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FRESH PRODUCE SAFETY AND GOOD AGRICULTURAL PRACTICES FOR PRODUCE GROWERS IN NEPAL

A GROWER'S GUIDE

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ABOUT THIS MANUAL

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This manual is a tool for produce growers to learn about food safety risks and apply that knowledge to review their farm practices and operations to identify where food safety improvements may be needed. By following the guidelines and recommendations outlined in this manual, growers can assess their current practices and take proactive steps to enhance the safety and quality of their fresh produce.

For growers, understanding the sources of disease-causing microorganisms and other food safety hazards and taking action to combat them is crucial for reducing consumers' risk of foodborne illnesses associated with fresh produce consumption.

PREFACE

Globally, the consumption of raw fruits and vegetables is on the rise, in both developed and developing countries. The growing awareness of the nutritional benefits of fresh produce has led to increased production by growers to meet this demand. However, handling fresh raw produce with care is crucial, as mishandling can lead to contamination by pathogens or chemicals, resulting in foodborne illnesses. In agriculture, the safety and quality of fresh produce have become paramount concerns for growers and consumers.

Produce growers worldwide play a pivotal role in nourishing our communities, providing essential sustenance, and contributing to local economies. However, with increasing attention on food safety and environmental sustainability, growers face ever-evolving challenges. It has become imperative to adapt to a new era of best practices, embracing modern techniques and standards that ensure both the health of consumers and the vitality of our planet. This detailed Good Agricultural Practices (GAPs) manual was developed to meet this need by enhancing the current Nepal GAPs for fresh produce growers. The primary goal is to empower produce growers with the knowledge, tools, and guidelines necessary to navigate the complex landscape of fresh produce safety and GAPs. Whether you are a seasoned farmer or a newcomer to the field, this comprehensive guide will offer valuable insights, best practices, and up-to-date information to support your journey toward safer, more sustainable produce cultivation.

Our exploration will delve into a wide array of topics: microorganisms, worker hygiene, agricultural water, biological soil amendments, preharvest activities, postharvest activities, farm equipment, livestock, wild animal intrusion, equipment, tools, buildings, chemicals, traceability, and crafting a food safety plan. By adhering to GAPs and embracing the principles of safe, sustainable agriculture, growers can not only reduce the risk of foodborne illness but also contribute to the preservation of our ecosystems and the well-being of our communities.

We extend our gratitude for the tireless efforts of growers, extension agents, researchers, and regulators, whose collective wisdom has shaped the content of this manual. The pursuit of safe and sustainable fresh produce is a shared responsibility that should not be taken lightly.

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Disclaimer: This manual is not a NepalGAP (Nepal Government's GAP document produced/published by the Ministry of Agriculture and Livestock Development) training program. NepalGAP sections related to the material covered in this manual are noted where relevant. Not all requirements to achieve NepalGAP certification are covered in this manual. Be sure to check and implement the most recent NepalGAP requirements if you wish to become or are currently NepalGAP certified, and seek guidance from a local extension associate or other expert if you wish to pursue NepalGAP certification.

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CHAPTER 1
INTRODUCTION

The production of safe fresh produce is essential for consumer health and the economic success of the produce industry (Food and Agriculture Organization of the United Nations, 2017). Chemical, biological, and physical hazards must be controlled to ensure the safe production of fresh produce. The consumption of fresh produce contaminated with pathogenic microorganisms (biological hazards) can lead to foodborne illnesses, which significantly impact the livelihoods and economies of consumers and producers (WHO Foodborne Disease Burden Epidemiology Reference Group, 2015). Produce can become contaminated with pathogenic microorganisms through various sources including soil, water, animal feces, cross-contamination during processing, and improper handling by workers (Santos et al., 2023). Despite the rise of supermarkets in Nepal, most consumers purchase produce from small shops, regional markets, and street vendors (Saavedra and Shrestha, 2021). During this journey from field to consumer, fresh produce is susceptible to microbiological contamination and the transmission of foodborne pathogens. To ensure the production of safe fresh produce, various measures can be taken, including Good Agricultural Practices.

WHAT ARE GOOD AGRICULTURAL PRACTICES?

GAPs

Good Agricultural Practices (GAPs) are a set of guidelines and principles that aim to minimize the risk of on-farm contamination of fruits and vegetables (USDA Food and Nutrition Service, 2023). They are a proactive approach to food safety, emphasizing prevention rather than reaction to contamination issues after they arise. This chapter explains how GAPs can help prevent on-farm contamination.

1.1 PRIMARY OBJECTIVES OF GOOD AGRICULTURAL PRACTICES (GAPS)

The primary objective of GAPs in Nepal is to **ensure the safety of fresh produce for consumers.** Secondary objectives include ensuring the quality, sustainability, and trade compliance of agricultural products, including:

- **Food Safety:** Implement practices to reduce the risk of contamination during production, harvesting, handling, and transportation.
- **Risk Management:** Identify and address potential risks associated with fresh produce production to mitigate the likelihood of contamination and disease outbreaks.
- **Compliance with Regulations:** Abide by local, national, and international regulations and standards governing the production and handling of fresh produce.
- **Traceability:** Establish systems for swift and accurate source identification and distribution of fresh produce in case of food safety issues.
- **Worker Health and Safety:** Ensure a safe working environment for farm workers and promote practices prioritizing health and wellbeing.
- **Consistency and Standardization:** Encourage uniformity in agricultural practices to attain consistent safety and quality standards.
- **Market Access:** Fulfill requirements set by buyers, retailers, and regulatory bodies to secure market access and enhance the competitiveness of fresh produce in Nepal.
- **Consumer Confidence:** Foster trust among consumers by showcasing a commitment to producing safe, high-quality fresh produce through adherence to GAPs.
- **Quality Assurance:** Enhance and uphold the overall quality of fresh produce through appropriate cultivation, harvesting, and postharvest techniques.
- **Environmental Sustainability:** Advocate for sustainable and eco-friendly agricultural practices to minimize impacts on ecosystems and conserve natural resources.

By achieving these objectives, GAPs contribute to a strengthened and resilient fresh produce system that prioritizes human health and nutrition.

1.2 PREVIEW OF KEY GAPS COMPONENTS

What should a producer do to ensure safe fresh produce and protect consumers? The following topics will be addressed in subsequent chapters:

Food safety training: Farm managers and workers should receive training about food safety hazards and foodborne illnesses (Chapter 2).

GAPs training: Farm managers and workers should receive training about GAPs before starting farmwork and receive refresher training regularly (Chapter 3).

Workers: Only healthy workers should harvest produce and handle harvested produce (Chapter 3).

Sanitary facilities: Handwashing and toilet facilities should be available on the farm premises and be maintained to ensure proper disposal of wastewater (Chapter 3).

Preharvest water: Clean water sources that minimize contamination from people and animals should be used to irrigate crops; never irrigate crops with human wastewater (Chapter 4).

Postharvest water: Potable (drinking) water should be used to clean equipment and harvested produce; if possible, test the water for *E. coli* and keep records (Chapter 4).

Soil amendments: When needed, the farm should use treated manure from a trusted source or synthetic fertilizers (Chapter 5).

Equipment: Tools and machinery used to harvest produce should be kept exceptionally clean and in a separate storage location from fresh produce (Chapter 6).

Containers, bags, and baskets for harvest: Containers should be in clean condition before and during harvest and kept off the ground (Chapter 6).

Damaged produce: All damaged produce should be removed and repurposed or destroyed (Chapter 6).

Harvested produce: Move fruits and vegetables from the point of harvest to a designated storage area away from the growing area (Chapter 6).

Coolers/shades: Shade or a walk-in cooler should be available for storage of harvested produce (Chapter 6).

Storage areas: Storage areas should be free of insects and other pests, such as rodents, cats, and dogs (Chapter 6).

Specific storage areas: Working tools, working clothes, and biopesticides should have separate areas dedicated to their storage (Chapter 6).

Animal management: Permanent fencing should be used to keep large domestic and wild animals away from fresh produce gardens and fields. Pets should also be kept out of the growing areas. Scare tactics, such as broadcasting a recording of a wolf howl through a speaker, can deter some animals (Chapter 7).

Farm animals: Animals should be raised away from fresh produce gardens and fields (Chapter 7).

Traceback records: Records of sold/given items should be maintained on the farm for traceback (Chapter 9).

Mock GAPs audit: Extension services or university staff can assist growers in writing food safety plans and conducting a mock GAPs audit (Chapter 10).

By addressing contamination risks and following recommended food safety practices, the likelihood of contamination is significantly reduced, ensuring that consumers can safely enjoy nutritious fruits and vegetables.

CHAPTER 2

MICROORGANISMS AND FOODBORNE ILLNESS

Fresh produce is a major food safety concern. When fresh vegetables, fruits, and root crops are consumed raw, pathogens are not killed by the heat of cooking, and they carry a greater risk of transmitting foodborne disease (Santos et al., 2023). Contamination can occur from animal feces or contaminated water, harvesting containers, soil, manure, or unhygienic/infected people. Pathogens may remain even after a thorough washing (Uhlig et al., 2017). Produce of greatest concern include **vegetables** (lettuce, cabbage, spinach, cilantro, and sprouts); **fruits** (tomato, pepper, cucumber, cantaloupe, watermelon, papaya, and mango); **root crops** (onions, carrots, and beets); and **mushrooms** (Bennett et al., 2018; Carstens et al., 2019).

2.1 EXAMPLES OF FOODBORNE PATHOGENS

Foodborne pathogens are microorganisms that cause disease in humans and are transmitted by food. You cannot see foodborne pathogens without a very high magnification lens; thus, produce may be carrying pathogens even if it appears clean. Foodborne pathogens can be grouped into different categories (Nichols, 1999; Food and Drug Administration, 2012):

- **Bacteria:** Certain types of *E. coli,* such as *E. coli* O157:H7, are pathogenic (disease-causing). Other bacterial pathogens include *Salmonella, Listeria,* and *Campylobacter.*
- **Viruses:** Viruses are the smallest disease-causing pathogens. Examples include norovirus, rotavirus, and the hepatitis A virus.
- **Fungi:** Mold-causing fungi such as *Aspergillus* species can produce aflatoxins, which are potent carcinogenic mycotoxins.
- **Parasites:** Parasites live on or inside fruits, vegetables, or herbs. Examples include *Cryptosporidium, Toxoplasma gondii,* and *Cyclospora* (on cilantro and basil).
- **Protozoa:** Protozoa are microscopic organisms and include *Balantioides coli, Cystoisospora belli, Blastocystis* spp., and *Enterocytozoon bieneusi.*

2.2 FOODBORNE ILLNESSES

Illnesses arising from foodborne pathogens are called **foodborne illnesses**. Foodborne illnesses caused by the consumption of contaminated fresh produce are a significant public health concern. Over the years, consumption of fresh produce has increased (Micha et al., 2015) as consumers pursue healthier and more nutritious diets, which raises the potential for foodborne illnesses if fruits and vegetables are not grown, handled, and prepared correctly.

Fresh produce can cause foodborne illnesses when contaminated with foodborne pathogens. Poor hygiene practices, contact with contaminated water or soil, and cross-contamination during processing are some of the most common routes of contamination for fresh produce (Rajwar et al., 2016; Alegbeleye et al., 2018). Foodborne illnesses arising from fresh produce can be significantly reduced by following proper food safety practices. Improper handling practices increase the risk of acquiring foodborne illnesses.

GLOBAL INCIDENCE OF FOODBORNE ILLNESS

- As many as 600 million, or almost one in ten people in the world, suffer from foodborne disease every year.
- Foodborne diseases are estimated to cause 420,000 deaths per year.
- Almost one-third of all deaths from foodborne diseases are in children under five years of age.

Source: WHO Foodborne Disease Burden Epidemiology Reference Group (2015)

2.3 SYMPTOMS OF FOODBORNE ILLNESSES

Foodborne illnesses, also known as food poisoning, can have a range of symptoms. While some people who acquire foodborne illnesses display very minor or no symptoms at all, the onset and severity of symptoms can vary depending on the type of pathogen involved and individual factors.

Symptoms often subside within two to ten days and commonly include (Switaj et al., 2015):

- **Nausea and vomiting:** Individuals may experience feelings of nausea and may vomit because of consuming contaminated food.
- **Diarrhea:** A frequent symptom of foodborne illness, diarrhea can range from mild to severe.
- **Abdominal pain:** Cramps and abdominal pain are common symptoms associated with many foodborne pathogens.
- **Fever:** A rise in body temperature often accompanies foodborne illnesses, leading to fever.
- **Muscle aches:** Some individuals may experience muscle aches and weakness.
- **Headache:** Headaches are a common complaint during foodborne illness episodes.
- **Fatigue:** Feeling tired and lethargic is a common symptom associated with the body's response to infection.
- **Dehydration:** Foodborne illness may lead to dehydration due to fluid loss from vomiting and diarrhea. Drink plenty of clean water or other liquids if experiencing these symptoms.

BE AWARE!

Vulnerable people, including young children, pregnant women, the chronically ill, immunocompromised individuals, and older individuals, are more susceptible to foodborne illnesses (Lund and O'Brien, 2011), but people of all ages can acquire severe foodborne disease.

PREVENTING THE SPREAD OF FOODBORNE ILLNESS

If you are experiencing symptoms of foodborne illness, it is important to take steps to prevent its spread. Symptomatic people should regularly wash their hands, use hand sanitizer, and not make food for others. Foodborne illnesses are not spread through the air, so sick individuals do not need to wear masks. However, the symptoms of foodborne illness can be similar to the symptoms of common colds, flu, and COVID-19, and you can wear a mask if it makes you more comfortable. Sick individuals should never work directly with food being sold to others. If you or a coworker are displaying any of the above symptoms, inform a supervisor to ensure the symptomatic individual does not harvest, handle, or prepare food for sale. Taking these precautions will prevent the spread of foodborne illness.

2.4 FOODBORNE OUTBREAKS

A foodborne outbreak occurs when two or more people experience foodborne illnesses after consuming the same food or drink, identified as the illness source (Carstens et al., 2019). Outbreaks may impact a small group or larger populations, prompting an investigation by health authorities to pinpoint the cause, prevent further cases, and take corrective actions.

The illness source may be a specific product, a specific food producer or farm, or even all food from a specific region. If several individuals are suddenly suffering from foodborne illness symptoms, it is possible that a foodborne outbreak has occurred. Contact a nearby Health Post or medical professional to report the outbreak.

Individuals may have a foodborne illness without realizing it, especially if symptoms are minor. However, for immunocompromised individuals, the same illness can pose life-threatening risks. Therefore, minor symptoms should still be taken seriously. Refer to the Foodborne Illness section above for details.

WHEN TO SEEK TREATMENT FOR FOODBORNE ILLNESS

Individuals should seek medical treatment if symptoms are significantly worsening, severe, or prolonged, especially in young children, pregnant women, the chronically ill, and older individuals. Seek immediate medical treatment if severe symptoms arise, including difficulty breathing, the presence of blood in vomit or stool (stools may appear black in color), severe pain in the abdomen, yellow eyes, double vision, or disassociation with surroundings. Seeking treatment too late or not at all may result in death.

The frequent occurrence of foodborne illness symptoms may indicate a recurring food safety hazard. Even if symptoms are minor, they should not be ignored, as chronic foodborne disease can result in immune susceptibility and malnutrition (Food and Agriculture Organization of the United Nations, 2020). Seek guidance from a medical professional to determine the cause of symptoms. If the causative agent is a foodborne pathogen, take action to mitigate its presence.

CHAPTER 3

WORKER HEALTH AND HYGIENE

3.1 RISKS OF WORKERS TO FOOD SAFETY

Workers represent a notable food safety risk due to their potential to carry human pathogens including *Shigella,* norovirus, *E. coli*, *Salmonella, Listeria monocytogenes*, and others (Todd et al., 2007). During the harvesting of fresh produce, there is a risk that these pathogens can be spread through contact with produce, clothing, hands, footwear, tools, and equipment. As a result, it is crucial to ensure that workers receive training in safe food handling practices and are aware of the importance of not handling produce when they are unwell (Adesokan et al., 2015). It is imperative to provide comprehensive training on personal hygiene practices to farmers and workers and maintain training records.

3.2 WHY FRESH PRODUCE IS A FOOD SAFETY RISK

Fresh produce does not undergo a "kill" step such as cooking or pickling, which can eliminate pathogens. If food handlers contaminate produce, it can become a potential source of disease to consumers. It is essential for all employees, particularly new ones, to receive training before they begin handling produce. This training equips them with the knowledge and skills needed to maintain hygiene standards and reduce the risk of contamination.

3.3 MAIN POINTS FOR FOOD HANDLER TRAINING

Food handlers can play an important role in preventing the contamination of fresh produce. Training for food handlers should include the following practices:

- Monitoring the crop for contamination risks before and during harvest, such as significant animal activity, the presence of fecal matter, damaged crops, or extensive animal tracks
- Avoiding harvesting produce that is visibly contaminated with feces
- Not harvesting dropped produce
- Using only clean containers for harvest and packing

Reinforce worker training by prominently displaying action instructions in key locations within the work environment. For example, hang a sign in the bathroom with the reminder "Wash Hands After Using the Toilet."

See NepalGAP sections 1.6.9, 1.7.11, 1.8.5, 1.9.8, and 1.10.11 for specific training requirements to achieve NepalGAP certification.

3.4 FACILITIES FOR WORKERS

In keeping with worker health requirements, the farm should provide the following items necessary for worker hygiene:

- Easily accessible clean toilet facilities which must be designed to prevent contamination of the farm and environment with human wastewater
- Toilet paper
- Soap
- Potable water
- Gloves
- Garbage cans
- Designated break areas appropriate for taking meals, storing personal clothes, and/or resting
- First aid kits to address personal injuries and prevent the spread of bodily fluids

Farms should ensure that the workers properly adhere to the following food-safe practices:

- Workers must maintain personal cleanliness (body and clothing).
- If hand jewelry must be worn, it should be covered.
- Eating, drinking, and smoking are forbidden in fresh produce work areas, and contact with animals is discouraged because it can result in produce contamination.
- Workers must employ proper handwashing methods (see section 3.6 below)

See NepalGAP sections 1.8.2, 1.8.4, and 1.8.8 for specific working conditions requirements to achieve NepalGAP certification.

3.5 DEALING WITH SICK OR ILL EMPLOYEES

Farm workers with exposed cuts, sores, or open wounds that are infected, and/or when their hands or clothing are contaminated, pose a food safety risk. Promptly reporting illness symptoms is crucial, and supervisors should monitor for signs of sickness.

While job dedication or concerns about understaffing and wage loss may deter reporting (Carpenter et al., 2013), it is essential for sick workers to refrain from handling produce to ensure food safety**. If an unwell employee must work, they should be assigned tasks that do not directly involve handling fresh produce, water in contact with fresh produce, or food contact surfaces**. Some suitable duties may include building or equipment repairs, field tilling, and compost turnover. This minimizes the risk of potential contamination and ensures the safety of the fresh produce and the overall operation.

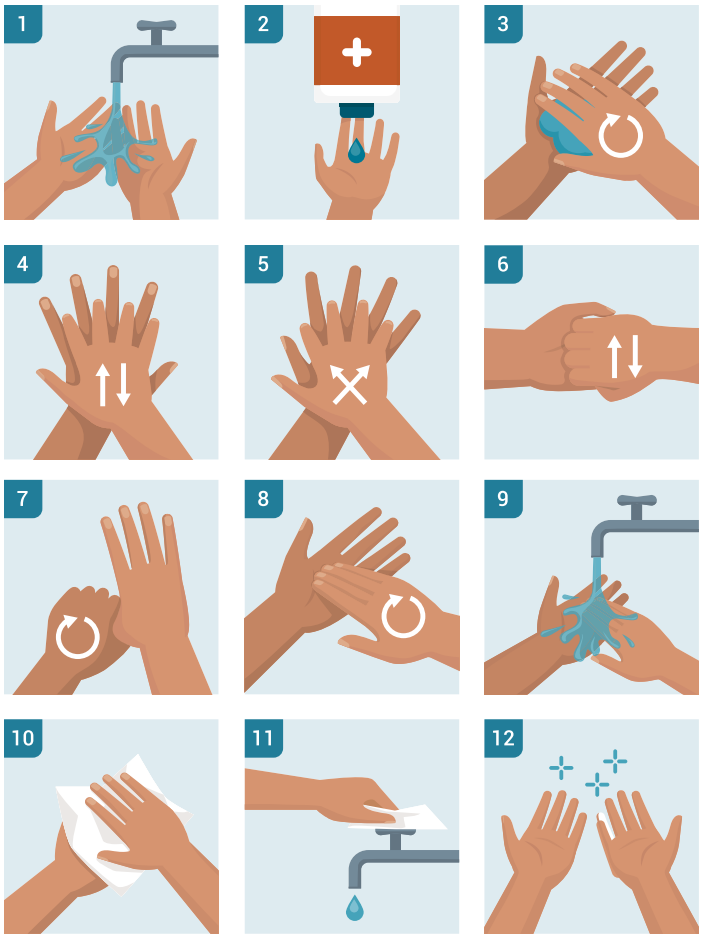
3.6 HANDWASHING

Handwashing is mandatory and should be performed after using the restroom; after eating, drinking, or smoking; before returning to work; and after any contact with animals. This practice is essential for maintaining proper hygiene and ensuring food safety.

3.6.1 PROCEDURE FOR WASHING HANDS

Contaminated hands, as well as cough or sneeze droplets, can transport harmful microorganisms. For effective handwashing, use the following recommended procedure (FDA, 2020):

- Rinse hands with warm, running, potable water (1). Potable water should be free of *E. coli* bacteria and other fecal coliforms which indicate the presence of harmful microorganisms (World Health Organization, 2024). Use potable bottled water if warm, running, potable water is unavailable (Pereira, 2020).
- Apply soap (2). Scrub your hands and wrists for at least 20 seconds (3-8). Make sure to vigorously rub the backs of your hands, the spaces between your fingers, the areas around the cuticles, the region beneath your fingernails, and the undersides of your wrists.
- After scrubbing, rinse hands with warm, running, potable water (9).
- Dry your hands using a single-use disposable paper towel (10).
- Prevent recontamination by using a paper towel when turning off the sink and opening doors (11).



All visitors to the farm or operational areas must adhere to the same safety practices as farm workers to ensure both the safety of the produce and their own well-being.

3.7 ANNUAL REFRESHER TRAININGS FOR FOOD HANDLERS

Refresher training offers benefits to both workers and the farm, ensuring consistently high food safety standards (Adesokan et al., 2015). Implementing a regular training and refresher-training schedule is crucial. It is the responsibility of the farm owner, manager, or supervisor to maintain records that document the training date, the individuals trained, the content covered, the name of the trainer, and the printed names and signatures of trainees.

BE AWARE!

Hand sanitizers do not replace proper hand washing. The best practice is to wash hands and then apply an approved sanitizer (e.g., 70% v/v ethyl alcohol sanitizers).

See NepalGAP sections 1.6.7, 1.8.3, and 1.10.2 for specific worker hygiene and visitor requirements to achieve NepalGAP certification.

CHAPTER 4

AGRICULTURAL WATER FOR FRESH PRODUCE GROWING

Water used for irrigation, washing, or cooling produce can serve as a vehicle for transmitting harmful microorganisms (pathogens) to fruits and vegetables (Faour-Klingbeil et al., 2016; Alegbeleye et al., 2018), potentially leading to foodborne illnesses. Water used in agricultural processes, such as irrigation, fertigation, pesticide sprays, or postharvest washing and cooling, often come in contact with plants, including the edible parts.

AGRICULTURAL WATER TYPES

Contaminated agricultural water has been linked to foodborne illness outbreaks (United States Food and Drug Administration, 2021), making it a critical element of fresh produce safety. There are two types of agricultural water:

- **Preharvest (irrigation) water:** water used to irrigate crops while they are growing in the ground. Follow a risk-based approach to prevent preharvest water contamination, as described throughout this chapter.
- **Postharvest (other activities) water:** water used for non-irrigation purposes including hand washing, tool cleaning, and produce washing. **Postharvest water should always be potable!**

BE AWARE!

The presence of any *E. coli* bacteria makes water non-potable. Water that does not meet requirements for potability should not be used for postharvest activities including handwashing, washing produce, cleaning tools, or any other postharvest activities until the issue is resolved and the water undergoes retesting.

Key agricultural water safety considerations include:

- **Pathogen-free:** Water used in irrigation or processes involving direct contact with fresh produce should be devoid of pathogens that might pose a contamination risk to crops.
- **Chemical-free:** Water used in irrigation or processes involving direct contact with fresh produce should be devoid of harmful chemicals and impurities that might pose a contamination risk to crops.
- **Regulatory compliance**: Agricultural water must adhere to local, national, and international regulations and guidelines governing water quality for agricultural use.
- **Testing and monitoring:** Regular testing and monitoring of water sources, especially postharvest water sources, is imperative to ensure continuous compliance with safety standards.
- **Prevention of contamination:** Agricultural water, especially postharvest water, should be handled and stored in a manner that prevents contamination, with proper sanitation measures in place during storage and distribution.

4.1 AGRICULTURAL WATER FOOD SAFETY RISKS

Water used in fruit and vegetable production poses several food safety risks. Water is a carrier of microorganisms that include pathogenic strains of *E. coli*, *Salmonella* spp., *Vibrio cholera*, *Giardia*, *Cryptosporidium,* and Helminths. The following practices and precautions are recommended:

- Ensure that the water used for irrigation/fertigation is free from harmful contaminants.
    - Use a risk-based approach to prioritize the use of less contaminated water sources. Water from hand pumps and tube wells is less risky than municipal tap water, which is less risky than river/stream/Khola water (Khanal et al., 2024, see below for details.)
- In cases of significant risk, either switch to a safe alternative water source or treat the water before use.
- Under no circumstances should treated or untreated sewage water (human wastewater) be used during production or postharvest handling.
- Farmers should adhere to the irrigation equipment maintenance practices and schedules in the manufacturer's guidelines/manual.
- Adequate measures should be implemented to prevent the influx of water from undesirable sources like municipal landfill areas, hospitals, and industrial waste dumps.
- Base irrigation on the water requirements of the crops, considering water availability and soil moisture levels. Maintain records that specify the date of irrigation, location, duration, and volume of water applied.

If a water source becomes contaminated by flood water or through other means, rectify the water source before use.

DID YOU KNOW?

In a study (Khanal et al., 2024) that examined water used by fresh produce growers in Nepal on the farm and before marketing the produce, the researchers found that:

- River/stream/khola water had the highest *E. coli* presence rate, followed by stored water.
- Among all sources used (river/stream/khola, stored water, tap water, and hand pump/tube well water), hand pump/tube well water had the least *E. coli* contamination.

4.2 BEST PRACTICES FOR PROPER WATER QUALITY AND USE ON THE FARM

4.2.1 PREVENT CONTAMINATION

- For preventing animal intrusion, storing clean water in controlled environments may prove easier than preventing animal intrusion into open water sources. Securing water reservoirs and implementing protective measures are essential to maintaining the integrity of potable water and minimizing the risk of contamination from external sources, including wildlife.
- Water source pollution can be avoided by preventing animal intrusion into surface water, using barriers such as fences.
- Prevent manure and other agricultural runoffs from contaminating ponds, rivers, and wells.

BE AWARE!

The cleanliness of water at a specific point in time does not guarantee its sustained purity. Ongoing maintenance of the water system is essential to address potential changes in quality, prevent deterioration, and ensure a consistent supply of potable water throughout fresh produce cultivation practices.

4.2.2 REGULAR INSPECTION

It is imperative to conduct comprehensive inspections to safeguard water safety and quality. The following key elements should undergo thorough scrutiny:

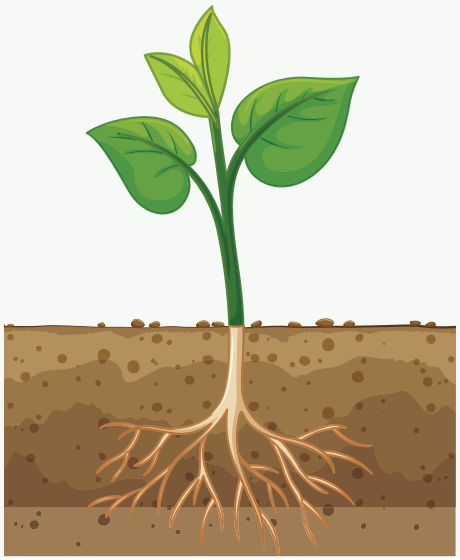
- **Water source:** Examine water sources to ensure they meet regulatory standards and are devoid of contamination, pollutants, and potential hazards.
- **Water quality parameters:** Regularly assess physical, chemical, and microbiological parameters of water quality through testing and monitoring to confirm compliance with safety standards.
- **Irrigation systems:** Inspect cleanliness, functionality, and potential contamination points in irrigation systems, encompassing pipes, hoses, and drip lines.
- **Storage tanks and reservoirs:** Regularly check cleanliness, structural integrity, and protection against contaminants, such as debris and pests, in storage tanks and reservoirs.
- **Backflow prevention:** Implement and inspect backflow prevention devices to maintain unidirectional water flow, preventing contamination of the water supply.
- **Pumps and filtration systems:** Ensure the efficiency and cleanliness of pumps and filtration systems, preventing the introduction of impurities into the water.
- **Water treatment methods:** Regularly inspect water treatment systems to verify their correct functioning and efficacy in reducing microbial and chemical risks.
- **Sanitation of equipment:** Regularly clean and sanitize equipment in contact with water, including harvesting tools, washing stations, and storage containers, to prevent cross-contamination.
- **Protective measures:** Evaluate protective measures, such as fencing or covers, to deter animal intrusion and other potential sources of contamination in open water sources.
- **Record keeping:** Maintain meticulous records of water quality tests, inspections, and corrective actions to establish traceability and demonstrate compliance with standards.
- **Employee training:** Ensure personnel engaged in water-related activities receive adequate training on proper handling, monitoring, and maintenance practices to uphold water safety standards.

4.2.3 WATER APPLICATION METHOD AND TIMING

The application method and preharvest timing of irrigation water can affect the risk of contamination with foodborne pathogens. The following practices can reduce the risk:

- Avoid irrigating crops close to harvest. Typical guidance suggests stopping irrigation four days before harvest. However, pathogens present in irrigation water can survive on crops longer than four days (Belias et al., 2020). Thus, growers should focus on preventing irrigation water contamination as described in this chapter.

- The more contact crops have with water, the more likely it is that those crops will be contaminated by foodborne pathogens. To minimize risk, growers should prioritize the use of drip irrigation methods (e.g., subsurface drip) over flood irrigation methods (e.g., furrow), and the use of flood irrigation methods over spray irrigation methods (e.g., sprinkler) (Fonseca et al., 2011).



HIGHEST RISK

Overhead spray and sprinkler irrigation methods increase contact between potentially contaminated water and produce.

MODERATE RISK

Compared to spray irrigation methods, flood irrigation methods such as furrow and surface irrigation can reduce contact between potentially contaminated water and crops that grow above the surface of the soil.

LOWEST RISK

Drip irrigation minimizes contact between water and crops that grow above the surface of the soil.

4.2.4 WATER QUALITY GUIDELINES FOR IRRIGATION WATER

- Agricultural water that will be used for irrigation and postharvest activities should be tested for generic *E. coli* bacteria.

- If tests indicate the presence of *E. coli,* generally this means that the water is contaminated and should not be used.

- Testing water for the presence of E. *coli* is a fundamental step in assessing water quality for irrigation.

- If generic *E. coli* is detected in the water, it is typically considered unacceptable for use in agriculture. The presence of *E. coli* indicates that the water may contain harmful pathogens that can lead to crop contamination or foodborne illness.

Water testing enables a grower to determine the status of their water quality and to know when corrective action is needed. The Government of Nepal, Ministry of Water Supply-Central and Regional Laboratories, Department of Water Supply and Sewerage Management Regional Laboratories, Department of Environment-Laboratories, Municipality Water Supply Board Laboratories, and universities like Agriculture and Forestry University (AFU) can assist farmers with water testing.

4.3 WASHING FRESH PRODUCE

- Potable water must be used to wash harvested produce, hands, and tools/storage bins.
- Contaminated water can cause cross-contamination of fresh produce during washing.
- There is a health risk associated with the consumption of vegetables washed with contaminated water.
- The risk is higher for fresh fruits and vegetables that are consumed raw.
- Any applied pesticides or substances requiring dilution with water should utilize potable water to ensure the effectiveness of the solution and prevent the introduction of contaminants.

4.4 WASTEWATER MANAGEMENT

Managing wastewater in a way that prevents contamination of preharvest and postharvest water sources is crucial for maintaining the safety and integrity of water resources in the agricultural environment. Wastewater is a combination of used water from domestic households, farms, institutions, and industrial establishments. It is composed of sewage/toilet water (black water), kitchen or bathroom water (grey water), and stormwater. The exact composition of such polluted water sources varies widely, depending on the garden-to-city distance, the sources of pollution (households, industry, agriculture), and how much the wastewater is diluted by other sources of water.

It is essential for farms to have a documented waste management procedure in place. This procedure should encompass the identification of waste products generated during production, harvesting, and produce handling. It must also include practices that focus on minimizing waste generation, reusing and recycling waste materials, and ensuring proper waste disposal.

See NepalGAP sections 1.6.5, 1.7.5, and 1.9.4 for specific water requirements to achieve NepalGAP certification.

CHAPTER 5

BIOLOGICAL SOIL AMENDMENTS

Growers of fresh produce frequently use organic matter to increase soil fertility. Organic matter, known as biological soil amendment (BSA), is an alternative to chemical fertilizers. BSAs make use of agricultural waste products from other activities. Crops use nutrients from BSAs to grow. Livestock manure is the most common BSA due to its availability and cost-efficacy compared to other BSAs and fertilizers. Additional BSAs include food waste, farm waste, hair, and feathers (Goss et al., 2013). It is crucial to handle BSAs properly, as they can harbor pathogens that cause foodborne illness.

Do not apply untreated BSAs such as raw/fresh manure to fields where fresh produce is growing or will be grown in the future. **Untreated BSAs applied to fields can contaminate fresh fruits and vegetables with foodborne pathogens.**

BE AWARE!

The use of treated or untreated human sewage (human wastewater) for fresh produce production is strictly prohibited to protect public health and prevent contamination risks.

5.1 FOOD SAFETY RISKS OF FRESH BSA

Harmful microorganisms commonly found in BSAs include pathogenic bacteria, such as *E. coli*, *Salmonella*, *Listeria monocytogenes,* and *Campylobacter* (Hutchison et al., 2005). Manure derived from farm livestock (cows, buffalo, sheep, goats, poultry, llamas, pig/swine, etc.) is rich in nitrogen, phosphorus, potassium, and micronutrients (Hashemi et al., n.d.) but poses the greatest food safety risk.

- Untreated BSAs applied to fields before planting can contaminate fruits and vegetables once they are planted.
- Untreated BSAs can directly contact leaves, roots, or other edible portions of plants when applied to fields.
- Fruits and vegetables with edible portions grown near or in the ground, such as lettuce and onions, are at higher risk of contamination.
- BSAs can contaminate surface and/or irrigation water that contacts plants.

DID YOU KNOW?

Pathogens from BSAs can survive in the soil and cause contamination long after application. Pathogen survival in the field varies depending on the temperature, season, soil moisture level, and soil type (Sharma and Reynnells, 2016). The survival time of pathogens in soil ranges from weeks to several months (Ramos et al., 2021).

5.2 COMPOSTING BSA TO REDUCE PATHOGENS

Composting is the controlled decomposition of organic materials (BSAs), facilitated by aerobic or anaerobic bacteria. When properly conducted, composting increases the temperature of BSAs high enough to kill produce-relevant foodborne pathogens in the raw/fresh organic matter (Gurtler et al., 2018).

Standard composting criteria require piles to reach an internal temperature of at least 55°C (131°F) for three days or more, with several variations of this depending on the composting method and regulating body (Erickson et al., 2018). *Salmonella*, pathogenic *E. coli*, and *Listeria monocytogenes* are effectively killed when compost is held at 55°C (131°F) (Singh et al., 2010).

Treated BSAs are those that have been composted or subject to other methods that kill the foodborne pathogens that may be present in the raw/fresh organic matter. **Always use treated BSAs to grow fresh produce.**

5.3 CHOOSING A COMPOSTING LOCATION

Choosing a composting location that minimizes fresh produce contamination (Bhullar et al., 2022) involves consideration of the following factors:

- Located away from crop fields, water sources, water distribution systems, animals, food contact areas, and human housing.
- Located on level ground where water cannot pool and accumulate.
- Located where crop fields, water sources, and food contact areas are protected from rain and other water draining from the compost.
- Located where the compost is protected from rain and other water draining from animals, human housing, and adjacent properties.
- Located away from foot and animal traffic to reduce cross-contamination.
- Located away from manure and other raw materials.
- Located in the sun, especially during the winter season, to ensure the pile gets hot enough. Note: if the pile is too hot, it will kill the microorganisms responsible for the composting. If the pile gets too hot in the sun, move it to a more shaded location.

5.4 COMPOSTING BSA

For a simplified and rapid composting process, follow this method (Raabe, 1991; CGIAR Technical Centre for Agricultural and Rural Development, 2007; Geisel and Unruh, 2007):

Step 1: Choose a composting location that does not pose food safety risks (see previous section). The area should be large enough to accommodate a compost bin or heap with dimensions of 1 x 1 x 1 meter and maintain an adequate buffer zone for crop fields, animals, etc. (5 meter). Use or build an aerated composting bin if possible.

Step 2: Collect dry plant material (dead leaves, dried rice stalks, straw, etc.), fresh plant material (fresh grasses, fresh leaves, wilted flowers, fruit and vegetable waste, etc.), and animal manure (from chickens, cows, etc.) separately in locations that minimize food safety risks. Do not put meat, bones, or dairy in the compost; doing so will attract pests. Small amounts of paper, cardboard, and newspaper can be used in place of dry plant material. Store materials dry and wait until there is sufficient material to fill the 1 x 1 x 1 meter bin or heap. Do not use less material because the pile will not get hot enough.

Step 3: Chop hard or woody plant material (dry and/or fresh) into 1 to 3 cm pieces. Soft materials (e.g., flower petals) do not need to be chopped. Chop or shred paper, cardboard, and newspaper if used.

Step 4: Combine dry and/or fresh plant material with manure in a 1:1 volumetric ratio. Mix thoroughly to prevent any plant materials from matting. Ensure that the mix is moist, like a wrung sponge. If the mix seems dry, add water. If the mix seems wet, add dry plant material. Pile the mixture into a bin or heap at least 1 x 1 x 1 meter.

Step 5: Cover the compost bin or heap with a lid, old sacks, plastic, or large leaves for heat insulation. If composting during the rainy season, ensure the bin or heap is sufficiently covered so rain does not increase the moisture content.

Step 6: Check the pile after two days. The inner temperature of the pile should be hot, around 70°C (158°F). Microorganisms from the raw materials produce heat through the composting process that kills pathogens. Do not apply external heat such as fire to the bin or heap. After uncovering the bin or heap, measure the temperature with a thermometer. If you do not have a thermometer, place a stick into the middle of the pile and leave it for 3 to 5 minutes; afterward, remove the stick: It should be hot. Turn the pile using a large fork to move the outer material to the center. After turning, re-cover the bin or heap.

Step 7: Continue turning the pile, uncovering it, moving the outer material into the center, and re-covering it, every other day for three weeks. The pile should remain hot. Do not add additional material to the pile. At the end of the three weeks, there will be little or no heat produced by the pile. This indicates the composting process is completed.

Step 8: Complete the composting process by applying the finished compost to the field or storing it in a location protected from contamination by animals, water, and non-composted materials**.**

5.5 USING COMPOSTED BSA

- Document and keep records of composting activity on the farm. Ensure raw materials and finished compost (treated BSA) are properly labeled with the date and duration of treatment.
- Store compost (treated BSA) in a location protected from contamination.
- Do not touch edible portions of the plant when applying compost.
- Do not store or apply compost near sensitive areas of the farm such as water bodies or wells.
- Apply compost as early as possible in the crop life cycle to ensure the longest possible window between treated BSA application and harvest.

See NepalGAP sections 1.6.4, 1.6.12, 1.7.3, 1.7.15, and 1.9.3 for specific soil additive requirements to achieve NepalGAP certification.

CHAPTER 6

FARM EQUIPMENT, STORAGE FACILITIES, HARVEST, AND TRANSPORTATION

Taking precautions with farm equipment and storage facilities is crucial to maintaining the quality and safety of harvested produce. Growers should ensure that harvesting equipment, including tools, containers, and storage facilities, are kept in a clean and sanitized condition.

6.1 STORAGE FACILITIES

Storage facilities are key infrastructure to prevent contamination with foodborne pathogens, and farmers should address the following considerations:

- Windows, doors, and roofs of fully enclosed buildings should prevent leaks and the entry of dirt, dust, debris, and pests.
- Floors should be designed to withstand both foot and equipment traffic, averting damage and the entry of pests. Additionally, ensure that buildings allow convenient access for the maintenance of both equipment and the building structure itself.
- The building design should incorporate the separation of operations to minimize the risk of contamination.
- Operative drainage should be employed to prevent the accumulation of pooled water for extended durations. Farms should be aware that floor drains can potentially harbor *Listeria monocytogenes*.
- Examine and identify potential points of entry as well as routes for pest movement. Minimize areas that attract or harbor pests, such as those containing nesting debris, food scraps, and pooled water in and around buildings.

DID YOU KNOW?

One of the greatest sources of risk during and after produce harvest is microbial contamination from contact surfaces including tools and bins.

6.2 HARVESTING EQUIPMENT SHOULD BE MADE OF MATERIALS THAT ARE NON-CORROSIVE AND EASY TO CLEAN

It is recommended to use equipment and tools crafted from **non-porous** and **non-corrosive** materials such as stainless steel and food-grade plastic (e.g., PVC, nylon) (Ohman et al., 2024). This choice enables a broader spectrum of effective cleaning methods.

Porous materials, such as wood, fabric, cardboard, foam, and carpet, can hold moisture, posing challenges in removing organic material and bacteria. Whether porous or non-porous, materials can contribute to contamination if their surfaces are damaged or not intact.

6.3 ENSURE THAT EQUIPMENT AND CONTAINERS ARE SUITABLE FOR HARVESTING AND CLEANED BEFORE USE

Clean and sanitary harvest tools and equipment are paramount to maintaining food safety. To achieve this, clean water, worker training, and the implementation of the following routine cleaning and sanitation practices are necessary:

- Regularly clean and sanitize all reusable harvest containers and tools, ensuring they are free from excess soil, vegetable matter, and debris. Clean reusable produce bins, buckets, bags, and other containers before and after use. An example follows (Hultberg and Schermann, 2018):
  - **Procedure for washing equipment and containers:**
    - o Rinse with water to ensure surfaces are free from soil and debris.
    - o Follow with a thorough washing using detergent and water, using a high-pressure sprayer hose, if possible.
    - o Complete the process by rinsing with clean potable water.
  - **Procedure to sanitize harvest containers:**
    - o After cleaning, apply a sanitizing solution, such as a diluted bleach solution, to harvest tools and containers, ensuring the elimination of pathogens.
    - o Formulate a simple yet effective sanitizing solution by combining 10 mL (2 teaspoons) of unscented household bleach (containing 5.25 - 6% sodium hypochlorite) with 4 liters of water. This mixture results in a solution with a chlorine concentration ranging from 100 to 175 ppm (parts per million).

DID YOU KNOW?

Even in the absence of sanitizer, it is essential to wash bins thoroughly with detergent and water. Cleaning alone may result in a marginal reduction of microorganisms on surfaces (Ohman et al., 2023). But more importantly, the removal of food residues minimizes the growth and proliferation of pathogens, contributing to a safer and more hygienic environment (Sogin et al., 2021).

6.4 MINIMIZING RISKS DURING HARVEST

Minimizing risks during harvest requires attention to cleaning and sanitation, management of workers, and care during harvest and storage. For cleaning and sanitation, bins, buckets, and crates should be washed with detergent and clean water, rinsed, and sanitized. This should be completed after all harvest activities. Rinse and dry bins and other containers before harvest.

Key aspects of worker management:

- Workers must be free of illnesses and open wounds.
- Workers must be trained to identify produce contamination. Fruits and vegetables that have been contaminated with fecal matter, bitten by animals, or show rot due to disease should not be harvested.
- Workers should use liners for rough surfaces and cover containers to reduce moisture loss.
- Workers should not overfill or stack containers unless containers are designed to prevent produce damage when stacked.
- To preserve produce quality and minimize the growth of pathogens, move harvested produce as quickly as possible to a cool area away from the heat of the sun, such as in a packing house. Temporarily storing harvested produce under a tree is fine, but keep produce covered to prevent fecal contamination from birds nesting or perching in the branches above.
- Provide workers with work gear (gloves, gum boots, hair nets, overalls), toilet facilities, and break areas.

Key aspects of produce harvest and storage:

- Avoid harvesting damp crops, especially leafy vegetables like spinach and lettuce. Leafy vegetables wilt rapidly in warm conditions.
- Harvesting produce during the coolest time of day, early in the morning, is a good practice.
- Produce storage areas should be clean and sanitized, including shelves and other contact surfaces.
- Prevent insects and other pests (rodents, cats, dogs, etc.) from entering buildings by placing screens on windows and closing doors. Address new entry points promptly.
- Promptly transport produce to its destination, covered, and kept at cool temperatures if possible (4°C/39°F) and when needed depending on the commodity.

6.5 MINIMIZING RISKS DURING POSTHARVEST HANDLING

- Clearly label containers for chemicals, waste, and hazardous substances, and refrain from using them for storing or holding produce.
- Promote health and hygiene in the workplace. Workers should be free of illness or wounds and practice proper hygiene behavior, especially handwashing.
- Regularly clean and sanitize all surfaces that will be in contact with produce, including containers, tabletops, cooler units, and any equipment. This reduces the risk of cross-contamination.
- If refrigeration equipment is used, maintain it in good working order, especially ensuring that it maintains the correct temperature. Proper refrigeration helps preserve the quality and safety of produce.
- Water used to wash, rinse, or cool produce should be potable. Regularly check the quality of the water and change it if necessary to prevent contamination.
- At the end of the day or after use, thoroughly wash and sanitize packing areas to eliminate potential sources of contamination.

See NepalGAP sections 1.6.7, 1.7.7, and 1.9.6 for specific harvesting and handling requirements to achieve NepalGAP certification.

6.6 TRANSPORTING HARVESTED PRODUCE

Transporting harvested produce safely is crucial to prevent pathogen contamination. Vehicles used for delivering produce, whether motorized or non-motorized (e.g., bicycles, ox carts), must be clean and maintained in sanitary conditions.

- Before loading, check for cleanliness, chemical spills, foreign objects, and pest infestation.
- Delivery containers, such as crates or boxes, should be clean and sanitary to avoid introducing contaminants to the produce.
- Conduct inspections of the delivery vehicle to ensure it is clean and has not been previously used to transport live animals, manure, or harmful substances that could pose a contamination risk.
- Keep records of who was responsible for the transportation to facilitate traceability and accountability in case of food safety concerns.

See NepalGAP sections 1.6.7, 1.9.6, and 1.9.12 for specific handling, packaging, and transport requirements to achieve NepalGAP certification.

CHAPTER 7

INTRUSION OF ANIMALS (LIVESTOCK, WILD ANIMALS, AND PESTS) INTO FARM AND FOOD-HOLDING AREAS

Livestock and wild animals harbor microorganisms in their digestive systems, some of which can be pathogenic to humans, such as the bacteria *E. coli, Salmonella,* and *Listeria*. Both domesticated and wild animals pose a potential risk to food safety because they can introduce fecal contamination into fields. Some instances of foodborne diseases have been linked to wild animals, as exemplified by the 2006 case in California, United States, where spinach contaminated with feral pig feces led to numerous illnesses and a few deaths among consumers (Kreith, 2007). While complete control over animals is challenging, it is advisable to make concerted efforts to manage and minimize their access to fresh produce fields.

7.1 KEEPING ANIMALS OUT OF FRESH PRODUCE FIELDS AND FOOD-HANDLING AREAS

Mitigating animal-related food safety risks on the farm involves preventing animals from entering fresh produce fields and areas where food is handled. Before implementing strategies to prevent intrusion into farm and food-holding areas, growers should conduct a thorough risk assessment:

- Identify the types of wildlife that frequent the growing area (birds, livestock, domestic animals).
- Assess the extent and distribution of feces in the field.
- Vigilantly monitor potential animal intrusion throughout the growing season. While addressing this complex issue, growers can employ various deterrents described in the following section.

7.2 STRATEGIES FOR EXCLUDING ANIMALS FROM FRESH PRODUCE FIELDS AND FOOD-HANDLING AREAS

- **Decoys:** Utilize figurines resembling animals, which effectively deter birds, monkeys, Bengal foxes, dogs, deer, rabbits, etc.
- **Fencing:** Deploy efficient fencing; however, be mindful that determined animals such as deer may leap over a 1.8-meter (6-foot) fence.
- **Distractor crops:** Plant crops like maize or others on the field's periphery, providing an alternative food source for antelopes and other animals.
- **Additional deterrents:** Consider installing supplementary deterrents, such as barking dogs, visual aids like predator bird figurines, and repellents like bloodmeal, if economically feasible.
- **Netting:** Apply netting, especially on produce like tomatoes, to deter birds and protect the crops.
- **Discouraging domesticated animals**: Implement measures to discourage domesticated animals, including dogs and livestock, from entering fresh produce fields. Regularly monitor fields for the droppings of animals.

By considering and implementing these strategies, growers can actively reduce the risk of animal intrusion into fresh produce fields and enhance overall food safety.

7.3 PROTECTING FRESH PRODUCE FROM WILDLIFE PATHOGEN CONTAMINATION

- Before beginning the harvest, it is crucial to evaluate the possibility of wild animal intrusion in the field. Look for signs such as fecal matter; paw, hoof, or bird feet marks; as well as evidence of foliage or fruit damage.
- If any of the indicators are detected, the grower or the person responsible for food safety should make informed management decisions. This may involve refraining from harvesting contaminated produce and establishing a no-harvest buffer zone, possibly up to an 8-meter (26-foot) radius around the defecated area. Additionally, it is advisable not to harvest nibbled or cracked fruits and vegetables.
- For certain produce, such as strawberries, avoid harvesting the edible portion if it meets the soil. This preventive measure helps minimize the risk of contamination.
- Maintain detailed records of all observations and corrective actions taken on a specific date. Recording contributes to traceability and accountability in maintaining the integrity of fresh produce.

BE AWARE!

Fruits and vegetables produced using IPM which are free of pesticide residues may still pose risks if washed with contaminated water after harvest. To ensure the delivery of safe and high-quality food to consumers, IPM must be complemented by Good Agricultural Practices (GAPs) to enhance food safety and quality on farms.

7.4 INTEGRATED PEST MANAGEMENT (IPM)

Implementation of Integrated Pest Management (IPM) demands a meticulous evaluation of available pest control techniques and the integration of suitable measures to deter the proliferation of pest populations, all while minimizing the use of plant protection chemicals. Only use commercial plant protection products registered and approved for use in Nepal.

- IPM strives to incorporate a diverse range of pest management strategies, with an emphasis on minimizing or eliminating the use of chemicals. The primary benefits of IPM include reducing human exposure to chemicals and employing management techniques with minimal negative environmental impact.
- Key components of IPM encompass cultural practices, mechanical and physical strategies, regulatory measures, biological controls, and judicious chemical use when necessary. Concerns about pesticide residues may arise if pesticides are applied too close to harvest.
- IPM methods are readily applicable in fruit and vegetable production.

It is crucial for all stakeholders, including farmers and sellers, to engage in IPM. Seeking guidance and information from university or government staff, agricultural knowledge centers, and agricultural extension personnel is recommended.

CHAPTER 8

CHEMICAL HAZARD RISKS IN FRESH PRODUCE

Only pesticides approved for use on fresh produce by the Government of Nepal should be used. Only purchase approved pesticides from trusted sellers. Pesticides, which protect crops from harmful pests, enhance crop productivity and come in chemical or organic forms. However, the use of chemical pesticides poses potential risks to the environment, human health, and non-target organisms. Individuals applying pesticides/chemicals are especially vulnerable, and improper use can lead to severe health consequences, including death (Damalas and Koutroubas, 2016; de-Assis et al., 2020). The contamination of fresh produce by chemical residues raises significant concerns for human health, emphasizing the importance of careful pesticide management.

DID YOU KNOW?

A maximum residue limit (MRL) is the highest level of a pesticide residue that is legally tolerated in or on food or feed when pesticides are applied correctly in accordance with Good Agricultural Practice.

To protect consumers from the potential harm of pesticides, the World Health Organization (WHO) evaluates available data and establishes internationally recognized **maximum residue levels** (MRLs) (Codex Alimentarius International Food Standards, 2022). The quantity of pesticide residue in food is influenced by factors such as the type and concentration of pesticides applied; exposure to environmental elements like wind, rain, and sun; and the level of food processing (including storage duration, washing, or peeling) (Tudi et al., 2021).

- The Government of Nepal has addressed this concern by publishing the Nepal Gazette – Mycotoxin, Pesticide Residue MRLs of Fruits and Vegetable Mandatory Standard, outlining the maximum residual levels of pesticides (Department of Food Technology and Quality Control, 2022).

- Testing produce for chemical residues should be conducted at a frequency specified by customers or market requirements.

8.1 PREVENTION AND CONTROL OF CHEMICAL CONTAMINATION

- Minimize exposure to pesticides.
- Pesticide applicators should wear personal protective clothing, including long-sleeved shirts, pants, closed-toe shoes, face masks, respirators, and gloves.
- Allow adequate time for pesticides to break down to levels below the maximum residue levels (MRLs) before harvest. Refer to product instructions for guidance on the appropriate time.
- Adhere to government rules specifying MRLs for pesticides on fresh produce; note that MRLs may differ between crops.
- Adhere to the directions on pesticide labels when applying them.
- Reduce pesticide residue risks by washing produce under potable running water after harvest (Yang et al., 2022).
- Chemicals must be stored in their original containers with clear and legible labels, following the directions specified on the label. In the event of transferring chemicals to another container, the new container must be distinctly marked with the name of the chemical, the prescribed dosage, and the required withholding period.

Used chemical containers must not be repurposed; instead, they should be gathered in a secure location and disposed of in accordance with Nepal's regulations. This disposal process should be conducted to prevent contamination of produce and the environment.

8.2 MANAGEMENT OF CHEMICAL CONTAMINANTS IN FRESH VEGETABLES AND FRUITS

Chemicals that contaminate produce can stem from various sources, including:

- Pesticides
  - Pesticides constitute the most prevalent residue contaminants in fruits and vegetables. While some chemicals remain on the surface, others are absorbed into the tissue of these crops. The responsible and prudent use of pesticides can significantly mitigate their impact on humans, animals, and the broader environment, including air, soil, and water.
- Lubricants, cleaners, sanitizers, paint, and refrigerants
  - Persistent organic pollutants (POPs) are compounds that accumulate in both the environment and the human body. Organochlorine pesticides (OCPs), a subgroup of POPs, exhibit a propensity for building up in the food chain, ultimately finding their way into the human body. Short-term exposure to OCPs has been associated with adverse health effects, including headache, dizziness, nausea, incoordination, vomiting, and convulsions.
- Vermin control chemicals
- Fertilizers, adhesives, and plastics
- Heavy metals such as cadmium, lead, and mercury
  - Lead, cadmium, and mercury, classified as heavy metals, can lead to kidney and neurological damage. Food contamination by heavy metals is predominantly a consequence of soil and water pollution.
  - Cadmium, a trace element with adverse effects on human health, can be encountered through ingestion (e.g., produce). Chronic exposure to cadmium primarily impacts the kidneys. While cadmium may naturally occur in food plants, elevated levels are a result of contamination in soil and water.
- Naturally occurring toxins, including allergens, mycotoxins, alkaloids, and enzyme inhibitors
  - Naturally occurring toxins, such as mycotoxins (e.g., aflatoxin and ochratoxin) produced by molds on grains, can accumulate in staple foods like maize. Other examples include marine biotoxins, cyanogenic glycosides, and toxins in toxic mushrooms. Prolonged exposure to these toxins can harm the immune system, impair growth, and potentially lead to cancer.

Documentation for the approval of pesticides and other chemicals must be preserved.

The tables below provide a comprehensive list of the causes of chemical contamination in produce with corresponding preventative actions.

Hazard: Pesticide residues in produce exceeding maximum residue limits (MRLs)

CONTAMINATION	MANAGEMENT
Poor quality pesticides (formula not meeting specifications)	Purchase quality pesticides from a trusted source
Incorrect mixing and application of greater than permitted dosages	Verify mixing and application instructions
Pesticide not approved for the target crop	Select appropriate pesticides for target pests
The withholding time (preharvest interval) was not observed	Follow withholding time (preharvest interval)
The application equipment was not calibrated or malfunctioned	Apply pesticides with calibrated, well-maintained equipment
The pesticide was dropped or accidentally spilled onto the ground or a water source	Prevent contamination of the surrounding area by creating a harvest exclusion zone; remove affected crops and soil from the zone

Hazard: Non-pesticide contaminants (e.g., lubricants, cleaners, paint, sanitizers, refrigerants, vermin control chemicals, fertilizers, adhesives, and plastics)

CONTAMINATION	MANAGEMENT
Improper cleaning and sanitation practices	Clean and sanitize tools and equipment away from produce and ensure proper pesticide application
Oil leaks, grease, and paint on equipment that contacts produce (such as in the farm storage area)	Maintain equipment to prevent oil leaks, grease, and paint on equipment
Contaminated transportation vehicles and containers	If oil or other contaminants are noticed on equipment, containers, or transportation vehicles, clean it before harvest and fix the equipment to prevent future leaks
Chemical spills (lubricants, cleansers, and vermin-control agents) close to produce and packaging materials	Conduct all maintenance and chemical mixing away from produce and packaging materials

Hazard: Heavy metal residues (e.g., cadmium, lead, and mercury) in produce exceeding maximum levels

CONTAMINATION	MANAGEMENT
Use of fertilizers or compost with high quantities of heavy metals	Purchase approved fertilizers and compost from trusted suppliers; prevent self-made compost from becoming contaminated by runoff
Misuse of household compost that contains mercury and cadmium from batteries	Only compost suitable materials: dry plant matter, fresh plant matter, and manure
Irrigation with polluted water	Irrigate crops with quality water free from heavy metal contamination
High concentrations of heavy metals in the soil, either naturally or because of leaks from industrial facilities or farmer use	Monitor heavy metals in the soil with occasional testing, especially on farms near industrial areas; contact an extension agent if you find high levels of heavy metals on the farm; some plants may remove heavy metals from the soil but should not be consumed

Hazard: Natural toxins (e.g., allergens, mycotoxins, alkaloids, and enzyme inhibitors)

CONTAMINATION	MANAGEMENT
Unsuitable storage conditions, for example: • Humid storage space leading to mold on produce • Potato storage in light	Store produce in appropriate storage conditions to prevent natural toxins from developing; dispose of produce with evidence of mold growth

See NepalGAP sections 1.6.6, 1.6.13, 1.7.6, and 1.8.1, 1.9.5, and 1.9.11 for specific chemicals requirements to achieve NepalGAP certification.

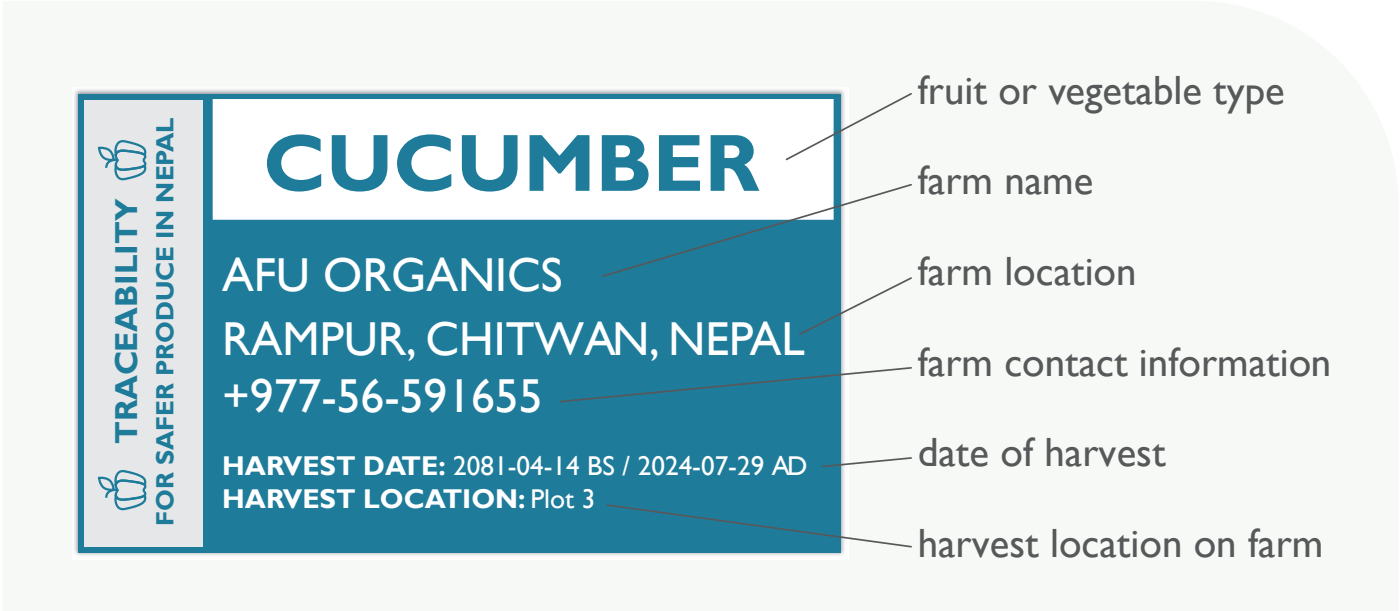
CHAPTER 9

TRACEABILITY AND RECALL

Ensuring food safety requires that growers or food vendors supplying retail shops, restaurants, and institutions maintain detailed records of the movement of their food items. It is imperative that farm production sites be designated with a name or code and documented on a site map.

Implementing a trace-back system for fresh produce can involve attaching tags to fresh produce crates/containers. These tags should include essential information such as the farm details, identity of the produce items, harvest date, and field location. An analogous practice is seen in the United States with freshly harvested oysters, where individual bags are affixed with zip-tied tags for clear identification and traceability.

SAMPLE PRODUCE TAG



All products certified under Good Agricultural Practices (GAPs) must have traceability to each registered producer and their respective farm. Robust systems and procedures must be implemented to minimize the risk of incorrect labeling or the inadvertent mixing of GAP and non-GAP products.

- Records should include information on the origin of the food and its destination, such as lettuce harvested on a specific date from a particular field bed, packaged, and delivered to ABC Restaurant on another date, received by Mr./Ms. _____.
- Records play a crucial role in tracing the source of food items in the event of a foodborne disease outbreak, facilitating swift containment and prevention of further illnesses among consumers.
- Recalls are initiated when a particular food type is identified as the source of a foodborne disease or discomfort, emphasizing the need for growers to conduct mock recalls as a practice exercise.
- During a mock recall, growers can contact their clients and inquire about the receipt and usage of specific produce (e.g., bell peppers) on a designated date, making it clear that it is a practice drill, and no items need to be returned.
- A mock recall helps growers assess product performance, identify successful sales, and understand the reasons behind any unsold items, ultimately contributing to informed decision-making and maximizing profits.

See NepalGAP sections 1.6.8, 1.9.7, 1.10.3, 1.10.14, 1.10.15, 1.10.16, and 1.10.17 for the specific requirements for traceability, recall, and complaint handling to achieve NepalGAP certification.

DOCUMENTS AND RECORDS

Record-Keeping Duration for GAPs: Retention of all Good Agricultural Practices (GAPs) records is mandatory for a minimum of two years, or a longer duration as dictated by the legal requirements of the respective country.

Document Management: Obsolete documents must be appropriately discarded, ensuring that only current versions are utilized.

See NepalGAP sections 1.6.10, 1.7.12, 1.8.6, 1.9.9, 1.10.5, 1.10.7, 1.10.8, 1.10.9, 1.10.12, 1.10.13, 1.10.20 for the specific requirements for documents and record-keeping to achieve NepalGAP certification.

CHAPTER 10

FARM FOOD SAFETY PLAN (FSP)

A farm food safety plan (FSP) is a document that outlines a set of standard operating procedures (SOPs) to be followed on a farm to meet food safety standards. While it is not mandatory, having an FSP is highly recommended. It serves as a reference guide for farm activities, ensuring accessibility to all workers. Additionally, in the event of a foodborne illness investigation, the FSP can aid in identifying sources of contamination. It is a concise document, typically two to three pages, although larger and more complex farms may require a more extensive plan. Extension and public health personnel are available to assist growers with the development of their FSP.

10.1 WHY DEVELOP A FOOD SAFETY PLAN?

A farm food safety plan aids in maintaining organization for the grower and workers regarding farm food safety by:

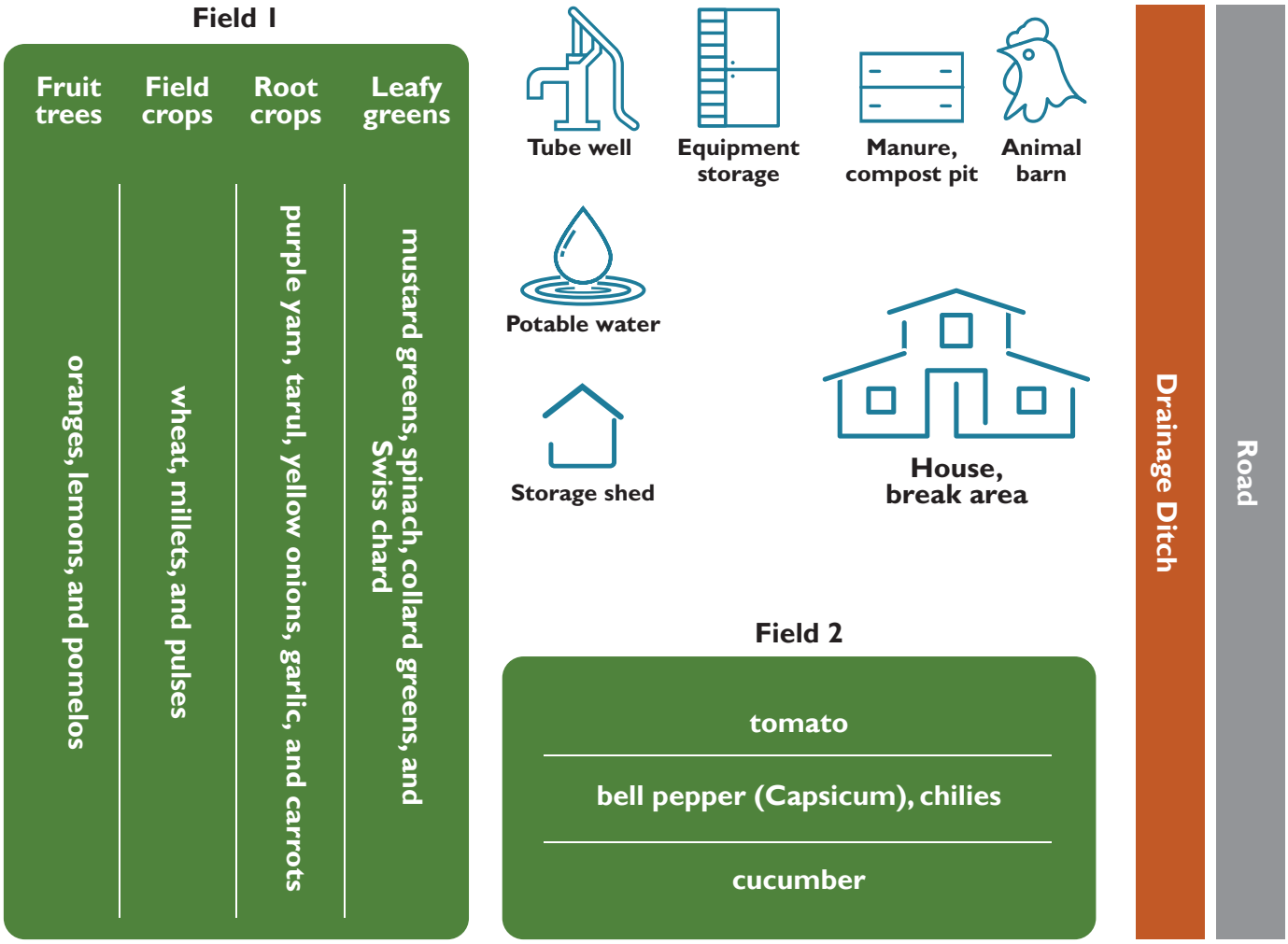
- Identifying food safety risks and the corresponding Standard Operating Procedures (SOPs) to be adhered to.
- Detailing corrective action items required to address deviations from SOPs.

10.2 HOW TO DEVELOP A FOOD SAFETY PLAN

To compose a comprehensive Food Safety Plan (FSP), consider the following:

- Specify the farm's name and address, if available, and identify at least one person who has received Good Agricultural Practices (GAPs) training to act as the reference person and/or worker trainer on the farm.
- Include the date the FSP was created.
- Acknowledge the distinct nature of each farm by listing the commodities grown, recognizing that risks may vary.
- Draw a map of the farm. On the map denote the following:
  - Fields or areas where specific crops are grown
  - Buildings and what they are used for, including:
    - Where chemicals are stored
    - Where equipment and tools are sanitized
    - Where harvested produce is stored
  - Sources and/or storage of preharvest and postharvest water
  - Areas of the farm that are specifically risky due to proximity to animals, surface water, or runoff from adjacent farms
  - Employee toilet and break areas
- Evaluate potential sources of farm risks (e.g., workers, water, manure, pesticides, neighboring farms) as outlined in this document.
- Define best practices for preharvest, harvest, and postharvest activities.
- Include only practices actively implemented on the farm, listing realistic actions that are feasible for the specific farm and emphasizing risk reduction.

SAMPLE FARM MAP



10.3 GUIDELINES FOR DEVELOPING A FOOD SAFETY PLAN

The following considerations are key to developing a farm food safety plan (FSP):

- Identify potential risks contributing to food safety concerns on the farm, encompassing microbial, chemical, and physical risks.
- Identify activities on adjacent land, including livestock, crops, agro-forestry, or wetland, and assess associated risks, prioritizing them based on severity.
- Compile a list of standard operating procedures (SOPs) to be followed for averting identified risks, and specify the resources required to implement these SOPs effectively.
- Revise the written plan whenever changes in farm operations occur or as necessary, ensuring its continual relevance.
- Maintain comprehensive records of activities outlined in the FSP.
- Seek assistance from agricultural extension agents, public health professionals, and relevant government staff in developing the FSP.
- Consider referencing another farm's FSP for guidance, tailoring it to suit the unique circumstances of the farm, as each farm is distinct.

See NepalGAP sections 1.6.1, 1.7.1, 1.9.1, and 1.10.4 for the specific requirements in making farm food safety and quality plans to achieve NepalGAP certification.

See NepalGAP sections 1.6.11, 1.7.13, 1.8.7, and 1.9.10 for a specific review of practices and requirements to achieve NepalGAP certification.

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This manual is a tool for produce growers to learn about food safety practices that reduce consumers' risk of foodborne illnesses. The manual was shaped by the collective wisdom of growers, extension agents, regulators, and an international team of food safety experts. We extend our sincere appreciation to all who contributed to the development of this manual and hope it will empower growers across Nepal to take proactive steps to enhance the safety and quality of their fresh produce.