. Don't invite friends into your garden
 - b. Wash your hands before touching fresh vegetables
 - c. Use plastic buckets to harvest

Activity

Using an existing or upcoming project, consider what postharvest approaches could be used to add value to and extend the shelf life of garden products.

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Chapter 12: Marketing Produce from a Garden

Rupert Best, Consultant

Learning objectives

After studying this chapter and its resources, you will know how to:

- Support gardeners in planning their garden to reflect local demand for scarce and indigenous vegetables, herbs and fruit.
- Support gardeners in selling surplus production from their garden.

Key messages

- **Better nutrition is the priority.** The priority of a garden is typically to help fulfill a family's need for nutritious food.
- **Gardens can make money.** If a garden produces more than a family can consume, you can help them make money by selling their surplus production, which will also increase access to nutritious food across the wider community.
- **Use the earnings to improve nutrition.** Money earned from selling surplus produce can be used to improve their nutrition by buying other nutritious foods, WASH products and health services.
- **Upgrading their garden.** Income from the garden can also be used to maintain and upgrade their production by buying inputs, materials to protect the garden from animals, tools and equipment to make their garden tasks easier, and inputs for processing produce.
- **Plan for success.** You can help the gardener make a plan about what to plant, when to plant, at what price to sell and how to sell. This will reduce the risks associated with a small business venture.

Key questions for decision-making

- Will the project support the sale of excess supply of garden produce?
- Will the project support entrepreneurship opportunities using garden produce?
- What support will the project provide for the sale of garden products?

Marketing is important for gardeners

Gardens are often promoted for home consumption. However, we hear from the people we serve that they also sell their produce for income. This is often done without a strategic process to determine what to produce, how much to produce and where/when to sell the produce. This leads to less than satisfactory outcomes. Since many of the families we target already sell some of their garden produce or are interested in doing so, we have the responsibility to ensure that they are successful.

Selling garden produce is not the same as selling staple crops. Gardens often have assorted products that are sold at many times of the year instead of just once or twice a year. For example, tomatoes can be harvested and sold over many weeks. Also, buyers are often looking for a specific type of vegetable or fruit, so gardeners need to know what type or variety people want to buy. As gardeners move from occasionally selling their surplus produce to neighbors to selling regularly to the wider community, they will be starting a small business and will be working toward becoming an entrepreneur. A successful entrepreneur has the capacity and willingness to take on and manage risk, and the knowledge needed for a successful garden business. Therefore, if this is a project objective, program managers should support building gardeners' capacity in garden enterprises.

Knowledge needed for marketing garden produce

Running a garden as a business requires some basic knowledge about producing and selling vegetables, herbs and fruit that customers want to buy. It also requires knowing about how to cover costs, count income, make a profit and protect the business against risks.

Selling produce versus marketing products

Selling produce refers to the occasional sale of surplus garden produce to neighbors, friends or local market stallholders. In this situation, the family grows the produce that meets their personal needs. They may plan their production or simply plant and hope for a good harvest. If there are good rains, a crop may produce more than the family needs. The family can then sell this surplus at a price that is attractive to both buyer and seller.

Marketing products refers to the planned production and regular sale of garden produce to customers. In this situation, the garden takes on a dual function: 1) **producing for home consumption**, where the objective is to produce vegetables, herbs and fruit that a family wants to eat, and which contribute to meeting their nutritious food needs; and 2) **producing for the market**, where the objective is to produce and sell vegetables, herbs and fruit that local customers want to buy, which contribute to meeting their nutritious food needs. The ideal situation is one in which the needs of the family and the needs of customers coincide or at least overlap. Producing for home consumption and producing for the market requires careful planning. A plan helps the family decide what to plant; when to plant; how to produce a crop; and, in the case of marketing, who to sell to when the crop is harvested.²⁰

20. To learn more about the marketing of agricultural products read: Lesson 1. What is agricultural marketing? In [Marketing Basics: A SMART Skills Manual](#) (CRS 2012).



The 60:40 home consumption-to-market sale ratio

In the Philippines, CRS encourages farmers to use their gardens to produce for home consumption and for sale. Farm families, organized in clusters of 10, aim to dedicate 60% of their production to home consumption and 40% to sale in the market. This means that a family with a garden of 1,000 square meters (e.g., 20 x 50 meters) will dedicate between 100 to 400 square meters to growing for the market. Of the 40% produced for the market, families target 60% for sale in the local market and bulk the remaining 40% with other cluster members for collective sale to an identified buyer.



Supply and demand for garden produce

Among the most important ideas in marketing is the concept of “supply and demand.” It is important to understand how supply and demand have a big influence on what to produce in a garden and the prices a family can expect when selling their produce. Over-supply of a product means its selling price drops and families may find themselves unable to cover their production costs. Some families may not be able to sell their produce at all and it goes to feed animals or make compost. This can easily discourage families and they may want to give up the garden completely. So, it is useful to understand supply and demand to avoid this happening.

Market supply

Market supply is the amount of a product that a family can produce and market for sale. The supply of a product partly depends on its price and local conditions.

High prices: If a gardener sees that the selling price of a product is high, they will be eager to sell as soon as possible. And if the price remains high, the gardener is likely to want to grow more of the same product in the next production cycle or season. This is when you need to caution gardeners producing for the market. If too many gardeners start to produce the same products and sell them in the same community at the same time, the amount available for purchase will rise and prices will drop.

High prices this season do not guarantee high prices next season.

Low prices: If a gardener sees the selling price is low and falling, they may want to keep their products until the price goes up. For fresh produce, like fruit and vegetables, this is difficult unless the products can be dried or conserved in some other way (see Chapter 11 on Postharvest Handling). Low prices can discourage the family from planting the same crop next season. Low prices in one year can mean that prices will rise the following year if the supply is low. Whether prices are high or low, a gardener should try to find out why.

The supply of a product also depends on local conditions. If the rains are good, gardeners may have a lot of produce to harvest. If there is drought and it is difficult to water the garden, the harvest will be poor.

Other things can also affect the supply of a product: pests and disease; availability of and access to organic fertilizer, such as compost and good-quality seeds; difficulty accessing the market; lack of information on key practices; poor health of family members; pregnancy and child rearing that leave limited time for tending the garden; difficulty in communicating with buyers; and fluctuating or rising production costs because of any of these factors. Other chapters of this guide explore some of these issues (see Chapter 5 on Gender Integration, Chapter 7 on Seed, Chapter 8 on Integrated Soil Health Management and Chapter 9 on Pest and Disease Management).

Market demand

Market demand is the amount of the product that customers are willing and able to buy. This amount partly depends on the price, food preferences, choice and quality.

Low prices: If the price is low, more people will want to buy, and each person may want to buy more of the product.

High prices: If the price goes up, fewer people will want to buy and each person will probably buy a smaller amount.

The demand for a product is also affected by other factors. For example, rural families generally want to buy more staple foods (such as maize, beans and potatoes) or major vegetables (such as onions and tomatoes). But they also want to buy smaller quantities of less common types of vegetables, fruit, or items they use only in small quantities, such as herbs. The garden is good for catering to these types of families. Ideally, a garden project will have a nutrition education component to influence families' food preferences (see Chapter 6 on Nutrition) and this can help determine what products a family grows for sale.

Most consumers prefer to buy good-quality products rather than items that are of low quality or damaged. This is an important factor for a garden because most products are highly perishable. Buyers value fresh products, such as vegetables harvested the same day, rather than produce that was harvested several days previously. And some buyers want to buy products that are scarce and hard to find at certain times of the year. If there is a demand for the conserved products, this becomes an option that a gardener may want to consider, either at the outset, or once they have gained some experience in selling fresh produce.

All these factors are important to consider when planning a garden. For example, if many families want to produce and sell vegetables, you should help them to find out what vegetables are in high demand, the quality in demand, the quantity of vegetables they are likely to sell, and the period of time for selling.²¹

Ideally, a garden project will have a nutrition education component to influence families' food preferences.



21. For more detail about supply and demand read: Lesson 2. Supply and Demand. In [Marketing Basics: A SMART Skills Manual](#) (CRS 2012).

Identifying the customer

The first task for the gardener is to explore who their potential customers might be and what kinds of vegetables, fruit or herbs these customers might want to buy. There are two main potential buyers for gardens: 1) families in the local community, such as neighbors and friends; and 2) local market stallholders, who are interested in sourcing their products locally. Initially, the focus should be on this local demand for garden produce. Only after several gardeners are producing and selling their produce—either individually or as a group—and there is the risk that supply of produce may exceed local demand, should a market beyond the local community be considered.²²

Making decisions on what to produce

In determining what to produce, the gardener needs to identify demand, determine production feasibility, estimate profitability and understand personal preferences.

Identify demand

The search for information about what to produce starts by asking potential buyers simple questions about what they want to buy. The table below provides examples of the types of questions the gardener should ask the two groups of buyers identified above.

Table 1: Questions to ask potential buyers of garden produce

Questions to ask FAMILIES in the community	Questions to ask local market STALLHOLDERS
<ul style="list-style-type: none"> What vegetables, fruit or herbs do you regularly buy for preparing food for the family? 	<ul style="list-style-type: none"> What vegetables, fruit or herbs do you buy and sell on a regular basis as a vendor?
<ul style="list-style-type: none"> Do you buy vegetables, fruit or herbs that have been conserved so that you can store them (e.g., dried and pickled products or fruit made into jam)? 	<ul style="list-style-type: none"> As a vendor, do you buy and sell vegetables, fruit or herbs that have been processed so that they can be stored (e.g., dried and pickled products or fruit made into jam)?
<ul style="list-style-type: none"> Which of these vegetables, fruit or herbs does your family like and consume a lot of? 	<ul style="list-style-type: none"> Which of these products are in high demand or do you sell most of?
<ul style="list-style-type: none"> Where do you buy the vegetables, fruit and herbs that you consume? 	<ul style="list-style-type: none"> Which of these products are scarce or difficult to obtain?
<ul style="list-style-type: none"> Which of these vegetables, fruit and herbs are you likely to buy and consume more of in the future? 	<ul style="list-style-type: none"> For each of the high-demand or scarce supply products: <ul style="list-style-type: none"> How often do you buy them? What is the minimum and maximum quantity you buy?
<ul style="list-style-type: none"> What vegetables, fruit or herbs would you like your family to consume but you are unable to find in the market? 	<ul style="list-style-type: none"> What quality do you need (e.g., size and shape, freshness, color and maturity)? What is the price you are currently willing to spend? When will you pay the producer?
<ul style="list-style-type: none"> If my family produces some of the vegetables, fruit and herbs that you mention, which ones would you like to buy from us and why? 	<ul style="list-style-type: none"> Which of the products that you have mentioned would you buy from us and why?

22. For more detail about how groups of gardeners can produce individually and sell collectively read: [The 7 Steps of Marketing—a SMART Skills Manual](#) (CRS 2012).

The family can collect this information in an informal fashion over a period of time, memorizing the information provided and recording it later in a *Garden Business Workbook* (Annex 1, Page 200). Writing down the information during an interview is not recommended as it can be intimidating for the person being interviewed, unless the gardener knows them well. Recording this information after an interview will help the family draw up a preliminary list of vegetables, fruit or herbs that are in demand in their community.

Literacy and numeracy skills



Some of the gardeners you work with may have low levels of literacy and numeracy. Recording information in notebooks may therefore pose problems for these families. Preparing learning materials that use drawings will help. Ideally, when embarking on projects that are promoting the sale of products, you should support families to improve their literacy and numeracy. This will increase the probability that their market venture will be a success.

Narrowing the crop list

The gardener will need to narrow down the options of what to produce to a shorter list of between two and five crops. Do this by eliminating any of the options that do not meet the following three criteria:

1. Seed is readily available at a price that the gardener can afford (see Chapter 7 on Seed)
2. Soil and climate conditions are suitable for production
3. Local knowledge on how to grow the crops is available

Once the gardener knows where they can find information about the crops that pass the above criteria, they will need to find out more about 1) productivity, 2) seasonal or yearly viability, 3) crop maturity, and 4) production needs, which are discussed in Chapter 4 on Crop Selection. They will also need to find out about the nutrition content of the crop and how it could meet nutritional gaps in the community (see Chapter 4 on Crop Selection and Chapter 6 on Nutrition). This information may lead to some crops being eliminated because of challenges that will be difficult to overcome. As an example, there may be a pest or disease that can be controlled only by using an expensive agrochemical whose cost is beyond the means of the gardener. See Worksheet 2: Production (Annex 1, Page 204) for a set of tables that can help gardeners collect and record this information.

Identify the most profitable crops

A third important factor that the gardener will need to consider is how much they will need to spend producing the crop and how much they will likely earn from selling it. At this point, the gardener does not need to determine the exact production costs. However, they should find out and record the following information for each option:

Costs: The cost of seed and other inputs that must be bought must be calculated, such as staking material or tools that the gardeners do not already have access to, transport and hired/family labor needs (see Chapter 5 on Gender Integration). More details on calculating costs are described in the section below on “how to record costs and prices and calculate income and profit.”

Prices: The prices that these crops are selling for in the local market need to be considered, and whether the price fluctuates through the year. Once it is determined how much of the crop they are likely to be able harvest for sale in a season and its value, the gardener can figure out how much they might be able to make by selling their surplus produce. By subtracting the cost of seed and other inputs, they will know which of the crops will earn them the most money after their family consumption needs are met. Since material and labor costs incurred will cover the entire crop (produce consumed by the family *and* produce sold), a record should be kept of how much is consumed by the family, along with its monetary value. Worksheet 3: Finance (Annex 1, Page 212) provides tables that can help families collect and record this information. For those with low numeracy, consider doing this as a facilitated group exercise.

Other considerations

Demand for a product and whether the gardener will be able to produce it are essential factors to consider when choosing what to grow in the garden; however, the gardener may not always select crops that will make the most money. For example, the gardener may want to prioritize crops that they are already growing for their own consumption, or new crops that they would like to grow to diversify their diet. If one or more of the family members is pregnant or looking after babies or small children, this may also affect their decision about what to grow. Also, vegetables and fruit that get higher prices may be more difficult to grow and require greater upfront expenses, which increase the risk of greater loss if the crop fails. If the gardener does not have to pay out more to produce a crop than the amount they earn from their sale, then these other considerations may be more important than monetary gain.

Vegetables and fruit that get higher prices may be more difficult to grow and require greater upfront expenses.



Children's time allocation

Children often help in gardens. They undertake important tasks such as watering, weeding and harvesting. When the garden becomes an enterprise, you need to ensure that children's time dedicated to the garden does not preclude their attendance at school, for example. Read [CRS' Protection Policy](#) on the use of child labor.

Generating value for buyers

When the family has made the decision to focus on two or three crops to produce for sale, it is time to think about how best to fill the customers' needs so that they will value what the gardener is selling. Selling to individual families in the community will be different from selling to local market stallholders. Table 2 describes some of these differences. The gardener will need to find out what these customer groups want and need to buy. They will find this out by talking to potential buyers about how much they want to buy and when, what quality they prefer, and how much they are prepared to pay. Specific questions that the gardener can ask are provided in Worksheet 2 (Annex 1, Page 204).

Table 2: Purchase factors based on buyer priorities

Purchase factors	Selling to families in the community	Selling to local market stallholders
Seller-buyer relationships	The gardener selling the garden produce may know many other families that reside in the community or that are related to them. Trust between the seller and buyers may already be established and transactions between them will be informal. In this situation, the buyer will largely accept the conditions of purchase set by the seller. Buyers will return to buy more produce if they are happy with the quality and the value for money.	The gardener may or may not know the stallholders personally, some of whom may come from other communities. The agreement between the gardener and the buyer will be informal—with no contract—but with the conditions of purchase clearly defined by the buyer. The relationship will flourish to the extent that trust between the gardener and the buyer is built. That is, the gardener providing the produce that the buyer needs and the buyer paying on time and at a fair price.
Quantity	The amount of produce that individual families buy will depend on the number of adults and children who make up a family, how much of these items they grow themselves, and income available for purchase.	A market stallholder will likely want to buy only an amount that they can sell in a day. This will be particularly true for itinerant stallholders who move from one community to another. The gardener needs to find out what the minimum and maximum amount of produce is that the stallholder requires.
Frequency	For perishable produce, such as leafy vegetables, frequency of purchase may be high with families buying two or three times a week. For less perishable products, such as carrots, purchase frequency will be lower, perhaps once a week.	Local markets may be held daily, two or three days a week or just once a week. The gardener should negotiate with the stallholder the days that they will deliver produce, which will depend on how much they have to sell and the minimum and maximum amounts that the buyer is prepared to buy.
Quality	Families will be attracted by fresh produce and knowing that it has been grown locally. Produce that has been grown without the use of agrochemicals to control pests and disease is also sought after.	Market stallholders may buy all of a producer's crop regardless of quality, sort the produce themselves, and sell different quality produce at different prices. Alternatively, they may specify quite precise conditions in terms of freshness, color, size, shape and agrochemicals used.
Price	If families are confident about the quality of the produce, they are likely to pay the same or more than they might pay at the market for the same product.	Stallholders pay at prices that will allow them to cover their costs and make a profit. The prices will fluctuate throughout the year depending on the supply and demand.
Location	Sale to families in the community is usually from the homestead. There are cases where the local authorities make space available in the market for households that produce vegetables to sell on certain days. There is usually a cost associated with the use of the space.	In only exceptional cases are market stallholders likely to collect produce from the homestead. It is more likely that the gardener producing for sale will take their produce to the market stallholder. If the amount of produce is large, the seller may have to hire someone to help them transport the produce to market.

The gardener who produces vegetables, fruit and herbs for sale will likely receive a lower price from a market stallholder, but should be able to sell greater volumes of produce. Selling to families in the community will require many smaller transactions but with the possibility of receiving a higher price per unit of produce sold.

How to record costs/prices and calculate income/profit

Smallholder farmers may not keep records of what it costs to produce a crop or raise an animal, but they can usually tell you what an input, like seed, costs when they must buy it or at what price they sold their last harvest. When faced with a choice of what to produce and what to sell in the market, keeping records and making simple calculations about how much money they could make from selling one crop instead of another is important for making good decisions for the next production cycle.

Recording costs

The farm family incurs three main kinds of costs in their garden: material costs, labor costs and hidden costs.

Material costs: These are the inputs (e.g., seed, manure or compost, string for row planting, sacks, bags and labels for storage and marketing) and tools (hoes and machetes). In this category, we can also include other costs associated with producing and marketing the garden produce, such as transport, phone fees for maintaining contact with buyers, and any fees the family may have to pay for advice on how to grow or market a crop.

Labor costs: Farm families seldom think about the labor that family members themselves use on the farm because they do not have to pay cash to cover the cost. Quantifying the amount of labor (either hired or family) used in the garden—no matter how the crop is used—is important for two reasons. First, the family will understand the full cost of their business and where savings might be made in the tasks that are most costly. Second, knowing the full cost will help the family decide between different production options. In the garden, many crops may not differ widely in terms of the time it takes to plant, water, weed, harvest and sell, but some crops may have different labor requirements, especially when it comes to preparing them for the market and selling them. If the additional time that these tasks take is not compensated by higher prices, it may be better to focus on crops that have less demanding labor needs. This is particularly important given the linkages between women’s time and energy expenditure on the nutrition outcomes for herself and her children.

Hidden costs: Hidden costs are those that are not directly associated with a production or market activity. They are difficult to quantify and may not have a monetary value. Hidden costs are usually associated with the loss of an opportunity to do something that benefits those involved in the garden activity. Since garden activities are often undertaken by the women and children of the family, hidden costs could affect them in different ways. For example, a mother who has to take garden produce to the market to sell may have to find someone to look after her children or prepare meals, or the children may neglect their homework from school to do the chores in the garden.

Keeping records and making simple calculations is important for making good decisions for the next production cycle.





Financing gardens

There is also the question of where the family will obtain the cash to start production. They may have their own savings to invest. If not, then the garden program should look at ways that families can start to save enough money to purchase the inputs they need. CRS' [Savings and Internal Lending Communities \(SILC\)](#) approach is ideal for this. It is strongly recommended that your garden program includes a SILC component if households do not have savings to invest in their gardens. SILC should be accompanied by the [CRS Financial Education module](#) so that families can learn how to make good decisions regarding their personal savings or loans they take from their SILC group.

Recording prices

Prices of garden produce will go up or down. Since prices will vary depending on what buyers want and need, gardeners need to find out:

1. The prices buyers are willing to pay for different types and amounts of product
2. Whether buyers will pay more for better quality products that have been cleaned, sorted, processed, or packed in a certain way
3. The prices paid by buyers in different markets (farm gate, village, town and city markets) and fluctuations in price during the year
4. Whether buyers require an agreement that sets the price for a determined period of time

Table 3 on the following page explains some of the most important factors to keep in mind when promoting the sale of garden produce to potential buyers.

Table 3: Factors affecting price

Type of product	Typically, the same weight of a fresh green vegetable will have a higher price than a root vegetable. So, as an example, a kilogram of cabbage has a higher price than a kilogram of carrots. Herbs will fetch higher prices relative to both green vegetables and root vegetables.
Amount of product	Buyers in bulk (wholesalers) and those who sell direct to the public (retailers) may offer higher prices when buying a greater amount of a product. Conversely, an individual buyer may expect a discounted price if they take, for example, two or more bundles of radishes instead of just one.
Quality of the product	Good-quality tomatoes will sell at a higher price than overripe or badly bruised tomatoes. Freshly harvested green vegetables will sell at a higher price than leaves that are wilting. Also, more and more families—both in large cities and small towns—are interested to know where their fresh vegetables and fruit are coming from and to know that they have not been sprayed with agrochemicals that are harmful to their health.
Cleaning and sorting the product	Some buyers want and are prepared to pay more for a product that is clean and sorted by size. These additional activities add value to the product and can increase the price.
Packaging the product	Attractive presentation of products in sacks, bags or boxes, and in amounts that buyers want, can fetch a higher price. Packaging can also protect a product from damage.
Place of sale	Prices will vary depending on where a product is sold. For example, buyers will expect to pay more in a market and less at the farm gate, and prices in towns and cities will be higher than in rural areas.
Season of sale	At peak harvest, when supply is plentiful, prices will be low. Prices will be higher during the “off-season,” when supply is low and demand higher. Growing during the off-season, however, may incur additional costs, such as time spent for watering or finding ways to manage pests that are more of a problem in the dry season or to manage diseases in the wet season. Seasonal fluctuations in price can also be overcome if there is a demand for vegetables, fruit and herbs that have been processed or transformed so that they can be stored.
Agreements with the buyer	The gardener can agree with a buyer that they will sell a given amount of produce at a fixed price over a given period. In this case, the gardener is obliged to sell the agreed-upon amount and the buyer is obliged to buy at the fixed price. This has the advantage of securing a price that will cover costs. However, when the time comes to sell, the price agreed upon may be higher or lower than the current price in the market.

***Know your buyer. Find out their preferences.
Use the information to try to meet their needs.***

Calculating income

The family's income from selling their garden produce depends on:

- The price per kilogram (or bundle, bag or sack) of the produce sold
- The number of kilograms (or bundles, bags or sacks) the family can sell

If, in a production cycle, a gardener sells 5 bundles of radishes at a price of \$2 each, 8 bundles of spinach at \$1.50 each and 10 heads of lettuce at \$1 each, the total income for the cycle is:

$$(5 \times \$2) + (8 \times \$1.50) + (10 \times \$1) = \$10 + \$12 + \$10 = \$32$$

The income does not take into consideration the costs but only what is earned.

Calculating profit and loss

The profit from the garden is the amount of extra money the gardener has left over from the sale of their garden produce after paying all the costs of production, cleaning, sorting, processing and marketing for the portion of the crops that was sold.

In the case above, the family made a total income of \$32. If their total costs were \$24, then the income is higher than the costs, and the gardener made a cash **profit of \$8**. But if the total costs came to \$35, then income is lower than the costs, and the family takes a cash **loss of \$3**. Taking a cash loss means that there is no extra money to buy food that the family cannot produce themselves or to buy seed or other inputs to keep producing in their garden.²³ This can have a negative impact on household nutritional status and the decision to continue to garden.

However, the above calculation has not considered the fact that the family may have consumed part of the produce. If we value the produce that is consumed at the same price as the produce that is sold, then the overall benefit for family from the garden may be positive. In the above example, let us suppose that the family consumed 2 bundles of radishes, 4 bundles of spinach and 2 heads of lettuce. The value of this produce is:

$$(2 \times \$2) + (4 \times \$1.50) + (2 \times \$1) = \$4 + \$6 + \$2 = \$12$$

So, even in the case of a cash loss of \$3, the family benefited from the produce consumed and would have saved at least \$12 which they otherwise would have spent to buy the same produce in the market. The ideal situation will be when the cash income from the garden covers all the cash costs and leaves a margin for buying other inputs or goods that the family needs.

23. For more detail about estimating costs, income and profit, read: Lesson 3. Costs, income, prices, and profit. In [Marketing Basics: A SMART Skills Manual](#) (CRS 2012).

How to organize the garden for market sales

An important part of planning for the garden business is how the gardener organizes to undertake the tasks that need to be done. All the tasks should not fall on one member of the family. At the outset, the family needs to designate one member to lead and manage the process of getting the business started. Traditionally, the job of looking after the garden is done by the female head of household, although not all of the time. Care must be taken to ensure that this responsibility does not considerably increase the female head of household's work burden, and that the male head supports her in these functions. Understanding who makes decisions related to marketing of garden crops and controls the use of income received is important to guide the intervention design so men and women benefit equitably from their effort.²⁴ In a context where women have limited household decision-making power, activities that support families in improving couples' communication and joint decision-making should also be included. The box below gives practical tips on how to facilitate inclusive household decisions about marketing.

How to facilitate inclusive household decisions about marketing

Chapter 5 on Gender Integration discusses how the commercialization of gardens can have significant effects on household gender roles and power relations. These effects can be positive but there is also a risk that they damage rather than improve relations. When a crop that has been typically managed by women is marketed and becomes profitable, it is possible that her husband—as the one often with more bargaining power in the household—may take over management of that crop. Therefore, it is important to understand the gender context by conducting a gender analysis to ensure women retain control, and to monitor for unintended consequences.

Couple communication and household-based agricultural livelihood training approaches can be effective ways to empower both men and women of the household to enter jointly made decisions about what food should be grown, eaten and sold, and how the money should be spent in a way that will have the maximum benefit for themselves and their families. These approaches are participatory and combine technical training with an examination of gender roles and social norms within the household. Some CRS examples include [SMART Couples](#) and the [Area Association Model \(internal\)](#). Other publicly available training toolkits include IFAD's [Household Methodologies: Gender, Targeting and Social Inclusion](#) and the Hivos' [Sustainable Coffee as a Family Business](#).

The main organizational tasks that need to be undertaken are:

- Decide how much space to dedicate to the production of garden products for sale.** Encourage the gardener to prioritize their food and nutrition needs first, and then decide how much land is available that they can use to produce for sale. In the Philippines case described earlier, a family with 1,000 square meters of total garden dedicated 400 square meters to production for sale. This can be used as a guide, and each family will need to make this decision for themselves. A good principle is to “start small and grow.” Once the family has gained experience and had success in producing and marketing over a couple of cycles, they can increase the area of the garden if they have available land.

24. For more detail about how to organize farmers for enterprise, read: [Organizing and Managing Farmer Groups—a SMART Skills Manual](#).

- **Decide what to produce and who to sell it to.** Best coordinated by the family member who is leading the process with support from other family members.
- **Plant and maintain the garden.** If the gardener can collect/access water all year round and the seasons do not restrict plant growth, cyclical planting and maintaining the garden can be a year-round task. Planting should be scheduled so that the harvest does not coincide with periods when there is abundant supply and prices are likely to be low. Ideally, the tasks should be divided up among two or three members of the family, with one of them in charge overall.
- **Build relationships, maintain communication with buyers, and sell garden produce.** This task is also a year-round activity. Contact with potential buyers begins when the gardener collects information on who to sell to and what to produce. It continues by building relationships with buyers who want to buy the produce, using periodic communication about when the produce will be available for purchase. Face-to-face meetings are always important initially for the gardener to get to know the buyer, or when they are negotiating a price, or determining the amount of product to sell. Also, until a high degree of trust is established between the gardener and their buyers, it is important that someone from the gardener's family personally delivers the garden produce to the buyer and receives payment. For other matters, however, a mobile phone is an important aid to communicating regularly with buyers. Having a mobile phone will save the gardener a lot of time in personal visits and traveling back and forth to talk with buyers. These marketing tasks are essential to the success of the garden business and should at first be undertaken by its leader.

Gender lens

When it comes to marketing produce that entails travel away from the home, you will need to consider several gender issues. In some cultures, it is not appropriate for women to engage with male buyers. In many situations, women do not have access to a mobile phone or cannot fully use its features. You may also have to pay attention to building women's negotiation skills. Also, consider what happens with the control over the income received.

- **Keep records of market and production information, expenditure and income.** One family member needs to maintain up-to-date information on the enterprise. Ensure that the following information is recorded:
 - Potential buyers and their mobile phone numbers with details of what, how much, and how often they want to purchase; any specific quality requirements; and the price they are willing to pay
 - Key production characteristics of all the crops that the family might consider growing (e.g., soil and water requirements, production practices, inputs and their costs and yield)
 - Amount of produce harvested, amount consumed by the family, and amount sold
 - Cash transactions—when/how much is collected/for what (income) and when/how much is paid out/for what (expenditures)

■ **Manage the finances.** There will be times when the family must buy seed, tools and/or other materials or services. Once they have sold garden produce, the money earned can be saved for future garden purchases; buying nutritious food items that the family cannot produce themselves; or products needed to support nutrition like tippy taps, latrines, soap, school fees, medical services, etc.²⁵ The family needs to make a decision early on about what percentage of the profit they will use to meet household expenses—such as food, healthcare, soap, etc.—and what percentage will be used to meet the needs of the next production and marketing cycle. Furthermore, a percentage of the earnings should be set aside as savings for planned future expenditures in the household or garden, and for a reserve for covering losses if the family experiences one or more poor production cycles. In supporting families to make these decisions, nutrition education should be included. To support the overall process of determining how to manage the finances, [Lesson Plans 1-4](#) of the CRS Financial Education Curriculum are very useful. These lesson plans include 1) making a seasonal calendar, 2) establishing goals, 3) understanding income/expenses and creating a budget, and 4) different types of expenses/reviewing your budget.

■ **Assess how production and sales have gone after each cycle and adjust the plans for the following cycle.** The records that the family keeps in their *Garden Business Workbook* will have taken considerable time and a lot of discipline to make sure the information is kept up-to-date. Since gardeners may not initially see the value of keeping records, we recommend that program managers and field staff highlight the importance of using the *Workbook* and provide accompaniment and coaching to families on how to use it for the first two seasons. An opportunity for demonstrating the use of the records will come at the end of each cycle when the family should get together to assess the business and plan for the next cycle. The field agent can help facilitate this process for the first two seasons.

The questions that families should ask themselves are:

- Which crops have been easy to sell and which have been difficult to sell?
- What specific problems have we had to face in selling the crops? How can we get around these problems in the next cycle?
- Which crops have been easy to grow and which have been difficult to grow?
- What specific problems have we had to face in producing the crops? How can we get around these problems in the future?
- How much money have we made and has it covered our costs?
- What should we do with the money we made?

The responses to these questions will shape the decisions that the gardener will make about what crops to continue planting or grow more of, what crops to discontinue planting or grow less of, and what changes to introduce in the management of the garden. The family will also be able to decide whether to stay with the same buyers or to explore sales to new buyers. The information and decisions made regarding how production and marketing is organized is recorded in the *Garden Business Workbook* Worksheet 4: Organization (Annex 1, Page 220).

25. Families who are members of a SILC group can borrow money to buy inputs and materials, and the income from sales can be used to increase their savings.

Farmers learn about gardening

In Latin America, CRS uses a “whole farm” field school approach to build farmers’ capacity to try out and employ new technology and practices. The approach is a collective one. It brings together families who have common interests, such as production and marketing of produce from gardens. It builds on the individual and collective experiences of the participating families and strengthens their capacity to observe, analyze, and make proposals about changes in how they run their gardening business.

The garden project manager will need to tailor the technical content of the learning process to the specific needs of the participating families. This guide provides the basis for this technical content, which will need to complement local knowledge and experience (Pavón 2012).

Using the *Garden Business Workbook* to plan/improve garden business and manage risk

A garden that produces for sale, just like a garden that produces for home consumption, must have a good plan. The plan shows what needs to be done when, where and by whom. In the process of making the plan, the gardener and family members involved can consider and foresee what risks might occur and make provisions to overcome them. Some typical risks that a gardener, who is producing for sale, might face and how they could mitigate them are described in Table 4 on the next page.

Table 4. Some typical gardening risks and how the gardener might overcome them

Risk area	Typical risks	Example	How the risks might be overcome
Marketing	Price fluctuations	Over-production locally results in the price dropping at harvest and so the income does not cover the costs of production and marketing	<ul style="list-style-type: none"> Stay informed about market trends for vegetables, fruit and herbs by talking regularly to market stallholders, local agricultural extension staff and families in the community Choose crops to sell whose prices are less susceptible to fluctuation because their demand is higher in scarce supply Diversify production so that if the price of one crop is low, the prices of the other crops may compensate Look at options for conserving garden produce (see Chapter 11 on Postharvest Handling) and find out about the demand for them
Production	Low technical know-how	Crops fail to produce well through lack of production know-how	<ul style="list-style-type: none"> Talk to the local agricultural extension agent to identify one or more local farmers who are growing the same crops Visit an agricultural research station that deals with horticultural crops
	Drought	Rainfall alone is not sufficient to maintain healthy crops and production fails or is severely reduced	<ul style="list-style-type: none"> Seek advice on the best means of water capture, water reuse, conservation and watering to minimize waste (see Chapter 10 on Water Resources) Find out from the local extension agent about soil management practices to conserve water (see Chapter 8 on Integrated Soil Health Management)
	Pests and disease	Attacks by pests and disease reduce quality and quantity of harvest	<ul style="list-style-type: none"> Seek advice from local extension agents and other farmers on how to identify and manage pests and disease (see Chapter 9 on Pest and Disease Management)
Finance	Unavailability or limited access to cash	Insufficient savings or inability to access a loan to start or maintain the garden and cover marketing costs	<ul style="list-style-type: none"> Join or initiate a SILC group Participate in training on managing household expenses Participate in training on making a business plan
Organization	Insufficient family labor	Garden is not maintained and production is reduced	<ul style="list-style-type: none"> Gather information on labor requirements when deciding on which crops to grow Hire additional labor for those times when family labor is not available; make sure you factor in this additional cost when deciding which crops to grow
	Insufficiently skilled family labor to manage the garden	Garden not maintained, resulting in reduced production	<ul style="list-style-type: none"> Have family members who are undertaking specific garden roles attend appropriate extension meetings
	Incipient business skills	Gardener did not make a profit as they overproduced the product without considering demand and price	<ul style="list-style-type: none"> Take a training in starting a small business if it is available Start small and learn as you go along

The *Garden Business Workbook* (Annex 1, Page 200) helps document the plan. Four separate worksheets are included so additions and changes do not lead to entries about marketing getting interspersed with production or cash transactions.

- Worksheet 1: Marketing
- Worksheet 2: Production
- Worksheet 3: Finance
- Worksheet 4: Organization

Each one is designed to aid the collection and analysis of information for decision-making by the gardener. The value of the *Workbook* will need to be emphasized by the program managers at the beginning as gardeners may not see the benefits initially. The time and resources of the field agents, who support families in planning and implementing gardens, need to be budgeted for and be at a level that will ensure support continues in the use of the *Workbook* over a period of at least two seasons.

Conclusion

This chapter covered the entrepreneurial and technical aspects of marketing garden produce. It drew attention to the importance of good planning before initiating production and marketing, to reduce risks associated with the business. A plan needs to lay out a) what to plant and who to sell it to, b) when to plant and how to manage the crop, c) at what price to sell and how to sell, d) the costs of production and marketing and where the money will come from to cover those costs, and e) how the garden business will be organized and run.

Quiz

1. Which of these statements about supply and demand of garden produce are true and which are false?
 - a. If supply goes up, prices will go up. T F
 - b. If demand goes up, prices will go down. T F
 - c. If supply goes down, prices will go up. T F
 - d. If demand goes down, prices will go up. T F
 - e. If supply goes up, prices will go down. T F
2. Which of the following statements are true and which are false?
 - a. Keeping records is the job of field agents not of gardening families. T F
 - b. The most appropriate places for small gardeners to sell their produce are local markets. T F
 - c. The more I produce, the more I will sell and the more money I will make. T F
 - d. The risks associated with producing and marketing garden products can be reduced by careful planning. T F
 - e. Gardening for sale is a man's job. T F

3. Which of the following statements most accurately describes the **primary purpose** of selling the produce from a garden? Select only one.
 - a. Generate an income to cover the costs of producing and marketing the vegetables, fruit and herbs grown in the garden
 - b. Provide family members, particularly the younger members, with something to do in their spare time
 - c. Generate income to spend on essential household needs, particularly food items that cannot be produced on the farm or in the garden
 - d. Generate a cash reserve to invest in improving and expanding the garden business
 - e. Motivate family members to maintain, improve and expand the garden to improve their nutrition and well-being by generating income to diversify diet, cover the garden's costs, and pay for other essential household needs
 - f. Offer the local community the opportunity to buy a range of healthy food products
 - g. Generate income to invest in the production of staple crops and livestock
4. Sort the following components into a logical sequence for a garden production and marketing plan.
 - a. How much you expect to earn from selling the garden produce and how much you expect to make after accounting for all your expenses
 - b. How you are going to organize as a family to run the garden produce enterprise
 - c. How you will use the money that you earn from selling the garden produce
 - d. To whom you are going to sell the garden products, at what price, when, where and in what quantities
 - e. What garden vegetables, fruit or herbs you are going to sell and why you have chosen these products
 - f. What it is going to cost to plant, grow, harvest, handle/process and market the products you produce
 - g. What risks you may face during the production and marketing cycle and how you will overcome them if they occur
 - h. How and where you will find the monetary resources to pay for the labor and materials that you will need
 - i. Where, when and how you are going to plant, harvest and handle/process the products before sale

Activity

Gardening, with its emphasis on vegetable, fruit, flower and herb production (which are all perishable crops that demand healthy soil and often abundant water) faces many risks. Producing these crops for home consumption and for sale can add to these risks. Considering an existing or upcoming project, what are the risks that a gardener may assume when they decide to produce for the market and how can these be mitigated?

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Chapter 12, Annex 1. Garden Business Workbook

- Garden Business Worksheet 1: Markets
- Garden Business Worksheet 2: Production
- Garden Business Worksheet 3: Finance
- Garden Business Worksheet 4: Organization

These worksheets have been filled in using example information. For the clean tables in which you can capture your own information, see the *Garden Business Workbook Templates*.

Garden Business Worksheet 1: Markets

The purpose of this worksheet is to keep a record of what types of vegetables, fruit or herbs potential buyers want to purchase; how much they want to purchase; when; and at what price. The information you gather will help you make a decision about the options you should consider for growing crops in your homestead garden.

Finding out what customers want to buy

Families in your local community. The first potential buyer group are the families in your local community. In Table M1 you can record the information that you collect from them.

In the left-hand column are seven questions that will help you find out what they are buying now and where they are buying them, what their preferences are, what other products they would like to buy, and whether they may like to buy some of those products from you in the future. We have filled in the information from five imaginary families to give you an idea of how the information can be used to make decisions on what to grow.

It would be good for you to get information from five families to start. If you cannot get a clear idea of what the opportunities are from these families, increase the number to eight or ten families.

When you talk to families, let them know that you are thinking about growing vegetables, fruit and herbs for sale and that you want to know what products families are interested in buying. Ask each family all the questions. If you can memorize the questions and engage in a conversation rather than holding a formal interview, you may get useful additional information.

The fourth column on the right side of the table is where you summarize the information that you collected for each question. In the example, all the families said that they regularly bought tomatoes and onions, so we put “5” in parenthesis beside these products. Four families said that they regularly bought carrots, three families said they regularly bought cabbage, two families said leafy greens, and so on. The same summary is made for all the questions.

What does this information tell you? First, and most importantly, all the families said that they would buy from you. Then, if you add up all the times families have mentioned a product in all questions **except the first one**, it will give you an idea of the products that they: a) consume a lot of, b) want to buy more of, c) want to buy but cannot find, and d) would buy from you. In this imaginary case, leafy greens are mentioned nine times, carrots six times, bell peppers five times, and cabbage four times. All the others are mentioned once or twice, or not at all. This suggests that you would quite likely be able to sell leafy greens, carrots, bell peppers and cabbage to the families in the community.

Table M1. Finding out what products families in your local community buy or would like to buy

Questions to ask families in the community	Family name	Responses	Summary
What vegetables, fruit or herbs do you regularly purchase for preparing food for the family?	Davis	Tomatoes, onions, cabbage, bell pepper, carrots, mango, avocado, coriander	Tomatoes (5), onions (5), carrots (4), cabbage (3), leafy greens (2), coriander (2), bell pepper (2), mango (2), avocado (1)
	Godfrey	Onions, tomatoes, carrots	
	Bruno	Carrots, cabbage, onions, tomatoes	
	Patel	Bell pepper, leafy greens, coriander, mango, tomatoes, onions	
	Bello	Leafy greens, tomatoes, onions, carrots, cabbage	
	Davis	No, too expensive	
Do you purchase vegetables, fruit or herbs that have been conserved so that you can store them (e.g., dried and pickled vegetables or fruit made into jam)? If not, explain why not.	Godfrey	No, not sold in the village market	No (4), dried ginger (1) Reasons for NO: too expensive, not sold, no use, personally dries fresh chili pepper
	Bruno	No, no use for them	
	Patel	Yes, buys dried ginger from the Obando market	
	Bello	No, but buys chili peppers fresh from neighbor and dries them	
	Davis	Tomatoes, carrots, avocado	
	Godfrey	Carrots	
Which of these vegetables, fruit or herbs does your family like and consume a lot of?	Bruno	Cabbage, carrots	Carrots (3), leafy greens (2), cabbage (1), bell pepper (1), avocado (1)
	Patel	Leafy greens, bell pepper	
	Bello	Leafy greens	
	Davis	Bell peppers, carrots	
	Godfrey	Carrots	
	Bruno	Carrots, cabbage	
Which of these vegetables, fruit or herbs are you likely to purchase and consume more of in the future?	Patel	Leafy greens, bell pepper	Carrots (3), cabbage (2), leafy greens (2), bell peppers (2)
	Bello	Leafy greens, cabbage	
	Davis	Saturday village market and sometimes Obando City market	
	Godfrey	Saturday village market	
	Bruno	Saturday village market	
	Patel	Saturday village market, sometimes Obando market	
Where do you buy the vegetables, fruit and herbs that you consume?	Bello	Saturday market in the village and leafy greens from my neighbor	Saturday village market (5), Obando market (2), neighbors (1)
	Davis	Leafy greens, sweet potatoes, bananas, parsley	
	Godfrey	Bananas, squash, bell pepper, leafy greens	
	Bruno	Leafy greens, bell pepper, coriander	
	Patel	Avocado, squash	
	Bello	Mango, coriander	
What vegetables, fruit and herbs would you like your family to consume but you are unable to find in the market?	Davis	Yes, tomatoes, if you don't use chemicals	Leafy greens (3), bananas (2), squash (2), bell pepper (2), coriander (2), sweet potatoes (1), parsley (1), avocado (1), mango (1)
	Godfrey	Yes, leafy greens, because they will be fresh	
	Bruno	Yes, cabbage, the quality in the market is poor and coriander is difficult to get	
	Patel	Yes, any of them, we will know where they come from	
	Bello	Yes, leafy greens, we eat a lot of them and like them fresh	
	Davis	Yes, tomatoes, if you don't use chemicals	
If my family produces some of the vegetables, fruit and herbs that you mention, which ones would you like to buy from us and why?	Godfrey	Yes, leafy greens, because they will be fresh	Yes (5), leafy greens (2) tomatoes (1), cabbage (1) Reasons: fresh (2), good quality, availability, known source, no chemicals
	Bruno	Yes, cabbage, the quality in the market is poor and coriander is difficult to get	
	Patel	Yes, any of them, we will know where they come from	
	Bello	Yes, leafy greens, we eat a lot of them and like them fresh	
	Davis	Yes, tomatoes, if you don't use chemicals	
	Godfrey	Yes, leafy greens, because they will be fresh	

Local market stallholders. The second group of potential buyers is made up of the local market stallholders who sell vegetables, fruit and herbs and who may be interested in sourcing their products locally.

In Table M2 (on the next page), you can record the information that you collect from market stallholders. Your conversations with local families will have told you where they purchase their vegetables, fruit and herbs; they may even have given you the names of some stallholders. Before deciding who to talk to, take time to walk through the market and observe who is selling, what they are selling, and at what prices. Look out for the products that families have mentioned to you as ones that they buy now or would like to buy. This will help you to decide which stallholders you should talk to—at least five. If you do not feel satisfied that you have got the information you need, choose two or three more to talk to. We have filled in the table with information for two imaginary stallholders to give you an idea of what type of information you might expect.

Once you have asked the stallholders about what they buy and sell, you will ask them which of the products are in high demand and which products are scarce. These are the types of products that will have a ready market if you produce them. For these products, you will ask for additional information: how often the stallholder purchases the product, the minimum and maximum amount purchased, the quality of product desired, the price that they are willing to pay, and how you will be paid. For example, Mrs. Sanjo is interested in buying any or all of her stall products if they are “*fresh, of good quality, and delivered on time.*” Since the market is held on a Saturday, she would want you to deliver the produce to her at the market place by 5 in the morning. If you are selling cabbage, her minimum purchase is one head and maximum purchase is seven heads each week. She prefers heads of medium size and with the soil cleaned off. Now she is paying \$0.24 per head. Later, if you decide that cabbage is a good option, you will want to find out whether the price is stable or fluctuates during the year. Finally, Mrs. Sanjo will pay you on the same day for the produce you sell to her. See how this information is input into Table M2 below for two stallholders.

From the information gathered from Mrs. Sanjo and Mr. Williams, it appears that for these two stallholders, tomatoes, onions, cabbage, leafy greens and coriander are products that have a ready market.

Summary of what your potential customers want and need

From our imaginary sample of families and stallholders, you have found out that:

- **Families in the community** are interested in buying leafy greens, carrots, bell peppers and cabbage.
- **Local market stallholders** are interested in buying tomatoes, onions, cabbage, leafy greens and coriander.

Leafy greens and cabbage appear in both lists. This means that you would have a good chance of being able to sell these two products to families and local stallholders. Having more than one potential customer group is always a good thing because it lowers your risk if that one group, for some reason, does not want to buy, giving you the option of offering the produce to the other group.

But before making a final decision on producing some or all of these, we should look at what you will need to produce these products, how much it will cost, and whether you will make any money from selling them. We will use the Production and Finance Worksheets to collect and analyze that type of information.

Table M2. Finding out what products local market stallholders buy and sell*

Name	Questions to ask local market stallholders	Responses					
Mrs. Sanjo	What vegetables, fruits and herbs do you buy and sell on a regular basis?	Carrots, tomatoes, onions, cabbage					
	Do you buy and sell dried or processed products (pickles, jams, etc.)? If not, why not?	No, there are others who sell dried products					
	Which of the products you sell are in high demand or do you sell most of?	Tomatoes, onions					
	Which of the products you sell are scarce or difficult to obtain?	Cabbage					
	For each of these high-demand or scarce products, what is the:						
	Tomatoes	Frequency of purchase Weekly, on Saturday, delivered by 5 a.m.	Minimum purchase* 1 tin 2 tins 1 head	Maximum purchase 5 tins 6 tins 7 heads	Quality requirements Ripe and firm, plum variety No damage or rots Medium size, clean of soil	Buying price now** \$0.90 per tin \$0.65 per tin \$0.70 per head	Terms of payment Cash, same day
	Onions						
	Cabbage						
	When are prices high? When are they low? Why do prices fluctuate?		All prices fluctuate. Price of onions is more stable as they can be cured for longer storage. At the end of the dry season, prices are highest. During the rains, prices are lower. Tomato prices fluctuate most and can double during the dry season.				
	Which of the above products would you buy from us and why?		Any or all of the above if fresh, of good quality, and delivered on time				
Mr. Williams	What vegetables, fruit and herbs do you buy and sell on a regular basis?	Bell peppers, eggplant, leafy greens, coriander, parsley					
	Do you buy and sell dried or processed products (pickles, jams, etc.)? If not, why not?	No, but I would if someone offered them to me and I could sell them					
	Which of these products are in high demand or do you sell most of?	Bell peppers, leafy greens					
	Which of these products are scarce or difficult to obtain?	Coriander					
	For each of these high-demand or scarce products, what is the:						
	Bell peppers	Frequency of purchase Weekly, on Saturday, delivered by 5:00 am	Minimum purchase 1 tin 2 bunches 5 bunches	Maximum purchase 3 tins 6 bunches 10 bunches	Quality requirements Ripe, no damage Fresh leaves of amaranth and sweet potatoes Fresh	Buying price now \$0.30 per tin \$0.75 per bunch \$0.35 per bunch	Terms of payment Cash, same day
	Leafy greens						
	Coriander						
	When are prices high? When are they low? Why do prices fluctuate?		Prices of all products increase in the dry season. Prices are lowest during the rainy season. The price of leafy greens can triple in the dry season.				
	Which of the above products would you buy from us and why?		Leafy greens and coriander, because they are always in short supply in dry season. I already have supplier of bell peppers, but if demand rises, I may need to buy more.				

* The units of measure (tins, bunches, etc.) will vary from country to country and from one village or community to another. Use the unit that is common in your village. In this example, 1 tin of tomatoes weighs about 800 grams, 1 tin of onions weighs about 1,000 grams, 1 bunch of amaranth or sweet potato leaves weighs about 500g, and 1 bunch of coriander weighs 100g.

** Use the currency that you buy and sell with.

Garden Business Worksheet 2: Production

The purpose of this Worksheet is to bring together information on producing the crops that look as if they will have a ready market. When you have this information, it will help you decide which crops to grow based on the resources that you have or can access.

Step 1. Gathering information to narrow down production options

The first step is to narrow down the crop options that came up in your market interviews. The three criteria to help you decide whether to retain or eliminate an option are:

1. Is the seed of the crop readily available at a cost that the family can afford?
2. Are the soil and climate conditions suitable for production of the crop?
3. Is there local knowledge on how to produce the crop available from other families, local government, or nongovernment extension services?

Table P1. Where to obtain seed and its cost, and where to find information on how to produce the crops

Crop option	Seed*			Where can we get information about growing the crop?	Decision on taking the option forward (Yes or No)
	Where can we get seed?	Price of a packet	Number of seeds per packet		
Leafy greens	Local families for amaranth seed and sweet potato vines	Free	-	Families growing these crops	Yes, we would also eat these
Carrots	Obando City agriculture supply stores	\$2.30	400	Some information on packet, local government extension service	Yes, we already grow carrots
Cabbage	Obando City agriculture supply stores	\$2.20	400	Local government extension service	Yes
Tomatoes	Obando City agriculture supply stores	\$2.50	20	Local government extension service	Not sure, need more information
Onions	Obando City agriculture supply stores	\$2.20	300	Local government extension service	Yes, we always need onions
Coriander	A local family can provide seed	Free	-	Family growing coriander	Yes, we want to try in our own cooking
Bell peppers	Farmer in next village saves seed and sells plant seedlings	\$2.60	10	Farmer who sells seed and local government extension	Not sure, need more information

* The information on seed prices was taken from a seed company that supplies seed to all continents. The relative costs of seed are likely to be similar to the local cost.

Just as you did when collecting information on the market for vegetables, fruit and herbs, you will need to find people who can either provide you with information about seed or who can direct you to people who can. If there are families who are already producing vegetables in your village or community, they will be a good source of information, not only on where they get their seed, but also to share knowledge about how to grow the crops. Local stores that sell seed are the best places to get reliable information on prices. Other sources of information will be the local government extension service or local development projects run by NGOs like CRS.

Use Table P1 to record the information you will need to make a decision on whether to maintain or eliminate the options that you identified from the market information you gathered. The crop options that you decided to find out more about are listed in the left-hand column of Table P1. In the subsequent columns, there is information about where the seed can be obtained, how much a packet costs, how many seeds are in a packet, and where information can be obtained about how to plant the crops.

The information in Table P1 tells us important things about seed that are worth remembering. The price per packet of carrots, cabbage, tomatoes and onions ranges from \$2.20 to \$2.60. However, the number of seeds per pack varies, with 20 seeds in a packet of tomato seed to 300 to 400 seeds in a packet of carrots, cabbage or onion seed. This means that if all the seeds germinate, the seed price for each tomato plant is about 15 to 20 times higher than for a carrot, cabbage or onion plant. Though tomato seeds are more expensive, tomato plants produce for several weeks, and can get a good price in the market in the dry season. So, despite the seed being more expensive, selling tomatoes can have a better return than carrots, cabbage or onions.

This information helps you make decisions about what crops you might want to grow. Leafy greens, carrots, onions and coriander are vegetables/herbs that you can either grow now (carrots) or would like to grow—not only for sale but also for home consumption (leafy greens, onions and coriander). Cabbage is also an option. You need more information on tomatoes and bell peppers before deciding whether to grow them.

Step 2. Gathering Information to plan production

Once you know where to find information about the crops that meet the above criteria, the family needs to consider:

- a) How much it can produce on a given area of garden
- b) How long the crop takes to mature
- c) Whether it can be grown all year round
- d) How to plant and manage the crop until it is harvested
- e) Whether it needs any special attention
- f) What material resources are needed

Other important information has to do with the type of soil that the crop likes, how much water it needs, what pests and diseases attack it, and how these can be managed.

Table P2. Basic production information for selected crops

Crop	Planting time	Soil condition	Sowing and planting	Plant spacing		Care	Harvesting	Can seed be saved?
				Between plants, cm	Between rows, cm			
Carrots	Rainy season	Sandy soil	Soak seed for 12 hours before sowing directly into garden rows	5-8	15-20	Thin 7-10 days after germination. Thin a second time when plants are 10 cm tall. Always keep soil moist.	Harvest young carrots at 60 days and large carrots at 90 days after sowing	No, have to buy
Cabbage	Rainy season	Sandy loam to clay soil	Sow in seed bed and transplant seedlings 15-20 days after sowing	45	60	Shade transplanted seed for a week after transplanting. Always keep soil moist.	Heads are ready for harvesting 90 days after planting seedlings	No, have to buy
Onions	Rainy season	Sandy soil	Soak seed for 12 hours before sowing in seed bed and transplant into garden when plants are 10 cm tall	8-10	18-30	Keep free of weeds or use mulch to control weeds. Loosen soil frequently. Keep soil moist. Watering can be stopped when leaves start to turn brown and onions are close to harvest.	Harvest about 160 days after planting seedlings, when 50% of plant tops have fallen and leaves turn brown; dry in sun for 2-4 days; remove tops and store in cool, dry place	No, have to buy
Amaranth leaves	Year round	Any soil containing compost or cow dung	Broadcast the seed in well-prepared garden, cover lightly with soil, and then water; can be planted at intervals of 10-30 days for continuous production	8-13		Keep soil moist until seeds have germinated (4-6 days). Thin when plants are 5-8 cm tall. Keep bed free of weeds, and water daily in absence of rain.	Harvest after 25-30 days, pick leaves often to prolong harvest for 3 months	Yes—leave some plants to go to seed, collect, and dry
Sweet potato vines and roots	Year round	Many soils; prefers fine, sandy loam or well-drained clay loams	Plant 45 cm vine cuttings directly into garden; plant at an angle so the tip and half the stem is above ground	25	60	Remove weeds until vines cover the surface of the garden. Always keep soil moist.	Harvest vine tips year-round, starting 30 days after planting; harvest tubers 6 months after planting	Yes—use the vines or stored roots
Coriander	In cooler months	Any soil containing compost	Soak seed for 24 hours, dry, and then broadcast in well-prepared bed; cover lightly with soil and water	5		Thin to 5 cm between plants when 10 cm tall. Keep weeded and water daily unless it rains.	Plant and harvest in coolest months; harvest weekly from 30-100 days; plants will go to seed in hot months	Yes—leave some plants to go to seed, collect, and dry

* The information has been adapted from Attfield HH. 2001. *A tropical guide to year-round vegetable gardening*. VITA Technical Publication.

Table P2 uses the selected crops from Table P1 as an illustration. This more detailed information tells you several important things that may affect your decision about what to grow. For example, carrots, onions and sweet potatoes all need sandy soils to produce well. If your soils are heavy (they have a high clay content) you may be better off not growing these types of crops. Cabbage and onion seed are first raised in a seed bed that will also require special preparation. The “Care” column highlights the importance of thinning plants grown from seed, and the need to keep the plots weed-free and the soil moist. Therefore, availability of and access to water is a must. The “Harvest” column indicates the range of harvest dates to help calculate how many harvests are possible throughout the year. Finally, the last column shows the crops from which you will be able to save seed.

Using the information from Table P1, P2 and other sources, you can start to calculate how much you will be able to produce of each crop in a square meter over a period of one year. Once you know how much produce to expect from a square meter you will be able to make a garden plan and planting schedule, which you will enter into Table P3. Below is an explanation of where to find information for each column.

Planting time. In our example, carrots, cabbage and onions are better planted at the beginning of the season or during the rainy season. Others—like amaranth, sweet potatoes and coriander—can be planted all year round. Information about planting time is location-specific. Obtaining local knowledge is best, but in its absence, you may resort to trial and error.

Plant spacing. The spacing between plants is important and this information is usually available from employees of agricultural input shops, extension agents or local development projects. The information on seed packets is usually based on spacing for mechanization.

Approximate maximum number of plants per square meter. Using the plant spacing information, you can calculate the approximate number of plants that will grow in a square meter. It will also tell you how much seed to buy once you have decided how many square meters of each crop you will plant.

Yield per square meter per cycle. Information on yield is not easy to obtain. You will have to rely mostly on what farmers or families have experienced. Take the opportunity to visit farmers who are producing vegetables, fruit or herbs for sale and find out how much they are producing.

Cycle length and number of cycles per year. The production cycle starts from the date of planting (either seed or seedling plants that have been sown in a seed bed) to the date of harvest. Depending on the seasons, the cycle length will give you an idea of how many production cycles can be fitted into a year. For example, if there are two rainy seasons in the year, carrots, which are planted at the beginning of the rainy season and take 90 days from planting to harvest, will have two production cycles in a year. You can stagger planting so that seeds can be planted a month apart, and in that way produce and sell over a longer period.

Total production per year. From the previous calculations, you can estimate how much you can produce for each of the crops in 1 square meter. You multiply the number of cycles per year by the yield per square meter in each cycle. For amaranth, sweet potato leaves and coriander, these figures give us an idea of how many bunches can be produced for sale.

Table P3. Planning homestead garden production: Estimated production per square meter per year

Crop	Planting time	Plant spacing		Approximate max. no. plants per m ²	Yield per m ² per cycle*	Cycle length (days) from Table P2	No. cycles per year	Total production per m ² per year
		Between plants, cm	Between rows, cm					
		A	B	C = 100 cm/A x 100 cm/B	D	E	F	G = D x F
Carrots	Rainy season (3 months, twice a year)	5-8	15-20	(100/5) x (100/15) ≈ 130	3.6 kg	90	2	7.2 kg
Cabbage	Rainy season (3 months, twice a year)	45	60	(100/45) x (100/60) ≈ 3	4 heads	90	2	8 heads
Onions	Rainy season (3 months, twice a year)	8-10	18-30	(100/8) x (100/30) ≈ 60	3.6 kg	180	2	7.2 kg
Amaranth leaves	Year round	8-13		(100/8) x (100/8) ≈ 160	3.2 kg	120	3	9.6 kg (≈ 18 bunches of 500 g each)
Sweet potato vines and roots	Year round	25	60	(100/25) x (100/60) ≈ 7	Vines: 3.2 kg	Vines: 150	Vines: 2	6.4 kg (≈ 12 bunches of 500 g each)
					Roots: 1.5 kg	Roots: 182	Roots: 2	3.0 kg
Coriander	In cooler months	5		(100/5) x (100/5) ≈ 400	1.6 kg	45	4	6.4 kg (64 bunches of 100 g each)

* Yield information from multiple sources including: [The Digitalisation of African Agriculture Report, 2018-2019](#) | Albert S. Vegetable crop yields, plants per person, and crop spacing. Harvest to Table | Rabin et al. 2012.

Step 3. Making a planting calendar and garden plan

The information in Table P3 will help you decide when to plant and how much you can expect to produce from a given area dedicated to each crop.

First, we will use the information to visualize when best to plant and when to harvest. This is represented in Table P4. Your aim should be to produce and sell vegetables and herbs over as long a period as possible. At the top of Table P4, we have noted the months that correspond to the dry and rainy seasons. In this imaginary case, there are two rainy seasons (March–May and September–November) and two dry seasons (June–August and December–February).

The information that you gathered shows that carrots, cabbage and onions are best planted in the rainy season. For carrots and cabbage, you could plant in monthly intervals during the rainy season. This would mean that you will have carrots and cabbage for sale for a total of six months a year (May–July, and November–January).

Table P4. Planting and harvest calendar

Month	January	February	March	April	May	June	July	August	September	October	November	December
Season	Dry		Rain			Dry			Rain			Dry
Carrots			Plant		Harvest & sell				Plant		Harvest & sell	
				Plant		Harvest & sell				Plant		Harvest & sell
	Harvest & sell				Plant		Harvest & sell				Plant	
Cabbage		Sow	Transplant			Harvest & sell		Sow	Transplant			Harvest & sell
	Harvest & sell		Sow	Transplant			Harvest & sell		Sow	Transplant		
		Harvest & sell		Sow	Transplant			Harvest & sell		Sow	Transplant	
Onion		Sow	Transplant					Harvest, store & sell				
				Sow	Transplant					Harvest, store & sell		
		Harvest, store & sell						Sow	Transplant			
Amaranth leaves							Plant		Harvest & sell			
	Harvest & sell									Plant		Harvest & sell
	Plant		Harvest and sell									
Sweet potato leaves						Plant			Harvest & sell			
	Harvest & sell									Plant		Harvest & sell
		Plant										
Cilantro			Plant		Harvest & sell				Plant		Harvest & sell	
	Harvest & sell				Plant		Harvest & sell				Plant	Harvest & sell

The situation for onions is different. Onions can be cured—a process that dries their outer layers—after harvest and then stored (see Chapter 11 on Postharvest Handling). Simple storage structures, on which you hang onions in bunches to dry and which allow air to circulate around them, can extend their storage time by up to about 45 days. Being able to store and sell over a two-month period means that planting need only be done twice during each rainy season and you would have onions available to sell for eight months (August–November and February–May).

Amaranth and sweet potatoes can be planted all year round. For a continual supply of amaranth leaves, seed is planted every three months. Sweet potatoes, with a four-month growing cycle, are planted every four months. You will have both crops available to sell all year round.

Coriander needs to be planted in the wet and cooler season (in this example that season is March–May, or September–November), as it will go to seed if planted in the dry and hot season. This means that you will have coriander to sell for eight months of the year (April–July and December–March).

This planting schedule will no doubt change after the first year, once you have gained more experience.

You may find that for some crops you can extend the planting season and therefore have produce for sale over longer periods. Or, you may learn that some crops do not do as well as expected and you will need to shorten the planting season or stop growing them altogether.

Garden plan

Now, go back to the Marketing Worksheet and decide which customers to produce for and how much to plant. To do this, calculate how much area will be dedicated to the garden, how much of each crop will be used for home consumption and how much to grow for sale.

The local stallholders gave quantitative information about how much of the selected crops they would buy, except for carrots (see Table M2 on the Marketing Worksheet). With this information, estimate the area required per production cycle to meet home consumption and market demands. This is summarized in Table P5 (on the next page).

In column A of Table P5, estimate the weekly home consumption of the crops. The information in Columns B and C is taken from Table M2 of the Marketing Worksheet and shows the minimum and maximum amounts that stallholders said that they were prepared to purchase. In column D, estimate how much will be sold each week. To start with, be conservative in your estimates. If you manage to sell all that you produce, and your buyers are interested in buying more, you can increase production in the next cycle. Column E is the sum of columns A and D, which gives the total weekly harvest required for home consumption and sale. Then, from Table P4, estimate the number of weeks per year that you are able to harvest, by counting the number of months in which harvesting takes place and multiplying the result by 4. In column G, multiply the values in column E by the values in column F to give the total projected yearly production required of each crop for home consumption and sale. Column H is the estimated production of each crop per square meter per year taken from Table P3. And finally, column K gives the area that will need to be planted with each crop to satisfy both the demand for home consumption and sales, calculated by dividing the values in column G by the values in column H. Adding up the area required for each crop gives the total area of garden on which to grow crops for home consumption and sale in one calendar year. In this example, this is 54 square meters.

Now that you know what crops you are going to grow and the area you will plant of each, decide what is the best type of garden to use. Chapter 3 on Planning a Garden describes the different types of garden. For the combination of crops that you have selected to plant, the use of raised beds and conventional row gardens might be a good choice. Raised beds would be appropriate for carrots, cabbage, onions and coriander, for which you need a total area of 34 square meters. A conventional row garden would be appropriate for sweet potatoes and amaranth, for which a total area of 20 square meters is required. The principal reason for this choice is ease of weeding. In raised beds, weeding is easier since a space is left between beds to make it more accessible. Once sweet potatoes and amaranth have closed their canopy, weeding is not such an issue.

Once you have concluded this exercise to estimate how much area to plant, you should take the following into account:

- a) If you have insufficient space, or you do not want to start your garden with such a large area, you can then rework Table P5 to reduce the area required by either removing a crop or reducing the amount of each crop that you will grow.
- b) You are growing sweet potatoes for the sale of the leaves. However, at the end of each production cycle there will also be a harvest of the roots. In the 12 square meters of production (Table P5), an estimated 18 kg of roots will be harvested twice a year (see Table P3). These can be used either for home consumption or for sale. Between harvests, sweet potatoes can be cured and stored for up to four months (see Chapter 11 on Postharvest Handling).

Table P5. Estimate of the area required per production cycle for each crop to meet home consumption and market demands

Products	Estimated weekly home consumption	Weekly purchase by local market stallholders (from Table M2)		Projected sale per week from the garden	Total weekly harvest required for home consumption and sale	Number of weeks of harvest per year (from Table P4)	Total projected yearly production required for home consumption and sale	Production per m ² per year (from Table P3)	Number of m ² required per year
		Minimum	Maximum						
	A	B	C	D	E = A + D	F	G = E x F	H	K = G / H
Carrots	1 kg			2 kg	3 kg	24	72 kg	7.2 kg	10
Cabbage	1 head	1 head	7 heads	2 head	3 heads	24	72 heads	8 heads	9
Onions	0.5 tins*	2 tins	6 tins	2 tins	2.5 tins	32	80 tins	7.2 kg	11
Amaranth leaves	1 bunch**			2 bunches	3 bunches	48	144 bunches	18 bunches	8
Sweet potato leaves	1 bunch**	2 bunches	6 bunches	2 bunches	3 bunches	48	144 bunches	12 bunches	12
Coriander	2 bunches***	5 bunches	10 bunches	5 bunches	7 bunches	32	224 bunches	64 bunches	4

Notes: Approximate weight: * 1 tin of onions 1,000g. ** 1 bunch of amaranth or sweet potato leaves. 500g. *** 1 bunch of coriander, 100g.

Garden Business Worksheet 3: Finance

The tables in this Worksheet on Finance record the costs involved in production and marketing, and the income from sales of produce. This information is important for finding out whether families are making a profit or loss when they sell their crops. The planting of crops that the family has opted to grow is staggered to be able to supply buyers for as long a period as possible. This means that the costs incurred and income generated will be spread out over the year. Some of the costs involved, such as for seed, will be specific to a crop. But many of the costs, such as for the purchase of manure or labor for weeding, may not be crop-specific and will cover several of the crops planted. So, calculating the profit or loss from producing and selling a single crop is not easy, and it is better to make profit/loss calculations based on the whole garden. In the examples below, we will record costs and income over the period of a year.

Recording production and marketing costs

Production and marketing costs are divided into durable items, consumable items and labor. Durable items are those that will last for several years, such as garden tools, the raised beds, materials for making a compost heap, and fences to keep animals out of the garden. Consumable items are those that are used in one season or over a period of a year. Labor is divided into the work done by members of the family and work done by someone who is hired to do a job.

Cost of durable items

Table F1 below gives examples of typical durable items that will be used for several years. They include garden tools, wire netting to keep animals off the garden, baskets/tins used in harvesting and taking the produce to market, and a scale for weighing produce. In column C, the useful life of each of these items is estimated, so that in column D we can calculate the yearly cost of these items, which we will factor in when calculating the profit. Ideally, each year the gardener would set aside an amount equal to the yearly cost of the durable items so that there is money available to replace them when they come to the end of their useful life.

Table F1. Purchases of durable items and pro-rated cost per year over the life of the item

Date of purchase	Item	Unit	Quantity purchased	Price per unit	Years of useful life	Cost per year (\$)
			A	B	C	D = A x B / C
3 Sept	Spade	1.7 m, metal with wooden handle	1	\$8	8	\$ 1.00
	Hoe	1.7 m, metal with wooden handle	1	\$10	8	\$1.25
	Rake	1.7 m, metal with wooden handle	1	\$15	8	\$1.88
	Watering can	8-liter, plastic	2	\$8	5	\$3.20
	Machete	Machete	1	\$7	5	\$1.40
10 Oct	Wire netting	Roll, H 90 cm x L 5 m. Caliber 1.6 mm	10	\$40	10	\$40.00
15 Nov	Baskets	Woven, medium size	2	\$2	3	\$1.33
	Tins	Used 20-liter cooking oil tins	4	\$1	4	\$1.00
	Scale	5 kg mechanical scale	1	\$10	10	\$1.00
Total durable costs						\$52.06

Cost of consumable items

Table F2 below records the items that will be consumed over the course of one year’s production. In our case, seeds for carrot, cabbage and onions need to be purchased. The vines for planting sweet potatoes and amaranth are available free from local farmers. Farmyard manure may be needed depending on the fertility of the soil. Once the garden has a supply of its own compost, additional organic matter it is not likely to be needed.

Table F2. Purchases of consumable items and cost per year

Date of purchase	Item	Unit	Quantity purchased	Price per unit (\$)	Cost per year (\$)
			A	B	C = A x B
10 Jan	Farmyard manure	Load, 2 tons	1	\$20.00	\$20.00
15 Feb	Carrot seed	Packet of 400 seeds	1	\$2.30	\$2.30
	Cabbage seed	Packet of 400 seeds	1	\$2.20	\$2.20
	Onion seed	Packet of 300 seeds	1	\$2.20	\$2.20
4 April	Cord for tying bunches	Roll, 20 meters	1	\$1.30	\$1.30
Total consumable costs					\$28.00

Cost of labor

The nature of gardening is that there is likely to be some activity every day of the year. These activities include preparing the beds for planting, weeding, watering, making compost, and harvesting or selling. Tables F3a and F3b record the time that our imaginary family spent every day tending the garden during their busiest time of the year—February and March. In this example, the gardener is getting ready for the onset of the rains when they will plant carrots, cabbage and onions (see the planting and harvesting plan, Table P4).

Tables F3a and F3b have columns for “Family labor” and “Hired labor.” Small gardens will likely only need family labor. Our garden example is nearly 60 square meters, which is a size that might need a family to use hired labor for some tasks. In our example, we have included hired help once a week to help with general maintenance, weeding, making/turning compost and preparing the raised beds.

At the beginning, making a complete record of time spent in the garden is a good idea so that the family knows how much time it is spending on daily watering and maintenance of the garden, harvesting and preparing the crops for sale, and taking produce to market. As time goes by and a routine is established, it may not be necessary to record labor activities so meticulously. Recording the time the family spends in the garden, along with its monetary value, can help determine whether to reduce or increase the amount that is produced for sale.

To make it easy to value the labor input, columns D and J of Tables F3a and F3b are used to convert the time taken for an activity in hours and minutes (columns B/C and F/G) into person-hours, which take into account the number of persons (columns A and E) that do the job.

Table F3a. Labor use during February

Date	Activity	Family labor				Hired labor				Total labor
		No. of persons	Time taken		Labor	No. of persons	Time taken		Labor	Person-hours
			Hours	Min.	Person-hours		Hours	Min.	Person-hours	
A	B	C	$D = A \times (B + C/60)$	E	F	G	$H = E \times (F + G/60)$	$J = D + H$		
2/1	Watering, maintenance	1	1	0	1.00					1.00
2/2	Watering, maintenance	1	0	40	0.67					0.67
	Prepare seed bed, sow cabbage seed	1	0	45	0.75					0.75
2/3	Watering, maintenance	1	0	40	0.67					0.67
	Prepare seed bed, sow onion seed	1	0	45	0.75					0.75
2/4	Watering, maintenance	1	0	50	0.83					0.83
	Prepare sweet potato plot, plant vines	2	1	30	3.00					3.00
2/5	Watering, maintenance	1	0	50	0.83					0.83
2/6	Watering, maintenance	1	0	45	0.75					0.75
2/7	Watering, maintenance	1	0	30	0.50					0.50
	Harvest and sell carrots, cabbage, amaranth, sweet potato leaves	2	2	15	4.50					4.50
2/8	Weekly maintenance; watering	1	0	55	0.92	1	1	0	1.00	1.92
2/9	Watering, maintenance	1	1	5	1.08					1.08
2/10	Watering, maintenance	1	0	35	0.58					0.58
2/11	Watering, maintenance	1	0	25	0.42					0.42
2/12		0	0	0	0.00					0.00
2/13	Watering, maintenance	1	1	0	1.00					1.00
2/14	Watering, maintenance	1	0	20	0.33					0.33
	Harvest and sell carrots, cabbage, amaranth, sweet potato leaves	2	1	45	3.50					3.50
2/15	Weekly maintenance; watering	1	1	5	1.08	1	1	0	1.00	2.08
2/16	Watering, maintenance	1	0	45	0.75					0.75
2/17	Watering, maintenance	1	0	45	0.75					0.75
2/18	Watering, maintenance	1	1	15	1.25					1.25
2/19		0	0	0	0.00					0.00
2/20	Watering, maintenance	1	0	35	0.58					0.58
2/21	Watering, maintenance	1	0	20	0.33					0.33
	Harvest and sell carrots, cabbage, amaranth, sweet potato leaves	2	2	5	4.17					4.17
2/22	Weekly maintenance; watering	1	0	50	0.83	1	1	0	1.00	1.83
2/23	Watering, maintenance	1	0	35	0.58					0.58
2/24	Watering, maintenance	1	0	40	0.67					0.67
2/25	Watering, maintenance	1	0	50	0.83					0.83
2/26	Watering, maintenance	1	1	5	1.08					1.08
2/27	Watering, maintenance	1	0	55	0.92					0.92
2/28	Watering, maintenance	1	0	20	0.33					0.33
	Harvest and sell carrots, cabbage, amaranth, sweet potato leaves	2	2	10	4.33					4.33
Total labor use in February in person-hours					41				3	44

Table F3b. Labor use during March

Date	Activity	Family labor				Hired labor				Total labor
		No. of persons	Time taken		Labor	No. of persons	Time taken		Labor	Person-hours
			Hours	Min.	Person-hours		Hours	Min.	Person-hours	
		A	B	C	$D = A \times (B + C/60)$	E	F	G	$H = E \times (F + G/60)$	$J = D + H$
3/1	Weekly maintenance; watering	1	1	5	1.08	1	1	0	1.00	2.08
	Prepare raised beds	1	6	45	6.75	1	8	0	8.00	14.75
3/2	Watering, maintenance	1	0	40	0.67					0.67
	Plant carrots and coriander, transplant cabbage and onion seedlings	2	2	50	5.67					5.67
3/3	Watering, maintenance	1	0	40	0.67					0.67
3/4	Watering, maintenance	1	0	20	0.33					0.33
3/5	Watering, maintenance	1	1	5	1.08					1.08
3/6	Watering, maintenance	1	0	40	0.67					0.67
3/7	Watering, maintenance	1	0	30	0.50					0.50
	Harvest and sell onion, amaranth, sweet potato leaves	2	2	10	4.33					4.33
3/8	Weekly maintenance; watering	1	1	10	1.17	1	1	0	1.00	2.17
3/9	Watering, maintenance	1	0	45	0.75					0.75
3/10	Watering, maintenance	1	0	30	0.50					0.50
3/11	Watering, maintenance	1	0	40	0.67					0.67
3/12		0	0	0	0.00					0.00
3/13	Watering, maintenance	1	1	10	1.17					1.17
3/14	Watering, maintenance	1	0	40	0.67					0.67
	Harvest and sell onion, amaranth, sweet potato leaves	2	2	0	4.00					4.00
3/15	Weekly maintenance; watering	1	0	35	0.58	1	1	0	1.00	1.58
3/16	Watering, maintenance	1	1	5	1.08					1.08
3/17	Watering, maintenance	1	0	25	0.42					0.42
3/18		0	0	0	0.00					0.00
3/19	Watering, maintenance	1		55	0.92					0.92
3/20	Watering, maintenance	1	0	40	0.67					0.67
3/21		0	0	0	0.00					0.00
3/22	Weekly maintenance; watering	1	1	0	1.00	1	1	0	1.00	2.00
3/23	Watering, maintenance	1	0	30	0.50					0.50
3/24	Watering, maintenance	1	0	45	0.75					0.75
3/25	Watering, maintenance	1	0	35	0.58					0.58
3/26	Watering, maintenance	1	0	20	0.33					0.33
3/27	Watering, maintenance	1	0	45	0.75					0.75
3/28	Watering, maintenance	1	1	10	1.17					1.17
	Harvest and sell onion, amaranth, sweet potato leaves	2	1	50	3.67					3.67
3/29	Weekly maintenance; watering	1	1	0	1.00	1	1	0	1.00	2.00
3/30	Watering, maintenance	1	0	50	0.83					0.83
3/31	Watering, maintenance	1	1	45	1.75					1.75
Total labor use in March in person-hours					53				13	66

To calculate the cost of the total labor input in a year, we could assume that the labor input in a dry month (February) and the labor input in a wet month (March) will be similar for dry and wet months throughout the year. Table F4 below makes this assumption to estimate the total yearly labor used in the garden. Alternatively, the family can be meticulous about recording daily labor use throughout the year.

Table F4 shows that the family spent 564 hours tending the garden and selling the produce, and the value of this labor was \$282. They also the hired labor for 96 hours which cost them \$48.

Table F4. Yearly family and hired labor input and value

Type of month	No. of months	Family labor				Hired labor				Total labor used in a year	
		Amount used in typical month	Amount used in a year	Value of family labor	Total family labor value	Amount used in typical month	Amount used in a year	Cost of hired labor	Total hired labor cost	Amount	Value
		person-hours	person-hours	\$ per hour	\$	person-hours	person-hours	\$ per hour	\$	person-hours	\$
		A	B	C = A x B	D	E = C x D	F	G = A x F	H	J = G x H	K = C + G
Dry months	6	41	246	0.5	123	3	18	0.5	9	264	132
Wet months	6	53	318	0.5	159	13	78	0.5	39	396	198
Total yearly labor input, person-hours and value, \$			564		282		96		48	660	330

Total costs

We can now add up the costs of durables, consumables and labor to find out how much cash the family will need to pay out over a year, and record it in Table F5. In total, this comes to \$128.06. If they had to pay for family labor, total costs would increase to \$410.06.

Table F5. Total yearly garden costs

Type of cost	Without family labor included as a cost	With family labor included as a cost
Durable items	\$52.06	\$52.06
Consumable items	\$28.00	\$28.00
Family labor	0.00	\$282.00
Hired labor	\$48.00	48.00
Total yearly cost	\$128.06	\$410.06

Recording production volumes and income from sales

In the same way that we recorded the time spent looking after the garden, each time produce is harvested the amount should be noted on a worksheet. Harvesting, whether for family use or for sale, will usually be done on the same day as the produce is to be consumed or sold. Tables F6a and F6b provide a template, with sales for the month of February recorded. Note that in February, there is no harvest of carrots or coriander (see Table P4). Table F7 is the template for recording the amount harvested for home consumption, with the amounts for February included as an example.

Table F6a. Sales of carrots, cabbage and onions in February

Date	Buyer's name	Market/Neighbor	Carrots			Cabbage			Onions			Total income
			Quantity	Price	Income	Quantity	Price	Income	Quantity	Price	Income	
			kg	\$/kg	\$	Heads	\$/head	\$	kg	\$/kg	\$	\$
			A	B	C	D	E	F	G	H	J = G x H	K = C + F + J
05-Feb-15	Ms. Jemimah	N							0.5	0.7	0.35	0.35
07-Feb-15	Mrs. Sanjo	M				2	0.80	1.6	2	0.66	1.32	2.92
12-Feb-15	Mr. Jones	N							0.6	0.7	0.42	0.42
14-Feb-15	Mrs. Sanjo	M				2	0.80	1.6	2	0.66	1.32	2.92
21-Feb-15	Mrs. Sanjo	M				2	0.80	1.6	2	0.66	1.32	2.92
23-Feb-15	Ms. Jemimah	N							0.5	0.7	0.35	0.35
28-Feb-15	Mrs. Sanjo	M				2	0.80	1.6	2	0.66	1.32	2.92
Total sales						8		6.40	9.6		6.40	12.80

Table F6b. Sales amaranth and sweet potato leaves in February

Date	Buyer's name	Market/Neighbor	Amaranth leaves			Sweet potato leaves			Coriander			Total income
			Quantity	Price	Income	Quantity	Price	Income	Quantity	Price	Income	
			Bunch	\$/bunch	\$	Bunch	\$/bunch	\$	Bunch	\$/bunch	\$	\$
			A	B	C	D	E	F	G	H	J = G x H	K = C + F + J
07-Feb-15	Mr. Williams	M	2	0.80	1.60	2	0.75	1.5				3.10
12-Feb-15	Grace	N	1	0.85	0.85							0.85
14-Feb-15	Mr. Williams	M	2	0.80	1.60	2	0.75	1.5				3.10
21-Feb-15	Mr. Williams	M	2	0.85	1.70	2	0.75	1.5				3.20
23-Feb-15	Jemimah	N	1	0.85	0.85							0.85
28-Feb-15	Mr. Williams	M	2	0.85	1.70	2	0.75	1.5				3.20
Total sales			10		8.30	8		6.00	0		0.00	14.30

C = A x B | F = D x E

Table F7. Amount of produce harvested for home consumption in February

Date	Carrots kg	Cabbage Heads	Onion kg	Amaranth Bunch	Sweet potato Bunch	Coriander Bunch
01-Feb-15		1	0.20			
02-Feb-15						
03-Feb-15				1		
04-Feb-15						
05-Feb-15			0.30		1	
06-Feb-15						
07-Feb-15						
08-Feb-15				1		
09-Feb-15		1				
10-Feb-15			0.20			
11-Feb-15					1	
12-Feb-15						
13-Feb-15						
14-Feb-15				1		
15-Feb-15			0.40			
16-Feb-15						
17-Feb-15		1			1	
18-Feb-15			0.20			
19-Feb-15						
20-Feb-15						
21-Feb-15						
22-Feb-15			0.20	1		
23-Feb-15		1				
24-Feb-15						
25-Feb-15			0.30		1	
26-Feb-15						
27-Feb-15						
28-Feb-15			0.50			
Total home consumption, February	0	4	2.30	4	4	0

At the end of the year, the harvest information that has been collected each month (Tables F8a and F8b) are brought together to show the yearly results for each crop. These results are then summarized in Table F9. This enables us to calculate the value of the produce used for home consumption (column F) and the total value of production (column G). To calculate the value of the produce used for home consumption, we use the average price received for the crop over the year. This will give us a conservative estimate of the value of the produce. The family would likely have had to pay more should they have had to purchase the same products in the market. Table F9 shows us that over the year the garden generated income of \$356.65 and the value of the produce that was used for home consumption came to \$141.26.

Table F8a. Monthly household consumption, sale and income for carrots, cabbage and onions

Month	Carrots				Cabbage				Onions			
	Amount consumed	Amount sold	Total production	Income	Amount consumed	Amount sold	Total production	Income	Amount consumed	Amount sold	Total production	Income
	kg	kg	kg	\$	Heads	Heads	kg	\$	kg	kg	kg	\$
	A	B	C = A + B	D	E	F	G = E + F	H	J	K	L = J + K	M
January	3.20	8.80	12.00	8.80	3	8	11	6.00	0.00	0.00	0.00	0.00
February	0.00	0.00	0.00	0.00	4	8	12	6.00	3.70	9.60	13.30	6.72
March	0.00	0.00	0.00	0.00	0	0	0	0.00	4.20	8.50	12.70	5.95
April	0.00	0.00	0.00	0.00	0	0	0	0.00	4.00	8.40	12.40	5.88
May	4.40	8.00	12.40	6.88	0	0	0	0.00	3.50	9.00	12.50	6.30
June	4.00	8.00	12.00	6.88	1	8	9	6.00	0.00	0.00	0.00	0.00
July	3.20	8.00	11.20	8.00	1	8	9	6.00	0.00	0.00	0.00	0.00
August	0.00	0.00	0.00	0.00	1	8	9	6.00	4.60	9.00	13.60	6.30
September	0.00	0.00	0.00	0.00	0	0	0	0.00	3.70	8.00	11.70	5.60
October	0.00	0.00	0.00	0.00	0	0	0	0.00	3.80	8.30	12.10	5.81
November	3.20	8.80	12.00	7.57	0	8	8	6.00	4.00	8.00	12.00	5.60
December	4.00	8.00	12.00	6.88	5	8	13	6.00	0.00	0.00	0.00	0.00
Yearly totals	22.00	49.60	71.60	45.01	15	56	71	42.00	31.50	68.80	100.30	48.16

Table F8b. Monthly household consumption, sale and income for amaranth/sweet potato leaves and coriander

Month	Amaranth leaves				Sweet potato leaves				Coriander			
	Amount consumed	Amount sold	Total production	Income	Amount consumed	Amount sold	Total production	Income	Amount consumed	Amount sold	Total production	Income
	Bundles	Bundles	Bundles	\$	Bundles	Bundles	Bundles	\$	Bundles	Bundles	Bundles	\$
	A	B	C = A + B	D	E	F	G = E + F	H	J	K	L = J + K	M
January	3	12	15	9.60	3	9	12	6.30	6	22	28	7.70
February	4	9	13	7.47	4	8	12	5.60	0	0	0	0.00
March	4	9	13	7.47	5	8	13	5.60	0	0	0	0.00
April	5	8	13	6.64	3	9	12	6.30	5	20	25	7.00
May	3	9	12	7.20	2	10	12	7.00	6	22	28	7.70
June	6	8	14	6.40	4	8	12	5.60	6	30	36	10.50
July	2	8	10	6.40	5	8	13	5.60	7	21	28	7.35
August	4	9	13	7.20	4	8	12	5.60	0	0	0	0.00
September	5	8	13	6.40	4	8	12	5.60	0	0	0	0.00
October	3	9	12	7.20	3	9	12	6.30	8	18	26	6.30
November	5	8	13	6.40	5	8	13	5.60	7	21	28	7.35
December	3	10	13	8.00	4	11	15	7.70	6	24	30	8.40
Yearly totals	47	107	154	86.38	46	104	150	72.80	51	178	229	62.30

Table F9

Crop	Unit	Amount consumed	Amount sold	Total production	Income generated	Average price	Value of produce consumed	Total value of production
					\$	\$/unit	\$	\$
		A	B	C	D	E = D / B	F = A x E	G = D + F
Carrots	kg	22.00	49.60	71.60	45.01	0.91	19.96	64.97
Cabbage	Head	15	56	71	42.00	0.75	11.25	53.25
Onions	kg	31.50	68.80	100.30	48.16	0.70	22.05	70.21
Amaranth leaves	Bundle, 500g	47	107	154	86.38	0.81	37.94	124.32
Sweet potato leaves	Bundle, 500g	46	104	150	72.80	0.70	32.20	105.00
Coriander	Bundle, 100g	51	178	229	62.30	0.35	17.85	80.15
Totals income and value					356.65		141.26	497.90

Calculating profit or loss

Bringing together the information generated in Tables F5 and F9 allows us to calculate whether the garden has made a profit or a loss. The costs (Table F5) and the income earned and value (Table F9) make up the basis of this calculation (Table F10).

In column A of Table F10, the value of family labor and the value of food consumed are excluded from the calculations. Neither of these costs (family labor) or income in kind (produce consumed at home) require an outlay of cash. The profit of \$228.59 is therefore the amount of cash that the family will have earned, once the production and marketing costs have been deducted. This profit can be used to cover future costs of production and other household necessities.

In column B, the value of family labor and the value of the food consumed have been included. This gives a more realistic understanding of the profitability of the garden and should be used as a guide when making decisions about how to reduce costs (including family and hired labor) and increase income.

Column C shows that if we include a payment for family labor and exclude the value of the food, then the garden would make a monetary loss.

And finally, Column D shows that if we exclude the value of family labor and include the value of the food consumed, the perceived profit is substantial. So, if the produce was sold rather than being consumed by the family, more cash would be available. However, the additional cash might not buy the same amount of food and the food bought might not be as nutritious.

Table F10. Garden profit and loss calculation

Cost and income	A	B	C	D
	Excluding the value of family labor and the value of produce consumed by the family	Including the value of family labor and the value of produce consumed by the family	Including the value of family labor but excluding the value of food consumed by the family	Excluding the value of family labor but including the value of the food consumed by the family
	\$	\$	\$	\$
Costs				
Durable items	52.06	52.06	52.06	52.06
Consumable items	28.00	28.00	28.00	28.00
Family labor	0.00	282.00	282.00	0.00
Hired labor	48.00	48.00	48.00	48.00
Total yearly cost	128.06	410.06	410.06	128.06
Income and value				
Income from sales	356.65	356.65	356.65	356.65
Value of food consumed	0.00	141.26	0.00	141.26
Total yearly value	356.65	497.91	356.65	497.91
Profit	228.59	87.85	-53.41	369.85

The two important conclusions from this analysis are:

- a) It is important to put a value on family labor. Other crop combinations may prove to be more profitable and reduce the amount of time that family members dedicate to the garden. If you do not keep records, you won't know.
- b) It is also important to put a value on the produce consumed by the family and include it as a benefit so that you can appreciate the contribution that the garden makes to income generation and the health of the family through the provision of nutritious food.

Garden Business Worksheet 4: Organization

The success of the garden venture, particularly when it comes to selling produce to make money, will hinge on good organization and planning. A plan is a list of a) activities that need to be done (what), b) someone responsible for doing the activity (who), and c) the time frame within which the activity will need to be completed (when). The plan, once it is written out, becomes a checklist that can be used periodically to review what has been done and what remains to be accomplished. Table O1 (on the next page) is a template that can be used to develop the plan. It is divided into sections that represent the principal steps in setting up and running a garden.

1. **Before planting:** These are the activities that you will need to carry out to decide who will manage the garden, what crops you will grow, how much of each crop you plan to consume, how much to sell, and to whom you will sell. Also, there will be start-up costs to cover the purchase of any tools and materials you will need. A planting and harvesting schedule is made.
2. **Planting:** Production of garden crops for home consumption is a continuous activity that spans the whole year, and timeliness is key to meeting the needs of potential buyers. Records of seed used, planting dates and germination rates are kept.
3. **Managing:** Crop management activities include watering, weeding and pest/disease surveillance. Records of daily activities, the emergence of pests and disease, and the practices used to manage them are kept.
4. **Harvesting and selling:** Timeliness in harvesting is also important for meeting the needs of buyers. Appropriate containers need to be on hand for transport, sorting and packing, with care taken to ensure the quality of the produce is maintained. Records of amounts harvested for home consumption and sale are kept. Relationships with potential and existing buyers are maintained. Amounts sold and prices paid are recorded.
5. **After selling:** At the end of a production cycle—or at the end of the year—the production and sales performance of the gardening activity is assessed. Decisions are made and recorded to show any changes in production and sales of crops.

In Table O1, some of the typical activities that need to be undertaken are included as examples. Many of them have been mentioned in the accompanying text on the Marketing, Production, and Finance Worksheets. In the “Comments” column, the garden manager should record decisions made where appropriate, e.g., at the end of a production cycle on changes to the crops and areas to be planted in the next cycle.

Table O1. Garden implementation plan (under each step, example entries are provided)

Steps	Activity	Responsible	Support	Period	Decisions taken and comments
Before planting	Decide who will responsible for managing the garden (garden manager) and who else in the family will be involved in helping to run it (support team)	<i>Female head of household</i>	<i>Male head of household</i>	<i>August, current year</i>	<i>Grace will be in charge of the garden. Ahmed (husband) will establish the garden site. Alice (daughter, 18 years) and David (son, 14 years) will help with record-keeping and day-to-day tasks</i>
	Collect market information from potential buyers to find out what produce is in demand and make a list of crop production options	Grace	Ahmed, Alice	September, current year	Options: Carrots, cabbage, onions, leafy greens, coriander, tomatoes and bell peppers
	Collect production information on the options selected and make final decision on what to produce, how much, and to whom to sell	Grace	Ahmed, Alice	September, current year	Chosen: Carrots, cabbage, onions, amaranth leaves, sweet potato leaves and coriander
	<i>Prepare planting and harvesting calendar</i>	Grace		<i>By end of first week of October, current year</i>	
	<i>Select garden type(s) and map how the garden beds will be distributed</i>	Grace		<i>By end of first week of October, current year</i>	<i>Raised beds for carrots, cabbage and onions; conventional rows for amaranth and sweet potatoes</i>
	<i>Lay out the garden, prepare the beds, and work in organic soil amendments</i>	Grace	Ahmed, Alice, David	<i>By third week of October, current year</i>	<i>Requires 1 day of hired labor</i>
	<i>Purchase tools and materials needed to set up/tend the garden and to prepare the produce for sale</i>	Grace		<i>By end of October, current year</i>	
Planting	<i>Purchase seed (carrots, cabbage and onions)</i>	Grace		<i>By mid-January, next year</i>	
	<i>Obtain amaranth seed from neighbors and sow</i>	Grace	Alice, David	<i>By mid-January, next year</i>	
	<i>Obtain sweet potato vines and plant</i>	Grace	Alice, David	<i>By end of January, next year</i>	
	<i>Obtain coriander seed and plant</i>	Grace	Alice, David	<i>By first week of February, next year</i>	
	<i>Prepare seed bed and plant cabbage and onions</i>	Grace	Alice, David	<i>By end first week March, next year</i>	

Steps	Activity	Responsible	Support	Period	Decisions taken and comments
Managing	Prepare rotation for daily tending of garden	Grace	Alice, David	By end December, next year	
	Maintain record of time spent on crop management tasks	Alice	Grace, David	Ongoing	
	Water beds	Grace	Alice, David	See planting and harvesting calendar	
Harvesting and selling	Consult with buyers on delivery schedule for produce and prepare harvesting plan and confirm quantity, quality, price and payment conditions	Grace		By end December, next year	
	Maintain records of time spent on harvesting and taking produce to market	Alice	Grace, Ahmed, David	Ongoing	
	Take produce to market for sale	Grace	Alice	Weekly, based on harvest schedule	
After selling	Visit potential new buyers and update market information	Grace	Alice	September–November, next year	
	Prepare cost and income tables for review of garden performance and decisions on cropping and purchases for the following season	Alice	Grace	By mid-December, next year	

Chapter 13: Behavior Change

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Learning objectives

After studying this chapter and its resources, you will know how to:

- Describe how applying behavior change (BC) principles could increase the adoption of gardening.
- List some formative research methods for understanding the context and point of view of the target group, factors that facilitate uptake of new practices or technologies, and both perceived and real constraints to the practices necessary for gardening.
- Describe the stages individuals go through when adopting a new practice or technology, and identify what project interventions or activities are needed to move people from one stage to another.

Key messages

- Knowledge does not equal behavior change; it is action by the target group that counts.
- Behavior change includes various forms of communication but also actions to create an enabling environment.
- The basis of achieving sustained BC is conducting good formative research.
- In adopting new practices, individuals go through stages of change with each stage requiring different BC activities to move them to the next stage.
- Gardening is a complex practice comprised of several activities, and not everyone is going to adopt gardening; many will adopt only after they see the success and benefits of others.

Key questions for decision-making

1. What behavior do we want to change?
2. Who are the target groups and influencers of this behavior?
3. What formative research methods/tools should we use?
4. What stage of change is the targeted audience at?

Behavior change is important for gardening

In 2014–2015, the CRS Ethiopia-led Food for Peace Development Food Aid Program learned that only 15% of keyhole gardens were functional after 1.5 years of construction. To understand why 85% of the gardens were not functioning, the program conducted a barrier analysis that revealed that behaviors related to perceived self-efficacy, positive/negative consequences, cues for action, perceived susceptibility and perceived action efficacy were significant determinants of adopting the behavior (Yohannes and Steelman 2015). Based on these findings, the project adapted its approach to be more integrated. They worked closely with the local agriculture and food security extension workers, health extension workers, and other woreda (district) stakeholders to build capacity to support beneficiaries in vegetable preservation and behavior change that promoted consumption over sale of vegetable production, and collaboration with local government and agro-dealers in making seed available for purchase.²⁶

Applying behavior change principles to gardens will help projects increase the number of individuals adopting and maintaining gardens. A fundamental principle is that increasing knowledge and skills, without creating the motivation and an enabling/accepting environment or addressing other barriers to change, will not bring about widespread BC. Behavior change offers the means to identify specific motivating factors or drivers of change and identify what is holding someone or a group of people back from making a change, i.e., the barriers or constraints. This chapter draws on concepts and principles of BC from different fields of study that can be useful in designing, implementing and evaluating uptake and maintenance of gardens.

Defining behavior change

Behavior change addresses behavioral, social, economic and cultural factors to achieve a change intended to improve well-being of a specific population. Behavior change includes not only communication (often expressed as BCC), but also actions to create an enabling environment for sustained change. The actions may include provision of needed systems (ongoing technical support from agricultural extension workers), services, or infrastructure (sustainable sources of seeds, tools or drip irrigation materials), formulation of supportive policy (local government rescinds market tax for products), or measures to sway social norms²⁷ (events to make gardening a fun, profitable and acceptable use of time). There are five tenets of behavior change accepted across fields of research that need to be considered:

1. Know exactly who the target group is and look at everything from *their* point of view.
2. The *action* is what counts, not the knowledge or the intent to change.
3. People take action when it *benefits* them. *Constraints or barriers* keep them from acting.
4. Social norms matter to most people.

Behavior change includes not only communication, but also actions to create an enabling environment for sustained change

26. Email discussion between Mekonnen Tesfamariam, CRS Ethiopia Country Program and Valerie Rhoe Davis on June 27, 2018.

27. Pattern of behavior in a particular group, community or culture, accepted as normal and to which an individual is expected to conform. For more information, see [Sociology Guide](#).

5. The decision to change behavior or adopt a practice is not necessarily rational nor linear.

In the following sections, we will explain these principles²⁸ and how to apply them through steps to answer these questions:

1. What is a behavior?
2. Who is the priority target group?
3. How do we learn the viewpoint of the priority target group and those who influence them?
4. What can we do to promote adoption and maintenance of gardens?
5. How can we measure uptake and maintenance of gardens?

What is a behavior?

A behavior is defined by six criteria. It is a behavior if it is:

- An action
- Observable
- Specific (time, place, duration or frequency)
- Measurable
- Feasible
- Directly linked to an intended outcome

For readers of this manual, an obvious example of a behavior is “gardening,” but does it meet the criteria for a behavior statement? It is an action or a series of actions, such as preparing the land, planting seeds, monitoring pests and disease, etc. All of these actions are observable, so we can measure the action or actions through observation or survey. However, to meet all the criteria of a behavior statement, we would need to expand our statement to include more details such as:

**Producing enough vegetables at home, all year round,
to improve the family dietary diversity every day.**

Gardening is a complex behavior and a composite of many practices: making compost; building beds or structures; acquiring and properly planting seeds; watering properly; controlling weeds, pests and disease; and harvesting and using good postharvest management practices. Each of these behaviors can also be written as its own behavior statement:

- Using locally available materials to make enough compost to fill a 1-meter-square raised bed twice a year
- Planting seeds at the proper depth every time
- Providing sufficient water to plants to maintain good growth in times of dry weather
- Removing weeds that compete with vegetable plants at least every week
- Applying homemade organic pesticides whenever troublesome insects appear

28. Adapted from Jimerson A et al. 2004. *Applying the BEHAVE Framework: A workshop on strategic planning for behavior change*. USAID/CORE Group.

Who is going to do the behavior?

Next, we have to define who is going to do the behavior. Do we expect all family members to be equally involved? Do we, as stated in the chapters on marketing and gender, want women to be the primary gardeners to keep them in control of the use of the produce? Is the overall program targeting a particular group of women? If so, that has to be included in the behavior statement, which might now read:

- Mothers of children under 2 years will grow enough vegetables at home, all year around, to improve family dietary diversity every day.

Or maybe our target group is older women who need to generate some income to help sustain the family members they live with. Our behavior statement would be:

- Grandmothers will grow and sell enough vegetables to be able to contribute [amount] of income toward family expenses.

The people named in our behavior statement (mothers of children under 2 or grandmothers in the examples) become our primary target group. They may need help, support or approval from others, who are considered influencers (see box below). We must first learn about the priority target group, their interest, needs, constraints, and perceptions of gardening and, from those, we will learn the role of the influencers. It is also often useful to talk directly to the influencing group, particularly where they are expected to be highly influential over behavior. Teams should build time into their formative research plans to allow for follow-up discussions with influencers.

Definitions of primary and secondary target groups

Primary target group: Individuals who will perform the action/behavior or lead a group behavior

Influencer: People who could provide help, support or approval of the primary target group in order for them to adopt and maintain the new behavior

Target group's point of view

A basic principle is that people are disposed to adopting a new practice or technology when they perceive their individual benefits or advantages to outweigh the perceived barriers (Jimerson et al. 2004). It may be affected by their cultural belief system, values and experience. Sometimes the perception matches reality, sometimes it does not. For example, one person may perceive that they do not have enough space for a keyhole garden (reality), and their neighbor perceives that growing vegetables is much more work than growing field crops (perception).

The benefits may not be what we, as development practitioners, perceive as priorities. For example, we may be promoting gardens to increase dietary diversity or consumption of food sources of vitamin A or iron, but the target group is motivated by potential income or being satisfied with an accomplishment. How do we know what our target group perceives as benefits or barriers? We learn these through formative research. In designing BC activities, our point of view no longer matters; we have to set that aside and work from the target group's point of view.

Tools for formative research



CRS staff conduct formative research in a market in Myanmar.

Photo by Thanng Za Lian for CRS

Formative research is all about learning from the target group. Using qualitative methods, we can better understand the results of the quantitative survey and why people do or do not do something. Generally, formative research is conducted before starting project activities to inform the way we will go about planning and implementing activities, but it can also be conducted for ongoing improvement of interventions and for evaluation. There are many formative research methods, but two have been extensively used with agricultural projects, and found particularly useful for learning the perspectives of the target group around gardening: 1) Positive deviance inquiry and 2) the doer/non-doer (DND) methodology. In addition to these two formative research methods, there are also focus group discussions (FGDs) and participatory rural appraisal (PRA).

Positive deviance

A good starting point for formative research is to look for *positive deviants*, that is people who are already doing the practice we plan to promote (gardening) before the project starts. They may not be doing it using all the same technologies we want to promote, but they are growing some vegetables for their own consumption and/or for selling. A positive deviant is not a commercial producer or someone with lots of land and resources; rather, they are very like the rest of our target group with similar resources, education and life experience.

From this person, the most important things we can learn are:

- What motivates them to grow their own vegetables?
- What challenges have they faced, and how have they overcome those challenges?
- Where did they learn about growing vegetables?

We can visit these people to have a conversation on these topics, and observe their solutions and practices with an aim of sharing this with other people. As stated above, positive deviants may grow vegetables without using all the proper techniques and may not necessarily be respected in their community for other reasons; therefore, they are not models. They may not even have the personality to teach other individuals, let alone lead groups. Therefore, we should see them only as key informants—people from whom we can learn in order for our project to motivate others or assist others in the same population to overcome challenges to growing vegetables. A complete guide to identifying and learning from positive deviants is [*Basic Field Guide to the Positive Deviance Approach*](#) (Tufts University 2010).

Doer/Non-doer methodology

The DND methodology involves surveying a certain number of people who **do** and a certain number of people who **do not** take up the practice we are promoting to learn what motivates or makes it feasible for some and what stands in the way of others taking up the behavior. This survey is only useful if there are already a considerable number of doers, that is, people practicing the desired behavior. DND is usually appropriate after the innovation is quite well-known and is being practiced by some people because there have to be enough doers to learn from in comparison to the non-doers. It is helpful in designing project activities and messages or to improve activities already underway.

A *doer* is a person performing the desired behavior as spelled out in the behavior statement discussed earlier—someone in the target group who *grows enough vegetables at home, all year around, to improve the family dietary diversity every day*. Someone who grows only a few carrots during the rainy season would not be considered a doer. A *non-doer* may be someone who does not grow any vegetables at all, or who only grows some, or only grows them for part of the year. The criteria for deciding who is a non-doer depends on why you are going to study them. Do you want to find out why some people are not taking up gardening at all? Or, do you want to find out why some only do it for part of the year, or why they grow only a few vegetables? The initial question to separate doers from non-doers would change accordingly:

- To find out why some people are not taking up gardening at all, ask: *Do you grow any vegetables for your family to consume?* (You could also discern this by observing whether they have a garden.)
- To find out why some people are only growing vegetables for part of the year, ask: *Do you grow vegetables in all months of the year?*
- To find out why they grow only a few vegetables, ask: *Do you grow enough vegetables for your family to eat some every day of the year?*

There are two versions of the DND survey. The original one consists of only seven questions that can be tabulated manually and requires a sample of 20 doers and 20 non-doers. These questions have been scientifically validated to determine the most important factors that facilitate or impede BC from the viewpoint of doers and non-doers, particularly those factors that apply to agricultural practices like gardening (Middlestadt 1996, Dooley 2007, Arbuckle and Roesch-McNally 2015).

The second version, known as barrier analysis (BA), started from the same seven questions, but many more were added that were derived from theories on health behavior not yet shown through rigorous research to be useful for adoption of agricultural practices. It requires a much larger sample of doers and non-doers and basic statistical analysis, which makes it more time-consuming and difficult for field teams to conduct. The original DND survey is the most useful and practical for gardens and related practices. The instructions for conducting DND surveys and three sample survey instruments, based on the questions above, are found in the Annex. More information on barrier analysis can be found in:

- [A Practical Guide to Conducting a Barrier Analysis](#) (Kittle 2013)

The box below presents findings from an actual DND study. If the results of the DND indicate that one component of gardening, such as making compost or saving seed, is holding people back from growing gardens, then, another DND will be necessary to understand the issue with that component. Therefore, when planning formative research using the DND/BA approach, teams are advised to build time into the plan to allow for additional follow-up exploration of issues that arise from the original findings.

Example findings from a DND survey in Nepal on uptake of gardens

Almost all doers and non-doers could recite the benefits of growing vegetables to provide better nutrition for their families and to earn extra income. The principal disadvantage mentioned by both doers and non-doers was that growing vegetables took time away from caring for field crops. The doers said it was easy to grow vegetables if they had land close by, help from other family members, and access to seed. The non-doers said having help from family and available land made it easy, but many non-doers said not having land close by was what made it difficult to grow vegetables. Both groups said that their in-laws and husbands were supportive and no one was against them growing vegetables. Therefore, the limiting factor in uptake of gardening was *unavailability of land near the house*. This is the barrier the project would have to decide how to address.

A word of caution about DND: if those being interviewed have been hearing promotional messages, they may tell you what they think you want to hear. In other words, when asked about the benefits of gardening, they may simply repeat back what they have been told by project staff. That does not mean they understand what they have heard or truly believe it. For example, they may say the benefit of raising vegetables is to prevent malnutrition or that their children will not be as likely to become malnourished. In this case, probing is required to learn whether they understand what “malnutrition” means and what types of malnutrition may be prevented by consuming garden produce. If they cannot explain, it is likely they are just repeating a message without having internalized it. Likewise, if there has been a clear message to project participants that they should grow vegetables to consume, but they are selling some, they may hesitate to admit selling vegetables is a benefit.

If those being interviewed have been hearing promotional messages, they may tell you what they think you want to hear.

A limitation of DND (or barrier analysis) surveys is that we do not learn the whole situation. For example, a non-doer may say her husband does not approve of her having a garden. The methodology does not allow us to ask why the husband does not approve. We need to do more formative research to learn the whys, and this should be built into the planning for formative research.

Another limitation is that behaviors need to be very specific in order to generate meaningful results. “Growing vegetables in a home garden” may not be specific enough to get useful findings (given the number of “sub-component” behaviors associated with gardening). DND/BA does not really get at whether differences between doers and non-doers are driven by access to resources/assets or socio-economic status. Therefore, the follow-on focus group discussions need to include questions on access to land, water, irrigation, seed, etc. to help ground the findings and enable design of effective interventions.

Focus group discussions

Focus group discussions are the most widely used formative research method. With clear objectives and questions and led by a good facilitator, FGDs can yield a wealth of information about the context and target group. Many guides for conducting quality focus groups are available including [Research tools: focus group discussion](#). A rule of thumb for quality FGDs is the 10/10 rule: No more than 10 questions and no more than 10 participants.

Focus groups can be very useful in new projects before any activities are designed.

Focus groups can be very useful in new projects before any activities are designed. Through such discussions, we can learn about the context and the target population’s situation in-depth. Do they have access to land, materials for compost, water for irrigation, etc? Do women have time? Who in the household would decide whether a young mother could grow vegetables? Questions on behavioral determinants that would be explored through DND/BA can be included. The discussions can be accompanied by careful observations in the target area.

It is useful to follow up DND/BA with focus group discussions with groups of doers, non-doers and influencers, to further explore issues raised in the initial findings, either separately or in mixed groups. In the case of the findings from Nepal in the box above, the line of questioning might look like this:

- How far away from your house is your land? How far would you be willing to go every day to tend a vegetable garden?
- Is there a way to make some small space near your house in the compound (this question could be combined with observations in the households)?
- Who in your household would have to approve making some change in order to create space for gardening? How could you persuade them?
- Some of you said it was a problem to get seed, but you are growing vegetables anyway. How or where are you getting seed?

Focus groups are also a way to verify the findings of the quantitative baseline survey, the DND survey or any other quantitative research methods. Good questions to ask a group whose participants have some kind of gardens are: “*Why do you think other households in the community do not grow vegetables to eat?*” “*What would you say or do to persuade them to grow vegetables?*” We are again asking about perceived constraints and benefits, by asking indirectly about *other* households. People are often more honest and thoughtful in talking about others, than when talking about their own situation.

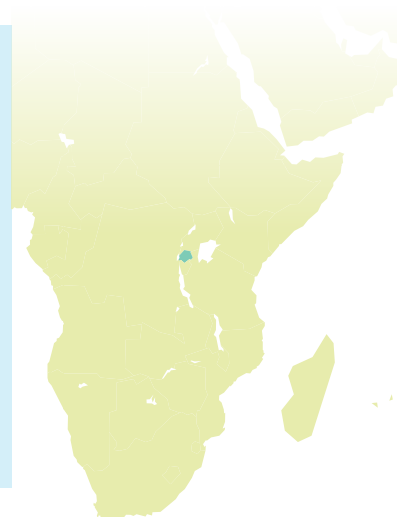
Participatory Rural Appraisal

Another form of formative research is participatory rural appraisal (PRA), originally developed for agriculture, which involves engaging the target group in identifying needs and constraints, which can be very useful in getting acceptance of a new practice. The methodology includes various tools for this participatory work with communities. The methodology is clearly explained in the CRS guide, *Rapid Rural Appraisal and Participatory Rural Appraisal: A manual for CRS field workers and partners* ([English](#), [French](#))(CRS n.d.). The box below gives an example of using multiple methods, including PRA, to fully understand a constraint to gardens.



Key learning before a project started in Rwanda

Village leaders confirmed the well-known fact that all households had sufficient land that was fertile and there was access to a small river for irrigation in the dry season. In focus groups, the community members also said they had land and they mentioned many sustainable agricultural practices they were already applying to their field crops, which they had learned from government agriculture extension workers. But, when the subject of growing vegetables was raised with the group, there was hesitation, and then they said they didn’t have enough land. After conducting transect walks—a PRA method—through the area to observe, project staff realized that the issue was availability of *unused* land. The local custom was to plant maize not only in fields, but right up to the walls of the houses.



Programs in many countries have conducted formative research, which has identified a wide range of constraints to garden adoption. The identified constraints are often very specific to the context and should not be assumed to exist or not exist in another context. Again, it is important to keep in mind that many constraints are perceived—that is, in the mind of project participants—but these have to be addressed just as much as any actual constraints. Some examples of constraints that have often been encountered are listed below.

- Lack of a suitable location (space, sun, soil)
- Free-range chickens or other livestock—particularly goats—destroy plantings
- Insects/pests
- Lack of time to give adequate attention
- Lack of water for irrigation
- Waterlogging in the rainy season
- Access to viable seed
- Fear or risk of losing time, effort or inputs

Finding the motivating factors

As mentioned earlier, we need to know what motivates people and we may learn some viewpoints from the positive deviants and the doers. Our target group is not always motivated by what we think should motivate them. For example, we often assume that young mothers will be motivated by wanting a healthy child or by wanting to keep their child from becoming malnourished. However, “good health” and “well-nourished” are not tangible; that is, they cannot be touched or necessarily seen. Stunting, in particular, is rarely recognized by local people in communities where the prevalence is high. As found in the CRS Zambia project, Mawa, mothers may be more motivated by having their child “do well in school” in the future or become a strong athlete. The mothers may crave recognition for themselves as being a good mother or wife. When promoting gardens, some people are competitive and may be motivated to grow the largest pumpkins or the most tomatoes. Others may simply be motivated by saving money by not having to buy vegetables, while others may find gardening relaxing and enjoyable. Some gardeners may take pride in having vegetables to share with friends and neighbors and to provide at community events. All possible motivating factors have to be explored to narrow messages to the ones to which most people will react.

Focus groups are also useful for exploring motivating factors. Questions need to be open-ended to obtain responses about aspirations and desires for the present and for the future.

For example, to explore long-term aspirations, we would start by asking “*What life do you envision for your child in the future?*” Then, we could probe: “*What will he or she need to get there?*”

For more immediate personal motivations, we could ask: “*What gives you a sense of accomplishment?*” or “*How important is it to you to find a way to save money?*” or “*What makes you feel good about yourself?*”

Once the key motivating factors for a specific target group are identified, it is critical to use them in messages rather than revert to the standard “have a healthier child,” or “prevent malnutrition.” Sometimes the motivating factor is not what we think it should be.

Stages of change

The stages of change construct (Prochaska and DiClemente 1992) has been developed to understand the process individuals go through when adopting an innovation or new practice. In any target group, individuals may be at different stages of adoption and, thus, need different types of project intervention to move up a stage or maintain the practice over time.

The five stages of change are:

1. Pre-contemplation
2. Contemplation
3. Preparation
4. Action
5. Maintenance

In the first stage, called pre-contemplation, the individual has not heard of the new practice or is not interested. In the contemplation stage, they have heard of the practice and its advantages. They may have seen it demonstrated or looked at a model and are starting to think about adopting it. In the preparation stage, sometimes called intention, the person begins to explore the practice. They may ask for more information, look into the cost, have discussions with those trying it, and try it themselves. If the trial or the additional information is not favorable, or if some material is not available, the person may go back to the contemplation stage. If they are motivated by the small trial or by the success of their neighbor, they may move on to the action stage and adopt the practice. If the practice becomes routine and continues over a long time, usually defined as two years or more, it is called the maintenance stage. It is possible that, due to loss of interest, a failure, or a major distraction, the person may drop all the way back to preparation or contemplation.

In garden terms, the stages of change might look like the following:

1. **Pre-contemplation:** Aisha and her neighbors plant in furrows and have not heard of raised beds.
2. **Contemplation:** Aisha has seen the model garden with raised beds and watched a video on how to construct one. The video explained all the advantages of preventing waterlogging and compacted soil.
3. **Preparation:** Aisha talks to women from a neighboring village about the time required for preparing the ground and maintenance, and the yields of the vegetables.
4. **Action:** Aisha and her husband prepare a small plot with raised beds; she plants and harvests it.
5. **Maintenance:** Aisha continues planting, harvesting and caring for the raised bed garden for many years.

So where does all we have learned from the target group fit into these stages? Where do BC activities enter into this to move people from one stage to the next? Remember that BC is not just about communication, but also about building skills (training, demonstrations and small trials), overcoming perceptions of risk (demonstrations), creating an enabling environment (working with communities to identify existing materials and linking participants with long-term sources of inputs and technical assistance). Projects may be designed with different combinations of these interventions to meet the needs of project participants who are in different stages of change. If the baseline survey or formative research showed that few people were in the pre-contemplation or contemplation stages (they already know the reasons for and advantages of the practice), then the project would invest the minimum of effort promoting the concept and disseminating motivating messages. Instead, project activities would focus on the later stages to resolve the constraints, reinforce skills and provide continual positive reinforcement. The following table shows how the formative research findings lead to different interventions for different stages.

Table 1: Applying behavior change activities to the stages of change

Stage of change	Link to the formative research	Project BC activities
1. Pre-contemplation	Use the motivating factors identified for both short- and longer-term benefits, such as tasty food, saving money, an alert child doing well in school, preventing anaemia.	Offer promotional messages that include benefits explicitly (think of this as advertising to sell the practice). If few people are in this stage, limit the effort on these messages.
2. Contemplation	Put emphasis on showing how the practice is done, that it is feasible and low-cost; add messages on benefits perceived by the doers and drivers of change that were identified in focus group discussions.	Use models, demonstrations, motivating messages (e.g. meetings, posters, radio, mobile phone). Develop model gardens to show and conduct demonstrations of specific steps, such as making compost and preparing the bed. Share positive experiences of those who already adopted the practice.
3. Preparation	Perceived constraints must be overcome or minimized. PRA research can engage the participants in developing their own solutions to some perceived or real constraints.	Provide opportunities for a small-scale trial of hands-on technical support to solve problems and build skills, assure access to inputs and other materials, and connect with other people who garden. The goal here is to minimize the perception of risk and have participants experience some success. Have participants try out the practices on a small scale ²⁹ (grow two tomato plants or a small patch of green leaves) or try a keyhole garden as a group. Connect them with a sustainable supply of inputs and make frequent home visits to help solve problems and reinforce skills.
4. Action	Assure participants that they can resolve future constraints and stay motivated. It may be necessary to conduct another round of DND surveys to identify additional constraints or reasons for lack of motivation and confirm perceived benefits.	Provide messages and activities for positive reinforcement, continue technical support to minimize failures, demonstrate preparing and using produce and conduct competitions with awards. Maintain frequent contact to help solve problems, distribute print materials as reminders of needed skills (e.g. IPM, compost) and link to long-term sources of technical support.
5. Maintenance	Reinforce perceived benefits.	Be in contact through mass media, meetings or visits to provide positive reinforcement, including repetition of the motivating messages, if enthusiasm is waning. Review sustainability of inputs. Having a permanent local garden promoter to follow-up each individual is useful. Celebrate successes.

29. School gardens are an example of a small-scale, low-risk trial. Children and their parents can experience some success, which will encourage them to start a garden at home.

Nuance in messaging

When data shows that many participants are in the pre-contemplation or contemplation stages, messages for promoting the benefits of gardens are appropriate, but must be nuanced. The goal of many garden programs is to improve dietary diversity and, thus, nutrition. Too often, this translates into messages that say growing vegetables in a garden will prevent malnutrition. The vegetables grown in gardens can help to prevent *certain kinds* of micronutrient malnutrition such as vitamin A deficiency and iron-deficiency anaemia. Garden vegetables will *not* prevent wasting or stunting, because they do not provide substantial amounts of protein or energy. Messages should be clear about this. *“Growing and eating these vegetables can help prevent anemia [using the locally understood term for anaemia].”* The messages should also be relevant to the current situation. A generation ago, vitamin A deficiency was widely recognized in the developing world as night blindness, one of the early symptoms. This is much less common since vitamin A capsules are distributed to children with immunizations. It is appropriate to say that children may be sick less often if they consume vegetables, but few modern mothers would be motivated by fear of night blindness.

While “messages” are usually associated with information dissemination or promotion of benefits, which is useful for the first two stages of change, their use is much broader in promoting BC. Well-designed messages also convey advice on overcoming barriers, share the experiences of others who have surmounted barriers, reinforce skills learned in demonstrations or events, and remind individuals of timely actions, such as a “push” message sent via mobile phones in Nepal that said: *“Your neighbors in the district are noticing white flies. Now is the time to prepare and apply the chili pesticide to prevent damage to your garden.”* Messages of positive reinforcement are particularly important for people in the action and maintenance stages to prevent them from losing interest or relapsing to an earlier stage.

Enhancing skills and self-confidence

When transmitting skills, hands-on learning followed by an immediate opportunity to put the skill into practice results in much greater uptake of the practice than looking at a model or watching someone else demonstrate the skill. Both repetition of the new skill and positive reinforcement from someone the learner holds in esteem lead to growing self-confidence. These concepts come from the field of adult learning, and application of adult learning principles in the box below results in greater BC (Vella 2001).

Use a learner-centered style for adults:

- Emphasize dialogue
- Build on what the learner knows
- Provide problem-solving opportunities
- Allow for practical application of concepts and skills
- Engage the learner’s intellect and emotions
- Provide affirmation

Feedback on the activities to promote gardens

As the project activities are rolled out, it is useful to monitor whether they are having the desired effect and whether we are impacting the barriers or utilizing the facilitating factors that were identified at the formative research stage. For example:

- If “access to seed” was identified as a significant barrier, and the project included interventions to help address this, then access to seed could be monitored.
- If “approval from husband” was identified as a significant enabler, and the project included interventions to engage and work with husbands to elicit their support for gardening, then the project could monitor a) whether more husbands were supportive of gardening and/or b) whether women felt supported by their husbands to garden.

Monitoring the determinants of behavior can be helpful for assessing whether the project strategy is effective, and therefore whether BC is likely to occur as planned. This type of monitoring can be embedded in the work of community-level staff or volunteers who would track through records or small household interviews. See Chapter 14 on Performance Monitoring for more information.

How do we know the behavior has been adopted and is being sustained?

Most projects will have an indicator of adoption and/or maintenance of gardening. The indicator might be worded in many different ways. Possible indicators include:

- Percentage of households planting and harvesting gardens
- Percentage of women, with children under 2, who plant and maintain a garden for at least two years.

These outcome indicators are usually measured in quantitative baseline, midterm and final surveys. In addition, the project should measure the adoption of the many practices that make up gardening, such as use of integrated pest management, preparation of compost, use of produce, etc. All of these are measures of BC or adoption of practices and new technologies. By conducting small surveys every 6 to 12 months or more frequent household monitoring visits, the project will be able to determine whether one or more of the practices is not being adopted and follow-up quickly with formative research to learn why not and improve the interventions.



This notebook with illustrated columns helped CRS project promoters in Guatemala log data on families that adopted practices. *Photo by courtesy of J. Bentley*

Realistic expectations: Diffusion of innovations

Early research into promoting agricultural technologies showed that a population does not adopt the new practices all at once (Rogers 1983); rather, there is an extended period over which adoption takes place. Some people catch on to new ideas and their advantages quickly and are willing to take risks. These are known as *early adopters* and make up less than 15% of the population. Only after seeing that they succeed and the advantages they gained, another group, the *early majority*, which is another 34% of the population, will adopt the new practice. The people who are more afraid of risk, or take longer to believe in the advantages of the new practice, or have resource limitations are considerably slower to adopt the new practice or technology. They are known as *late adopters* and make up another 34% of the population. The remainder of the population, dubbed *laggards*, will either adopt the new practice much, much later or not at all and they can comprise nearly 16% of the total population. This theory of adoption is known as **diffusion of innovations**, with innovations meaning an idea, practice, service, technology or object that is perceived as new by the population. Diffusion refers to the social process by which innovations are spread within a group or population.

What does this mean for projects? Projects need to set realistic targets for indicators. Project life is relatively short, and it may take longer for an idea like gardens, or a more specific technology, such as keyhole gardens, to become widely adopted among the target group. It may take much longer for some households than others to adopt integrated pest management or consistently practice weed control. According to this theory of the diffusion of innovations, if we succeed in getting the early adopters and some of early majority to embrace successful, sustainable gardening, others will eventually take it up, but it may be long after the project has ended. The example (FAO 2010) in the box below shows that diffusion may take many years.

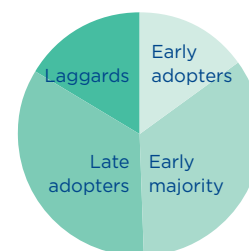
Example of diffusion of innovations—long-term success

A three-year food security project introduced simple urban gardens in an impoverished slum area of Honduras. The project's endline survey found that just under 30% of households were practicing urban gardening in small spaces. While this was an increase from the 7% at baseline, it did not seem like a significant achievement. Ten years later, when another survey was conducted in the target area, it showed that over 65% of households were growing vegetables.

Conclusion

Applying concepts of behavior change can greatly increase uptake of gardening and the many practices and technologies that comprise it. BC goes beyond communicating knowledge and benefits to creating an enabling environment through skills transfer, assuring access to supplies and inputs, and providing long-term support to help solve problems that are often encountered. First, we must clearly identify the behavior or practice to be promoted and the primary target group, i.e., those who will carry out the behavior.

A population does not adopt the new practices all at once.



Then, through formative research, we learn their viewpoint and situation as well as their perceptions about the practice, and the viewpoints and perceptions of those who are influential over the target group. This learning becomes the basis for planning appropriate activities that will move them through stages to attain sustained maintenance of the behavior.

Quiz

1. True or false: If we can convince people of the benefits of gardens, they will adopt the practice.
2. True or false: Behavior change only requires using communication to reach the target group.
3. True or false: People will always be motivated to do something that makes them or their children healthy.
4. The formative research method that helps us understand the priority target group's point of view is:
 - a. Focus group discussion
 - b. Positive deviance study
 - c. Doer/non-doer survey
 - d. All of the above
5. Which of these BC activities will best enable the priority target group to start making compost?
 - a. Visiting a household that has made a large pile of compost
 - b. Collecting needed materials with neighbors and making a compost pile under the guidance of the extension worker
 - c. Watching the extension worker and garden volunteer make a perfect pile of compost
 - d. Watching a video on how to make compost

Activity

Read the case study and then discuss the follow-on questions

Case study: On islands in Lake Victoria, village women were interested in starting gardens to vary their diet, which consists mostly of cassava and fish. They value vegetables and had heard that some were good sources of vitamin A, a deficiency of which is widely recognized on the islands by symptoms of night blindness. They had been willing to pay fairly high prices for tomatoes and peppers occasionally brought from the mainland and said they could better use this money to buy seeds. In spite of this enthusiasm, after a year, the garden program foundered. Few people were growing vegetables. The families perceived that they did not have enough materials to make compost for the thin soil, particularly since the manure from the scarce livestock had to go on the field crops.

1. At what stage of change are these women? Why do you think this?
2. What is a motivating factor they perceive?
3. Did the project overlook some critical formative research before starting? What should they have investigated more thoroughly?
4. What is the perceived barrier after a year of project promotion of gardens?
5. At this point, what can be done to minimize the perceived barrier?
6. How can the participants be involved in finding a solution to the perceived barrier?

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Chapter 14:

Performance Monitoring

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Learning objectives

After studying this chapter and its resources, you will be able to:

- Support teams and communities in adaptive monitoring and evaluation systems for gardens.
- Support staff in collecting, analyzing and using data for more effective program delivery.
- Document program implementation, successes and challenges, and identify when strategies or activities need to change.

Key messages

- Performance monitoring is important to ensure that the project is on the right track to achieving its objectives.
- It is important to include key indicators to monitor garden outcomes.

Key questions for decision-making

- What information is needed to make informed decisions?
- How will the project engage the community in performance monitoring?
- What do staff and community members need to know to successfully contribute information and suggest program adjustments?

Performance monitoring is important for gardens

Performance monitoring that includes indicators connected to the program's results framework gives program managers access to real-time information on outputs and associated results that enable them to make informed changes to design. It systemizes information collection and data use to help administrators, program managers and field staff to identify trends and barriers as well as observe differences between program implementation in different locations. The box below illustrates why this level of monitoring is important.

Performance monitoring in action: Encountering and surmounting unanticipated barriers

Women in Afghanistan learnt to compost as the first skill in starting kitchen gardens. When farmer field school leaders went to check on their students' gardens after composting training, a trend emerged. Many women were storing their compost in plastic bags, not a recommended practice. They had another series of trainings on composting, but the problem persisted. Finally, the women's program director asked why women were using plastic bags. It became clear after speaking to only a small sample of women that family members saw the compost piles as refuse and insisted that the women put it where it belonged: in plastic bags. At the next training session, staff explained the science behind compost: aerobic bacteria play a critical role in the composting process and need air. Women could now explain to their families why compost should not be in plastic bags. Furthermore, after demonstrating plants growing in compost to family members, families became supportive of proper composting and plastic bags disappeared from composting.



Properly aerated compost at a women's program training in Kabul, Afghanistan.
Photo by Najia Hamdard for CRS



Performance monitoring

In its simplest form, performance monitoring is the observation of activities that support a program's results framework. Data from performance monitoring tests show causal links between activities (trainings), outputs (people trained and gardens started), and outcomes (harvest from gardens, income from gardens), and monitors assumptions to know how they are affecting the activity implementation and outcomes. For example, a program provides training because it assumes people do not possess the technical knowledge to overcome a given production barrier and that by addressing just the technical knowledge hurdle, the problem will be solved. Often change is more complex than that. Information on indicators can help program managers and field staff investigate other motivators or constraints that are holding people back from creating their own gardens. The box above reiterates how an unanticipated barrier—women's family members—created challenges to adopting proper composting.

Performance monitoring provides data to inform the progress of a project. It can help adjust and adapt program trainings, messages and approaches.

Performance monitoring will gather information throughout what is typically a season for a garden. It focuses on gathering a broad spectrum of both quantitative and qualitative information. As data comes in from the field, analysis and reflection happen frequently with an eye to identifying trends, barriers and differences by field staff and program managers. This information can help adjust and adapt program trainings, messages and approaches if an adaptive program management style is used. This management style allows for constantly integrating feedback from performance monitoring into program approaches and delivery, and ensures emerging needs and challenges are being addressed and new opportunities are identified and included in a program's activities.

Performance monitoring and the results framework

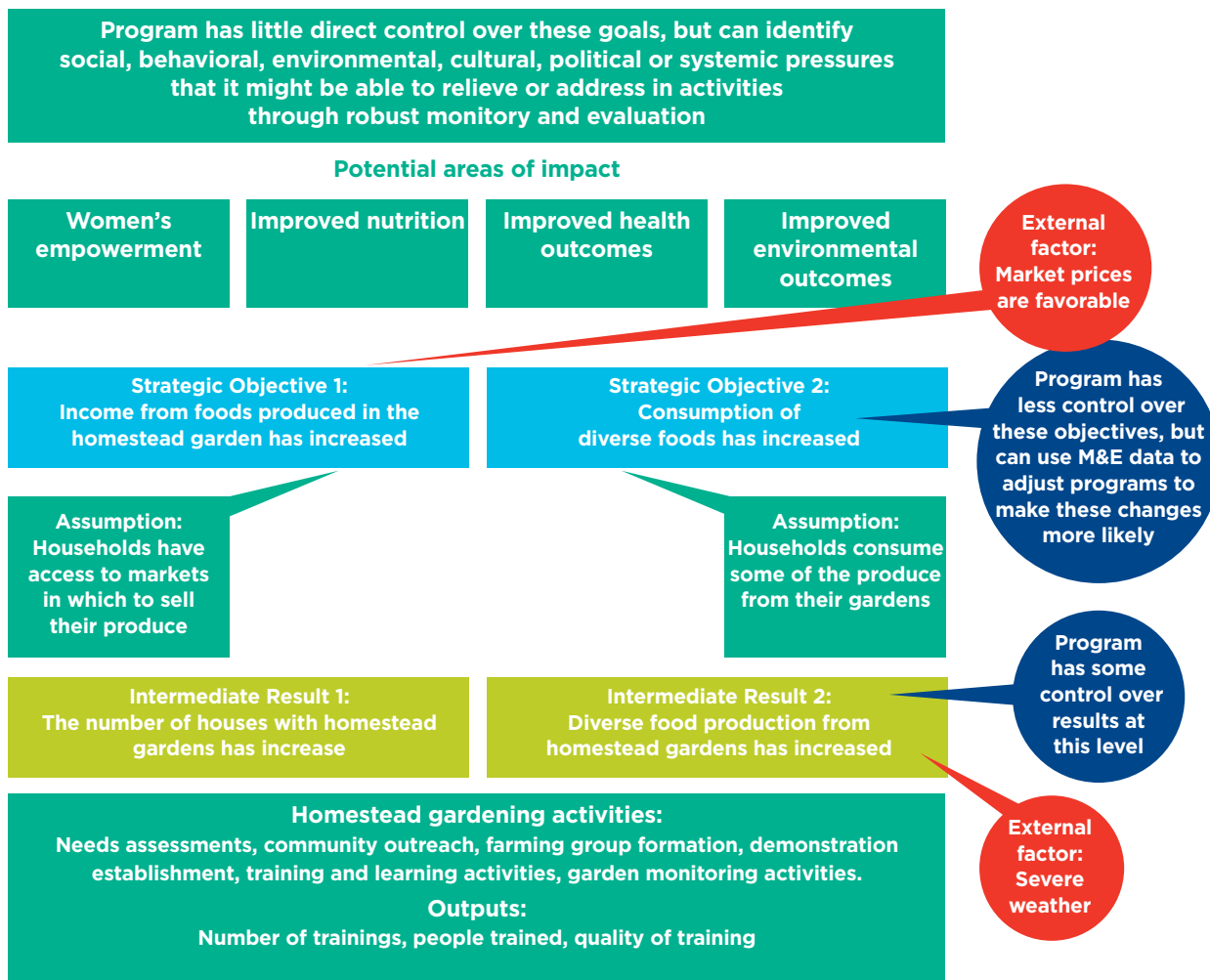
Adjust program in response to new information

Using evaluation data for an adaptive program management process, USDA funded a school garden program that integrated math and science curriculums into the practice of students managing school gardens. The midterm review of student math and science scores revealed that they had not moved upward as anticipated. The evaluation team visited school sites and learned from observing and speaking to teachers that instruction time was used to haul water for the gardens. The evaluators recommended that wells be sunk to eliminate the need for this activity. Funds were provided to the schools to establish wells, and in the program's second half, time was spent on instruction rather than water hauling.

For performance monitoring, a results framework is needed. Such a framework uses logic to organize intermediate changes between a program's activities and its overarching goals and objectives. It is the cornerstone of performance management because it identifies what changes a program anticipates are necessary to reach a goal and help identify what kinds of information is needed to test this anticipated process. Although gardens are usually one intervention within a project, understanding the intermediate changes for garden adoption and use of garden products to reach higher-level impacts will help identify the proper indicators and support the program manager to monitor progress.

An example of a results framework for a garden intervention is presented in Figure 1.

Figure 1: Example results framework for a garden program



Activities at the bottom of the framework should connect with the results they support. Often, garden programs need to conduct a variety of activities and work with different groups of partners to reach objectives, such as increased incomes or increased consumption of diverse foods. There may be activities that need to take place chronologically. For example, an assessment and gender analysis is needed to inform the best design for gardens; identify constraints related to soil health, pests, disease, seed access, water; and approaches that farmers have the most interest in. To learn more about assessments for guiding the garden design, see Chapter 2 on Assessing Local Context.

One of the most common methods used for garden promotion includes some form of training. The first result in Figure 1, *an increase in the number of households with gardens*, assumes that if a program uses trainings to increase people’s knowledge of how to manage and plant a garden, they will adopt this food production technique. The second result follows the first; *if households adopt gardens, then there will be increased production of diverse foods*. This assumes gardens are managed properly to yield, and that there are no external factors like extreme weather causing crop damage or failure.

To reach the objectives, there are two pathways demonstrated. The first, in Objective 1, is that incomes are increased through the sale of garden produce. This assumes market access and market prices make the sale of produce profitable. The second objective is that an increase in the consumption of diverse foods can be reached either directly through consumption of garden produce or indirectly through purchase of diverse foods from income from gardens.

Indicators for use in garden programs

The next step is to determine what information needs to be collected to make informed choices; how to collect that information; and how often you need information for making choices, communicating challenges and sharing successes. Data should be collected frequently enough so a program manager has enough time to adjust budgets and address challenges in achieving targets. For example, if no sales were recorded in the baseline of the income indicator, but farmers were growing produce, a program manager might want to spend some time with that community to discuss how to best overcome barriers to market access if income is an important potential result of the program. Table 1 presents a few indicators that could be used for a garden program. These indicators are a mix of custom and U.S. Government (USG) standard indicators commonly used to measure progress toward the results and objectives outlined in the example.

Table 1: Suggested indicators for measuring results in example RF

Indicator name/number	Suggested indicator	PIRS/guidance to calculate
Output		
Number of people trained on gardening	Number of individuals who have received USG-supported short-term agricultural sector productivity or food security training (sex and age disaggregated)	2019 Food for Peace Indicator list—page 5
Intermediate results		
IR 1: Increase in the number of households with gardens	Number of individuals in the agriculture system who have applied improved management practices or technologies with USG assistance (sex and age disaggregated)	2018 Feed the Future Indicator Handbook—page 89
IR 2: Increase in diverse food produced in gardens	Yield of targeted agricultural commodities among program participants with USG assistance (changes in quantity)	2019 Food for Peace Indicator list—page 6
	Diversity of food produced on farm, i.e., garden (changes in diversity)	Compendium of indicators for nutrition-sensitive agriculture—page 26
Objectives		
Objective 1: Increase in income from foods produced in the garden	Value of annual sales of producers and firms receiving USG assistance (FFP page 10)	2019 Food for Peace indicator list—page 10
Objective 2: Increase in consumption of diverse foods	Percentage of female beneficiaries of USG nutrition-sensitive agriculture activities consuming a diet of minimum diversity; this indicator can be adapted to include sub-categories reflecting crops being promoted in the garden	2019 Food for Peace indicator list—page 3
	Prevalence of children 6–23 months receiving a minimum acceptable diet	2018 USAID Feed the Future Indicator Handbook—page 161 WHO Infant and young child Minimum Dietary Diversity score

Incorporating feedback

Indicators can only tell part of a program's story and only present quantitative information. Indicators are wonderful to use to understand *what* is happening, but they typically cannot provide information on *why* or *how*. Qualitative data can provide answers to how and why change is happening. The strongest monitoring and evaluation (M&E) systems include feedback loops where beneficiaries, program staff and other stakeholders can learn from one another and communicate directly about challenges, opportunities and changing or persistent needs. The methods for these feedback loops are heavily dependent on context. Focus group discussions are one method commonly used to gather this kind of data.



Some of these indicators for measuring progress may need to be adapted. For example, the dietary diversity score needs to be adapted to the local context and program goals. For example, Afghan diets are carbohydrate heavy and include fats and oils but few vegetables. A women's program included more vegetable categories than the dietary diversity score required so that they could look at which vegetables they were specifically promoting were being consumed, and which they should not focus on as heavily. This helped them tailor their local activities to village-level preferences and helped them understand the importance of incorporating training on proper cooking, preservation and safe storage of vegetables and fruit. Program managers should work with their country programs and field staff to determine additional categories to be included. Keeping track of this on a code sheet is important because it can be used to remind field staff in surveys how foods are categorized and also during analysis. When the indicator is calculated, the specific foods are included in the larger category that they belong to. However, including more sub-categories does not harm the validity of the indicator as long as food groups are aggregated consistently and correctly. For more information, see the [FAO *Guidelines for Measuring Household and Individual Dietary Diversity* \(2010\)](#).

Setting meaningful targets for indicators

To monitor the success of a garden program, targets should be set. This process can take some time up front, but it is worthwhile. Factors to consider for informing meaningful targets include:

- 1. What is reasonable to achieve in a given time frame and with limited resources?** You can only do what your program can pay for; do not set targets that a program cannot afford to achieve. For example, say your budget can only fund 350 demonstration gardens. If you use the gardens for outreach to 25 women each, the total number of women your program can reasonably expect to reach is 8,750.
- 2. What do communities and gardeners see as success?** This is especially important for higher-level results, objectives and impacts. For example, a meaningful target for households might be to earn enough income from a garden to send two children to school. This value can be used by the program to set aggregate targets for the value of income from gardens per household. Assuming that all 8,750 women who are trained on gardens adopt them and that it costs \$150 each year to send two children to school, an aggregate income target from garden sales of \$1,312,500 would meet that goal.

3. **Donor input: What does your funder need to see to report back to their governing bodies?** Public donors might have rigid targets they are reporting against. Work with donors to understand their needs and communicate clearly to them based on your local context why some targets may or may not be reasonable.
4. **What does research say?** In community-led total sanitation programs, reducing open defecation practices to only 20% of households engaging in the practice has similar results on reducing diarrheal disease outbreaks as 0% of households open defecating.³⁰ Gardens in certain contexts may have similar effects on nutrition impacts when considered from a community perspective. For example, say a program wants to increase dietary diversity scores of women from five food groups to seven food groups. Given first-year yields from demonstration gardens, a program manager may find that enough surplus is produced and sold at the market to supply the community's markets with only 50% of households in a community actively managing gardens.
5. **Taking a proportional approach: What is the total population of the areas where the program operates and what percentage is needed for meaningful change?** For example, the Government of Rwanda has a "1 cup a day" campaign that aims to provide a cup of milk per day to children; in this case 100%—full coverage—is the goal; targets along the way should be set to accommodate contextual realities as the program's reach expands, such as: time for local production to increase, time for messaging to take effect, and time for feeding behaviors to change.
6. **Stage of behavior change/diffusion of technology:** As explained in Chapter 13 on Behavior Change, the adoption of behavior(s) that affect the targets to be set will be based on participants' readiness to adopt (i.e., stage of change) and the length of time for adoption to happen through diffusion.

Collecting data—Who does what, when?

Determining who is responsible for collecting data and when this should be done is the next step to managing performance monitoring, and an M&E system overall. A timeline, calendar or basic schedule table is useful for clearly defining responsibilities and deadlines. Program managers should work closely with the respective M&E staff to make sure that they are collecting, analyzing and reporting data appropriately.

For example, field staff overseeing a given district should be expected to visit each village on a rotating schedule and reports should be due at the end of these visits. Field visits can be learning opportunities and should be designed to help farmers come up with their own solutions to problems they have encountered in trying out a new technique.

30. *Community-led total sanitation in East Asia and the Pacific: Progress, lessons, and directions*. March 2013. UNICEF East Asia and Pacific Regional Office. https://www.unicef.org/publications/index_74615.html.

Designing tools for collecting data on gardens

This section does not cover all aspects of designing tools but presents a selection of key points relevant to gardens and potentially applicable to other interventions.

- Include field staff in tool development: Staff participation in designing their own tools gives them control over the process, makes frequent monitoring visits less of a burden, and creates ownership of the tools. It also lends an understanding of why tools and data are collected in a certain format and ensures more consistency in data collected from different villages, districts or regions. Program managers, M&E staff and field staff should work together to develop and adjust tools so that they are uniform across an entire program, at a minimum. Consultations with regional and senior technical advisors on tools can increase uniformity across projects, countries and regions.
- Provide unique identifying information not only for each person but for each garden; a numbering system that stores personal identifying information separately from field observations will need to be developed.
- Timing: Field staff may need multiple tools for specific uses depending on the growing season. For example, there may need to be tools developed for garden planting, garden harvest and postharvest. If a garden has just been planted it would not make sense to ask questions about yields.
- Easy to use: The tool should be easy to use in the field and it should be easy to input data into a central system. Mobile data collection systems can be used to help reduce data management time and costs. Forms could be created with CommCare, an open-source data collection platform.

Keeping these guidelines in mind, data collection tools must provide the data that are required for reporting and performance monitoring. By starting with what the final indicator is, a tool can be developed by working backwards. For example, the standard indicator “Number of individuals in the agriculture system who have applied improved management practices or technologies with USG assistance (standard Feed the Future Indicator)” has to be disaggregated by sex, value chain actor type and technology type. For this indicator, a farmer can adopt many technology types in a single area in a single year. A tool that collects information from farmers allows for multiple selections of technology type such as cultural control, mechanical control, crop rotation and gm/ccs. Having a tool that enables staff to select multiple technology types relevant to gardens from a list ensures data are collected consistently and follows the rules of the donor.

Using data to guide programs

The program manager, M&E staff and project staff must work together to synthesize all of this rich information coming from activities and the M&E system so that it can be *used to make more effective use of program resources*. This information can be shared across field staff and with the program leadership to advocate for resources needed to keep the program achieving its best results. Data from indicators, coupled with field observations and outcomes like productivity, provide rich information that identifies trends and correlations.

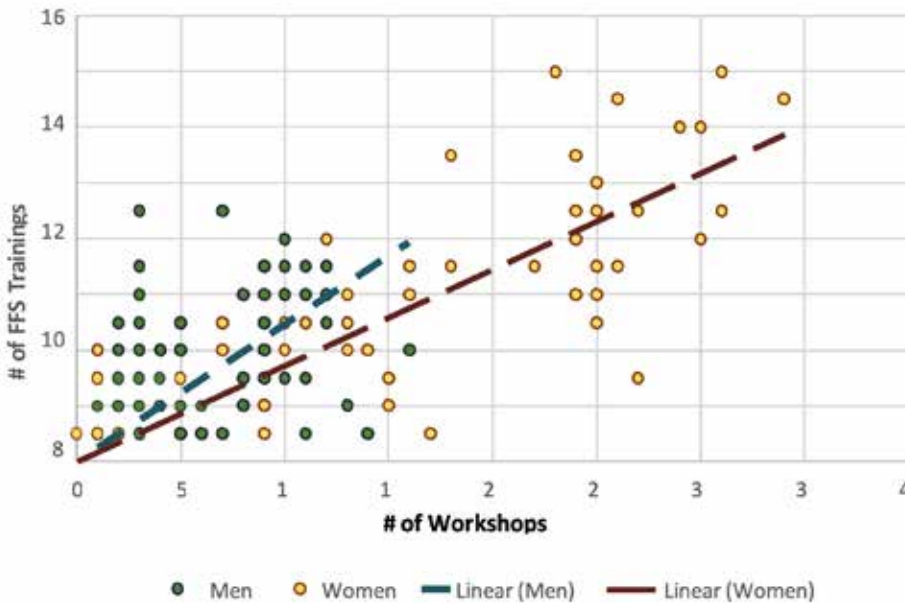


Data collection tools must provide the data that are required for reporting and performance monitoring.

Trends across multiple program sites help highlight critical lessons learned in the field that should either be acknowledged (if it is a success) or addressed (if it is a constraint). Program managers play a key role in communicating this rich, detailed, process-based information so that programs can be managed in a flexible, information-responsive manner. They also play the critical role of supporting field staff by using data to illustrate areas that are strengths and areas where focus needs to be maintained or increased to maximize impacts. Engaging the gardeners themselves in this process is critical to gaining insights into innovative, locally dependent ways that programs can be adjusted to meet each individual's and community's unique set of needs.

An example of how the extension program in Afghanistan used data to identify a trend in training differences between women and men is shown in Figure 2. This figure was generated using simple training data that illustrated that 1) women required more trainings than men and 2) women had a greater likelihood of leading more trainings in their communities the more trainings they were given. This information was used to justify a higher per-women cost for trainings than for men. It also allowed the program to investigate differences in the expectations that the women's program was using to motivate their trainees and the constraints that men faced in working with government employees over whom they had very little control.

Figure 2: Correlation between farmer field school-led trainings and workshops attended for male and female extension workers and community leaders, October 2014–September 2015.



Conclusion

This chapter is meant to be used as a starting point and reference for program managers to work with M&E staff, field staff and local communities to monitor the performance of gardens. It builds knowledge on performance monitoring, including identifying indicators through the results framework, setting targets and designing data collection tools. There is a constant level of uncertainty when encouraging the kinds of BC that gardens promote. Embrace this uncertainty, monitor results and adapt programming. Allow this chapter to help guide you to other resources that you can use that better fit your region and program's context and reality.

Quiz

1. True or false: Process monitoring allows administrators, program managers and field staff to have access to real-time information on outputs and associated results to identify trends, barriers and observe differences between program implementation areas that will help make informed changes to program design.
2. Your program seems to be running smoothly. Families are planting their gardens and are earning enough money to send their children to school. Select the best answer:
 - a. Consider this to be a good impact and only report on this one positive impact of the garden program.
 - b. Review the data on other indicators to see if dietary diversity scores or other outcomes have also shifted.
 - c. Launch a special survey to see what other effects on household incomes the gardens are having.
 - d. Work with other sites in the program that are seeing lower levels of adoption to coordinate a visit to your area.
3. You are starting a new program that is aligned with a new national policy designed to increase consumption of vegetables. One of the activities in this project is gardens. Previous research in your area has shown that most families' main concern is earning enough income to send their children to school. You are unsure of how much food from the gardens will be consumed in the household, but you are certain that, if gardens yield the way they should, this activity will contribute to increases in school attendance. When you design your evaluation, do you (select the best response):
 - a. Include a school attendance indicator in addition to the other main program indicators like dietary diversity score and income?
 - b. Include only the women's and children's dietary diversity scores as indicators?
 - c. Include only information on yields, since this will allow you to estimate changes to incomes and dietary diversity score if you assume food is eaten or sold for income to be used for nutritious foods?

Activity

1. Revisit the example about composting from the garden program in Afghanistan given earlier in this chapter. Composting was critical to rebuilding severely degraded soils, increasing the water-holding capacity of soils, and maintaining plant health so that they produced high-quality food. These linkages between soil condition, plant health and yield are well researched. When field staff observed compost that was not being treated properly, the program held a meeting to review the evidence and outline their response.

Pretend you are on that team. Field staff members are reporting that women are adopting composting techniques, but they are not doing so properly. Composting materials are kept in plastic bags, resulting in smelly, slimy messes and not the high-quality rich, organic matter compost should be.

- a. What other evidence would be helpful to have?
 - b. How could you and your team get this evidence?
 - c. Does it justify the cost of a survey or can informal feedback loops be used?
2. The first season of the garden activity is wrapping up. Final harvests from this season's crops are coming in. Field staff and gardeners are all reporting productive yields; however, initial survey results from the dietary diversity score show little improvement. Increasing dietary diversity is an important impact that the donor expects to see. Describe how you approach this situation (Hint: think of the assumptions that were made between productivity and use; think of questions that you can ask of gardeners that would inform what part of this assumption holds and what part may be incorrect).

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Quiz Answers

Chapter 2: Assessing local context

1. False. The design team should conduct a preliminary assessment to ensure that the project can help address barriers related to the determining factors of the garden: culture, access to quality land, access to water, willingness to contribute resources, and gender dynamics.
2. B and D. It is important to know the characteristics of the target audience that will plant the garden, along with those who will benefit from the garden produce, to ensure the assessments get information from the correct audiences. It is also important to know the objective(s) for planting the garden to guide what questions the assessment should include.
3. True. The assessment conducted during project design is with potential communities where the project may or may not implement, and it addresses key barriers that need to be considered that affect the decision to include a garden, and staffing and budget needs. A post-award assessment will target communities where the project will be conducted, which will allow the project implementation team to validate the design and make necessary revisions to address the opportunities, constraints and existing capacities of the target audience in the project communities. It allows the intervention to be tailored to project participants.

Chapter 3: Planning a garden

1. False. There are various garden types to meet various needs and constraints. The decision on what type of gardens to promote should be based on land availability, water access, soil fertility and types of crops to be grown.
2. Container gardens, keyhole gardens and vertical gardens can be used in constrained spaces since they only require limited space to produce crops.
3. Sun exposure, distance to water, distance to home, and wind.

Chapter 4: Crop selection

1. False. Each crop has its own water requirement with some requiring much less water than others. Water requirements should be considered in crop selection, particularly if water availability and access is limited.
2. True. All crops have a set of other crops that can be planted nearby that provide benefits in terms of productivity, soil health or pest management. Most crops also have crops that they do not grow well beside—they may attract harmful pests or compete for nutrients, sun and water.
3. Garden objective (nutrition and/or market), gender, productivity, companion planting, seed availability and accessibility, soil characteristics, water requirements, perishability, garden type, soil and air temperature, and sun exposure.

Chapter 5: Gender Integration

1. C.
2. True. When women cultivate household gardens, it is often considered to be an extension of their domestic tasks that does not require the same type of resources as commercial farming operations (Verhart et al. 2014). Enterprises and organizations that provide access to resources—such as agricultural inputs, extension services, training, labor and membership in water-user associations—are not as likely to extend those services to gardening. Labor is another resource that is often less available, depending on the size of the garden, the physical ability of the person responsible, and the time they have available to work on it.
3. False. In contexts where women have limited agency in their household or community, women-only groups can be a necessary alternative. They provide a safe space for women to assert their agency by gradually and collectively challenging cultural practices and social norms, and reducing the risk of sanction—whether socially or through more serious measures, such as violence or harassment.
4. A and D.

Chapter 6: Nutrition

1. True. Evidence shows that interventions reducing malnutrition make a greater and more rapid impact on poverty than those aimed at economic growth on its own. A 1% decrease in the poverty rate achieves a 0.25% reduction in malnutrition; a reduction of 1% in undernutrition eventually yields a 4% decrease in poverty (Alderman 2005 in Tirado et al. 2013).
2. There are three ways gardens can contribute to good nutrition: 1) food production, 2) agricultural income, and 3) women's empowerment.
3. Create a seasonal calendar to stagger planting and harvest times, and use food preservation methods.
4. False. Recipe books are a great way for those participating in cooking demonstrations to remember what they have learned.

Chapter 7: Seed

1. C. Save seed from the plants with the best traits, even if that means not being able to eat or sell those plants. It is best practice to save seed from as many plants as you can that exhibit the desired qualities of the variety. Seed should be saved from open-pollinated varieties. The seed should be dry when put into storage.
2. False. Depending on the seed, a pinch of seed could include hundreds of seeds.
3. D. All of the above. When considering direct seed distribution, the program does not want to undermine local commerce, cause dependency on free materials among gardeners, or disrupt traditional food preferences or seed-saving/sharing practices.
4. False. Most commercial vegetable seed is imported, no matter who is selling it or where it is purchased.

Chapter 8: Integrated soil health management

1. A, B, C and D. Soil is made up of water, organic matter, minerals and air.
2. False. In most cases, land should not be tilled. Gardeners may have to till in the first year to break up hard layers of soil, but in most soils it should not be a common practice; too much tilling harms soil structure, reduces organic matter, multiplies weeds by exposing weed seeds below the surface to sunlight, and damages important soil animal life, such as earthworm populations.
3. A, B and D. Gardeners can transform poor soil into rich productive soil with 1) minimum tillage, 2) adding organic matter, and 3) crop diversification and rotation.

Chapter 9: Pest and disease management

1. A. IPM promotes four strategies for managing pests and disease: 1) cultural control, 2) biological control, 3) mechanical or physical control, and 4) chemical control.
2. E. These options are great strategies to try to attract beneficial insects to your garden.
3. False. Certain types of insecticides may also be made at home, including those from soap as well as from commonly found plants.

Chapter 10: Water resources

1. Three ways to water one's garden crops are hand watering, bottle/clay pot irrigation, and drip irrigation.
2. False. In each growth stage, a plant needs differing amounts of water. During the crop development stage, the amount of water the crop needs gradually increases to the maximum amount it will need. The maximum amount of crop water needed is reached at the end of the crop development stage, which is the beginning of the mid-season stage. It is estimated that 50% of the crop water is needed during the mid-season stage, when the crop is fully developing (i.e., flowering and beginning to fruit). However, freshly harvested crops, such as lettuce, cabbage, etc., need the same amount of water during the late season stage as during the mid-season stage.
3. E, all the above. Factors that influence the amount of water required for a healthy garden are crop type, soil type, seasonality and climate.

Chapter 11: Postharvest handling

1. False. Quality is related to maturity and harvesting gently. Quality can be maintained by keeping vegetables cool and handling them gently, but quality cannot be improved once crops are harvested.
2. B. When water evaporates from the storage chamber walls, it takes heat away from the vegetables stored inside the chamber.
3. True. Home processing options include solar drying, canning, fermenting, pickling and preserving in sugar.
4. B. Wash your hands before touching fresh vegetables.

Chapter 12: Marketing produce

- 1a: False. If supply of a garden product goes up and there is more available in the market, producers will lower the price to encourage customers to buy more of the product or to buy their product rather than someone else's.
- 1b: False. If demand for a product goes up, and supply remains the same or goes down, then a producer can increase the price because the product is going to be more difficult to find in the market.
- 1c: True. If supply of a product goes down, and the demand remains the same or goes up, then producers will be able to increase their price.
- 1d: False. When demand goes down, that means that fewer people are buying. A producer will need to lower the price to encourage more people to buy.
- 1e: True. If supply goes up, then producers will lower their price to encourage more people to buy.
- 2a: False. Household gardening families need to keep records so they can plan production, market their produce, know how much it costs to produce, and how much is earned or lost every season.
- 2b: True. It is best to sell in local markets when the amount of garden produce is small and there is local demand. If family household production increases and more families start to produce, markets outside the local area will need to be identified.

- 2c: False. Producing more does not automatically mean that neighboring families and local traders will buy more. Prices may fall if supply exceeds demand, and the income received may not cover costs.
- 2d: True. Good planning reduces the risks associated with marketing garden produce. Keeping records on what is grown, how much is produced, how much is sold—and at what price and to whom—helps plan production and sales, and to know whether income is exceeding costs. This will help in deciding such things as how to reduce costs, increase production, and increase sales.
- 2e: False. In most rural communities, gardening is the responsibility of the female head of household. This tradition should be encouraged, with the female head of household seeking the support of the male head of household and other family members. The field agents should also work with families to ensure that the female head of household maintains control and influence over how the income generated should be used.
3. All other statements are either included in “e” or are additional benefits from marketing garden produce.
4. A logical sequence for these components of the plan is the following:
- (e) What garden vegetables, fruit or herbs you are going to sell and why you have chosen these products
 - (d) To whom you are going to sell the garden products, at what price, when, where and in what quantities
 - (i) Where, when and how you are going to plant, harvest, and handle or process the products before sale
 - (b) How you are going to organize as a family to run the garden produce enterprise
 - (f) What it is going to cost to plant, grow, harvest, handle/process, and market the products you produce
 - (a) How much you expect to earn from selling the garden produce and how much money you expect to make after accounting for all your expenses
 - (h) How and where you will find the monetary resources to pay for the labor and materials that you will need
 - (c) How you will use the money that you earn from selling the garden produce
 - (g) What risks you may face during the production and marketing cycle and how you will overcome them if they occur

Chapter 13: Behavior change

1. False. Knowledge does not equal behavior change; it is action by the target group that counts. People take action when it *benefits them*. *Constraints or barriers* keep them from acting.
2. False. Behavior change addresses behavioral, social, economic and cultural factors to achieve a change intended to improve the well-being of a specific population. Behavior change includes not only communication (often expressed as BCC), but also actions to create an enabling environment for sustained change. The actions may include provision of needed systems (ongoing technical support from agricultural extension workers), services, or infrastructure (sustainable sources of seeds, tools, or drip irrigation materials), formulation of supportive policy (local government rescinds market tax for products), or measures to sway social norms (events to make gardening a fun, profitable and acceptable use of time).

3. False. Our target group is not always motivated by what we think should motivate them. We often assume that young mothers will be motivated by wanting a healthy child. However, “good health” is not tangible, that is, it cannot be touched or necessarily seen. In the CRS Zambia project, Mawa, mothers may be more motivated by having their child be intelligent, “do well in school” in the future, or become a strong athlete. The mothers may crave recognition for themselves as being a good mother or wife.
4. D, all of the above. The formative research methods that help us understand the priority target group’s point of view are focus group discussions, positive deviance studies and doer/non-doer surveys.
5. B. Collecting needed materials with neighbors and making a compost pile under guidance of the extension worker.

Chapter 14: Performance monitoring

1. True.
2. B. Make sure that the school attendance is an additional benefit from the gardens and not a substitute benefit—that is, food is being sold rather than eaten by the family and money earned from the sale of produce is being used for school fees and not additional food stuffs.
3. A. This information would be especially useful in making sure that the people in your program are achieving goals that are important to them. C is tempting, but assuming that high yields are being eaten or sold does not give the kind of information you would need to know that nutrition is being impacted through consumption or increases in income.

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