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SECTOR ENVIRONMENTAL GUIDELINE:

PEST MANAGEMENT

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PREFACE: ABOUT THIS DOCUMENT AND THE SECTOR ENVIRONMENTAL GUIDELINES

This document presents one of the *Sector Environmental Guidelines (SEGs)* prepared for the United States Agency for International Development (USAID) under the Agency's Environmental Compliance Support (ECOS) program. SEGs for all sectors are accessible at https://www.usaid.gov/environmental-procedures/sectoral-environmental-social-best-practices/sector-environmental-guidelines-resources.

Purpose. The purpose of this document and the SEGs overall is to support environmentally and socially sustainable sound design and management (ESDM) of common USAID sectoral development activities by providing concise, plain-language information regarding:

- The potential for beneficial impacts from well-managed pest management activities;
- The typical adverse environmental impacts of activities in the sector;
- How to prevent or otherwise mitigate adverse impacts, both in the form of general activity design guidance and specific design, construction, and operating measures;
- How to minimize vulnerability of activities to climate change; and
- More detailed resources for further exploration of these issues.

Audience. This SEG is mainly for USAID Agreement and Contracting Officers' Representatives (A/CORs), USAID Mission, Regional and Bureau Environmental Officers and Advisors (MEO/REA/BEOs), Agricultural Officers, Project Design Teams, and implementing partner (IP) staff engaged in implementation of pest management activities. However, this SEG, like the entire SEG series, is not specific to USAID's environmental procedures. SEGs are written generally and are intended to support ESDM of pest management by all actors.

Environmental Compliance Applications. USAID's mandatory life-of-project (LOP) environmental procedures require that the potential adverse impacts of USAID-funded and managed activities be assessed prior to implementation via the Environmental Impact Assessment (EIA) process defined by 22 CFR 216 (Reg. 216).

They also require that the environmental management/mitigation measures ("conditions") identified by this process be written into award documents, implemented over LOP, and monitored for compliance and sufficiency.

The procedures are USAID's principal mechanism to assure ESDM of USAID-funded and managed activities—and thus to protect environmental resources, ecosystems, and the health and livelihoods of beneficiaries and other groups. They strengthen development outcomes and help safeguard the environment.

The Sector Environmental Guidelines directly support environmental compliance by providing information essential to assessing the potential impacts of activities, and to the identification and detailed design of appropriate mitigation and monitoring measures.

However, the Sector Environmental Guidelines are not specific to USAID's environmental procedures. They are generally written and are intended to support ESDM of these activities by all actors, regardless of the specific environmental requirements, regulations, or processes that apply, if any.

Guidelines Superseded. This Pest Management SEG (2024) replaces the *Environmental Guidelines for Small-Scale Activities in Africa (EGSSAA): Chapter 12 Pest Management I: Integrated Pest Management (IPM)* (2009).

Development Process and Limitations. This update substantially restructures the guideline to align with other documents in the SEG series. In developing this document, content in predecessor guidelines has been retained when applicable. In addition, consideration of social and economic impacts of sector activities, occupational and community health impacts from the sector, and a more substantial assessment of climate change adaptation and mitigation considerations for the sector have been included.

Please note that the *Sector Environmental Guidelines* are not a substitute for detailed sources of technical information or design manuals. Users are expected to refer to the accompanying list of references for additional information.

Comments and Corrections. Sectors are constantly evolving, and therefore, these guidelines are a reflection of the sector at their time of development. Comments, corrections, and suggested additions are welcome. Please provide feedback via email at: environmentalcompliancesupport@usaid.gov.

Document Structure. The SEG introduces practices and information that can be used to address management of environmental and social impacts from pest management activities. The impacts and mitigation measures described in the Pest Management SEG are intended to be used as a reference when completing 22 CFR 216 requirements. Specifically, the impacts described can be used as reference when completing USAID's Environmental Impact Assessment (EIA) Process, described below in Figure 1, or IEE for USAID Pest Management Activities. After impacts have been assessed through the EIA Process, the mitigation measures described for each impact in the SEG can be used as a resource in developing Environmental Mitigation and Monitoring Plans (EMMPs) for USAID Pest Management Activities.

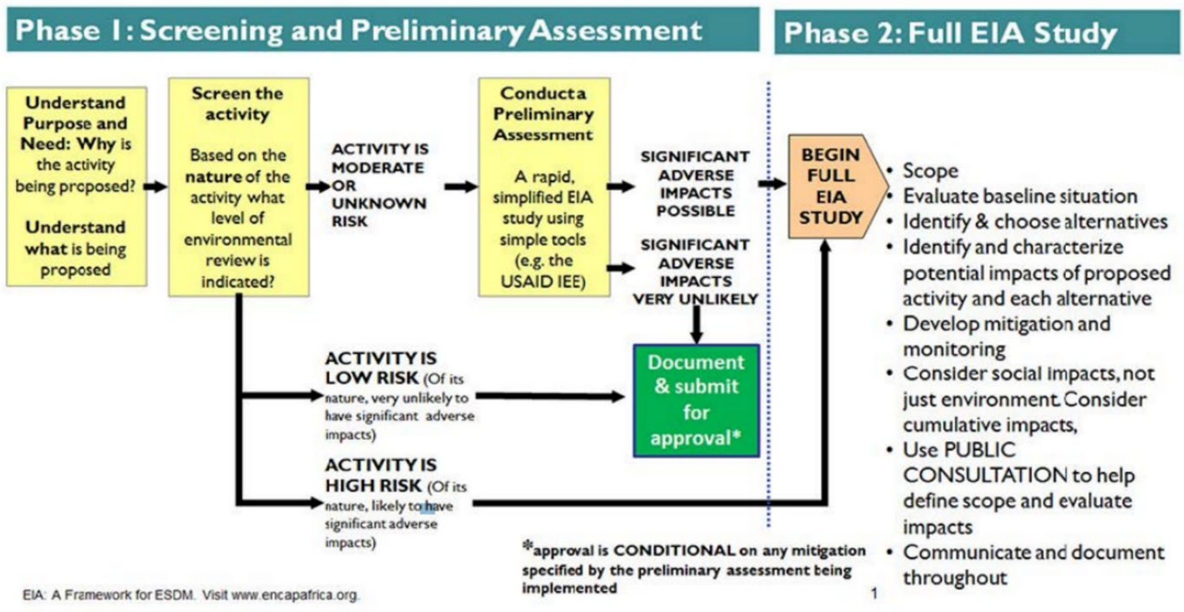

Figure 1. EIA Process (USAID 2019).

The structure of the document is as follows:

Chapter One: How to Use this Document provides a brief introduction to the purpose of the documents and the topics to be covered.

Chapter Two: Sector Description briefly describes the goals and types of pest management.

Chapter Three: Environmental Impacts summarizes the environmental impacts and mitigation measures that are associated with pest management.

Chapter Four: Climate Change Mitigation and Adaptation describes the potential impacts of pest management to climate change and the impacts that climate change has on pest management along with adaptation and mitigation practices.

Chapter Five: Social Impacts of Pest Management associated with pest management are discussed.

Chapter Six: Climate Change and Pest Management impacts that should be evaluated when conducting pest management activities are explained.

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LIST OF ACRONYMS

A/COR	Agreement/Contracting Officers' Representative
BMP	Best Management Plan
CDR	compulsory displacement and resettlement
CFR	Code of Federal Regulations
CRM	Climate Risk Management
CSPM	climate smart pest management
EA	Environmental Assessment
ECB	European corn borers
ECOS	Environmental Compliance Support
EGSSAA	Environmental Guidelines for Small-Scale Activities in Africa
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EJ	Environmental Justice
EMMP	Environmental Mitigation and Monitoring Plan
ERS	Economic Research Service
ESDM	environmentally and socially sustainable sound design and management
ESIA	Environmental and Social Impact Assessment
FAO	Food and Agriculture Organization of the United Nations
FIRFA	Federal Insecticide, Fungicide, and Rodenticide Act
GBV	Gender Based Violence
GHG	Greenhouse Gas
GRM	Grievance Redress Mechanism
GUP	General Use Pesticide
IEE	Initial Environmental Examination
ILO	International Labor Organization
IP	Implementing Partner
IPM	Integrated Pest Management
ISFM	Integrated Soil Fertility Management
IVM	Integrated vector management
JMPR	Joint FAO/WHO Meeting on Pesticide Residues
LAP	Livelihood Action Plan
LGBTQI+	lesbian, gay, bisexual, transgender, queer, and intersex
LOP	life-of-project
MRL	maximum residue level
OCP	organochlorine pesticide
OPP	organophosphorus pesticide
PEA	Programmatic Environmental Assessment
RUP	restricted use pesticides
SEG	Sector Environmental Guideline

SEP	Stakeholder Engagement Plan
SIRS	Social Impact Risk Initial Screening Tool
USAID	United States Agency for International Development
WHO	World Health Organization

1. HOW TO USE THIS DOCUMENT

This document presents the unique risks and opportunities present when engaging in pest management activities. The information contained herein, addresses pest management approaches and considerations for pests found in the crop production, livestock management, post-harvest grain storage, other structural and facility fumigation applications, as well for vector-borne disease and water/waste treatment applications in the public health sector.

The general strategy of pest management is a chemicals-as-a-last-resort intervention with cultural, mechanical, and other practices first, and then a review of whether bio-chemical, least-toxic chemical (general use pesticides – GUP), and eventually restricted use pesticides (RUP) application based on the presence of pest infestations that pass a certain threshold and have an economic impact on yield (mostly for crops and structural applications). Certain preventive measures or control strategies are also used in livestock and for vector-borne disease applications to ensure that pest prevalence is kept below levels of concern.

1.1 GOALS AND OBJECTIVES OF THE DOCUMENT

The goal of the Pest Management Sector Environmental Guideline, a part of the USAID Sector Environmental Guidelines series, is to provide information essential to assessing the potential impacts of pest management activities, and to identify appropriate mitigation and monitoring measures. However, this SEG is not specific only to USAID's environmental procedures. It is written to support broad environmentally and socially sustainable approaches to pest management. Site specific context should be taken into consideration when using the Pest Management SEG. Additional or modified impacts and mitigation measures may be required.

This document presents considerations for developing economically, socially, and environmentally sustainable pest management plans. Each section describes considerations for the impacts of pest management and provides mitigation measures to avoid, minimize, and reduce adverse impacts of pest management. Adherence to mitigation measures described herein will enhance the sustainability of pest management activities. Concurrent analysis of all impacts discussed in subsequent sections of this document while designing activities will lead to more sustainable outcomes.

The SEG can assist USAID stakeholders in developing compliance documentation, project development questions and environmental impacts assessments.

1.2 INDICATORS FOR MEASURING IMPACTS

Choosing metrics for measuring environmental impacts is important for adaptive management—that is, to assess effectiveness or impacts during the life of the project and make changes to ensure that programmatic and environmental goals are achieved.

Discussions of indicators for measuring impacts are also included throughout the chapters of this SEG. Existing resources and conditions should be assessed prior to project implementation to establish a baseline and select relevant indicators to monitor throughout the project lifecycle.

For determining the appropriate metric or assessment framework for measuring environmental impacts, the following should be considered. Please note that environmental impacts are multi-dimensional in nature, and a holistic approach to measuring and addressing all environmental impacts should be prioritized in USAID activities.

- Determine the resources (i.e., time and funding) available to develop an evaluation program.
- Determine the length of time that the evaluation program should be implemented in relation to the proposed project.
- Develop a framework for measuring the impact to the resource:
    - What will be measured?
    - What is the spatial scale of the assessment?
    - Who will conduct the assessment?
    - How will the assessment be prepared?
- Determine how the outcome of the assessment will be used during project implementation.

2. SECTOR DESCRIPTION

Chapter 2 introduces the goals and types of pest management, the importance of integrated pest management, critical pesticide use considerations, and the key pathways pesticides can migrate from target to non-target areas.

2.1 DEFINITION OF PEST MANAGEMENT

According to the USDA Economic Research Service (ERS), **pest management** strategies are mitigation measures in agriculture "to control weeds, insects, fungi, viruses, and bacteria" to "improve crop quality and increase crop yields" (USAID 1991; USDA 2020a). Pest management also addresses animals that are the target of pests, especially livestock, through the use of insecticides, antibiotics and other controls (Walker and Stachecki 1996).

Pest management activities can be divided into three main approaches: exclusion, eradication, and management of established pests.

2.1.1 EXCLUSION/QUARANTINE

Exclusion methods are used to decrease the probability of pests entering areas where they did not formerly exist. Successful exclusion depends on a well-organized system for detection and quarantine so that pests can be eliminated before becoming established over a wide geographic area. Nearly all countries have enacted phytosanitary regulations to limit the introduction of exotic species (FAO 2023), although many developing countries may lack well-developed systems for detecting and eliminating introduced pests and should be encouraged to institute effective quarantine procedures.

There are hundreds of examples of pests entering geographic areas where they did not formerly exist. A recent case is fall armyworm (FAW, *Spodoptera frugiperda*), a pest of maize and other grasses in the Americas, which invaded West Africa in 2016 and rapidly spread across the continent where it poses a major threat to maize and other cereal production. By 2018, FAW had invaded India and subsequently moved into several southeastern Asian countries and finally into China (Prasanna et al. 2022).

Invasive pests often cause much greater damage in their new habitats than in their places of origin because they are relatively free from regulation by natural enemies. This was the case with the cassava mealybug, an insect so innocuous in its native South America that it was an undescribed species before being introduced to Africa (Neuenschwander and Herren 1988).

2.1.2 ERADICATION

The aim of eradication is to eliminate a pest species from a defined geographic area. If successful, eradication removes the future need for control of the target pest. Sometimes referred to as "total pest management", eradication is most often initiated against introduced pest species before they become established over large geographic areas and when the economic consequences are potentially great. Eradication is only appropriate in limited situations and has been successfully employed in only a few cases. The New World screwworm was eradicated from the USA in 1966, and by 2000 all North America. The same insect invaded Libya in 1988 and was eradicated by 1991 (Wyss 2000). Eradication programs typically rely on three types of control strategies: release of sterile insects, chemical control, and the destruction of hosts.

- Sterile Insect Technique: A control strategy developed by the USDA to introduce sexually sterile insects of the target pest species to reduce the chance for reproduction and population growth.
- Chemical Control: Pesticides either alone or in combination with the sterile insect technique, are often used in eradication and control programs. In some cases, pesticides in bait formulations are used to attract and kill the pest species.
- Host Destruction: In cases where pests have a limited host range, it may be possible to eradicate a newly introduced pest by temporarily destroying all of the hosts in the infested area. However, this is an extreme approach that is not generally pursued.

2.1.3 REDUCTION/ PEST MANAGEMENT

The goal of reduction is to decrease the evolution of pest resistance to pesticides and other pest management practices. Pests can be managed by a variety of methods, including biological control, host resistance, cultural control, and the use of pesticides. The current practice is to use combinations of these techniques to manage pest populations so that their numbers remain below economically damaging levels with minimal disruption to the ecosystem. This approach is called integrated pest management (IPM).

The University of California's Statewide IPM Program (UCIPM, n.d.) defines IPM as:

> "An ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, and the environment."

2.2 TYPES OF PEST MANAGEMENT

2.2.1 CULTURAL PEST CONTROL

Cultural pest management practices can generally be identified as practices that interrupt the life cycle of pests and interfere with their movement to make the crop environment less favorable to pest species. These methods pose little to no risk to people or the environment. While they are cost-efficient, they also have the potential to be very effective. Example types of cultural pest control practices involve:

- Choosing sowing and harvest dates that minimize damage,
- crop rotation that provides the benefit of breaking crop pest cycles, preventing the carry-over of crop specific pest,
- selecting pest-resistant crop varieties; trap cropping; intercropping,
- destruction of volunteer plants; weed management (USAID 2019).

More complex approaches, such as the 'push-pull' strategy to manage stemborers of maize in East Africa are also possible, see Figure 1.

2.2.2 MECHANICAL PEST CONTROL

Mechanical or physical control aims to prevent pests from accessing host plants or animals, or, if the pests are already present, physically removing them by some means. Examples of mechanical pest control are noted below and are most applicable in control of malaria and related vector-borne disease pests (mosquitos) and in crop production where low level pest prevalence may be controlled by picking pests off crops by hand:

- Screens on windows or bednets to keep out flies, mosquitoes, and other pests,
- Well-sealed entry-ways,
- Sticky traps,
- Destroying pests by hand,
- Using heat, cold, humidity, and sound to change the environment (physical) for pest control (USAID 2009a).

A habitat management approach referred to as 'push-pull' was developed to suppress maize pests (Pickett et al. 2014). The approach involves growing plants attractive to egg-laying stemborer moths around the perimeter of a maize field to attract (pull) the moths away from the maize and intercropping the maize with repellent plants to 'push' the moths out of the maize. The 'push-pull' approach to pest management in maize has been adopted by thousands of farmers in Kenya, Uganda, Tanzania, Ethiopia and other East and southern African countries. To learn more about 'push-pull' visit http://push-pull.net.

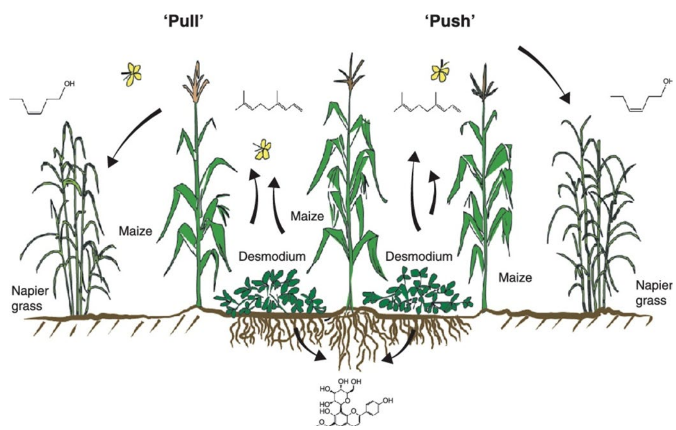

Figure 2. Example of a Cultural Pest Management Practice

2.2.3 BIOLOGICAL PEST CONTROL

Biological control refers to the use of a pest's natural enemies to reduce the pest population. The natural enemies may be insects (predators and parasitoids) or pathogens. Biological pest management is desirable for its cost-effectiveness, and it is considered sustainable and environmentally safe. (USDA, n.d.) Example biological pest control methods include releasing natural enemies of the target pest into the target environment or enhancing the environment to support populations of the natural enemies.

A relatively new type of biological control has been developed using bacteria in the genus *Wolbachia*. Various strains of *Wolbachia* have been used to infect mosquitoes to reduce their ability to transit disease and to decrease their ability to reproduce (referred to as the 'incompatibility insect technique', IIT). In Cairns Australia, dengue fever has been effectively suppressed through the release of *Wolbachia*-infected *Aedes aegypti* mosquitoes that are unable to transmit the disease.

2.2.4 CHEMICAL PEST CONTROL

Chemical control involves the use of pesticides to suppress a pest population. The Federal Insecticide, Fungicide, and Rodenticide Act (FIRFA) defines pesticide as (1) any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, (2) any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant, and (3) any nitrogen stabilizer. Nitrogen stabilizers are considered pesticides because they kill soil bacteria involved in nitrogen degradation processes (nitrification, denitrification, ammonia volatilization, or urease production).

The United Nations estimates that the world population will reach 9.8 billion by 2050, an increase of about 23% over the 2022 population. To feed this rapidly growing population, pesticides will remain a necessary component of pest management for the foreseeable future. FAO estimates that 20-40% of crops are lost due to pests, but without pesticides, losses would double (Saravi and Shokrzadeh 2011). In addition, it is estimated that insecticide impregnated bednets reduced clinical cases of malaria in Africa by 450 million between 2000 and 2015 (Bhatt et al. 2015).

Pesticides may be synthetic or from natural sources, with the vast majority in use today being synthetic. Some consider microbial diseases of insects as pesticides (often referred to as biopesticides), but others consider microbials, such as *Bacillus thuringiensis* (Bt) as augmentation biological control. Regardless, biopesticides are used in a similar manner to chemical pesticides, but are generally less toxic to non-target organisms.

Pesticides vary greatly in their toxicity and those with low mammalian toxicity and considered to have minimal impacts on the environment, are sometimes referred to as "biorational pesticides."

Pesticides should only be used when other, less ecologically disruptive, methods are not available. When pesticides are used, efforts should be made to cause minimal perturbation to the ecosystem, which may be accomplished through the development and use of economic action thresholds, careful choice of pesticide, and the manner and timing of application.

Figure 3 below illustrates chemical pesticide usage volumes by region for the period 1990-2020. As the figure illustrates, the majority of pesticide usage occurs in Asia, the Americas, and Europe (Srinivasan, Tamò, and Subramanian 2022). Irrespective of regional use, it is always important to ensure that usage is undertaken in a manner that limits exposure to humans, is carried out in a way that limits run-off to water bodies, and is conducted according to best practices.

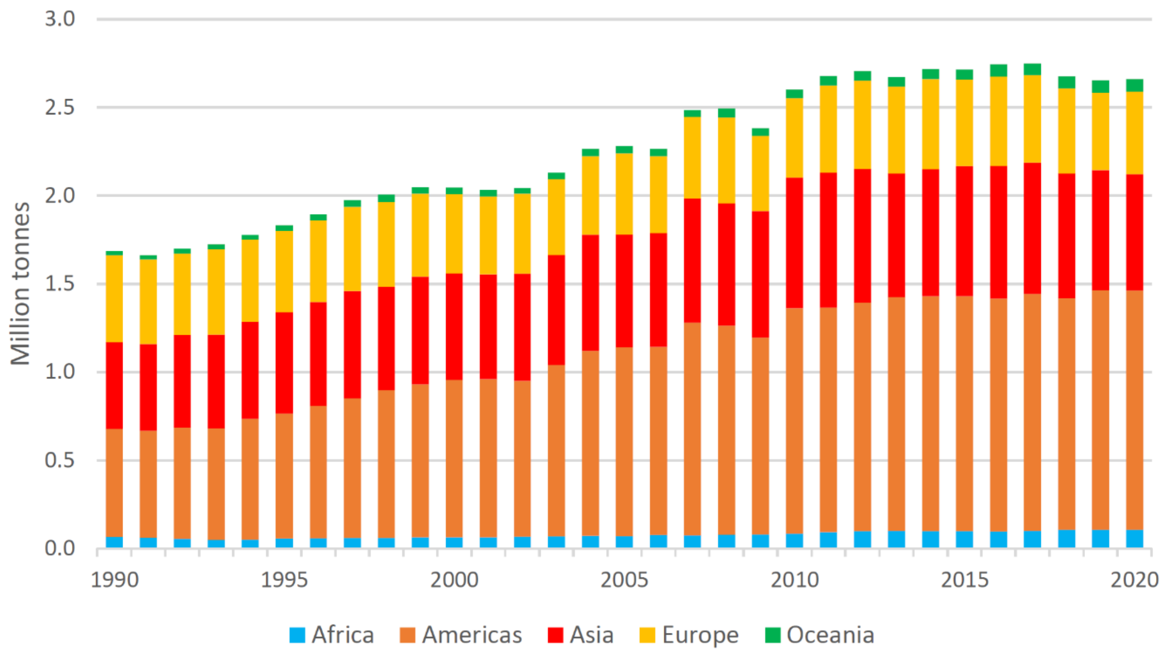

Figure 3. Total pesticide use by region (Srinivasan, Tamò, and Subramanian 2022).

2.2.5 GENETIC METHODS

Genetic tactics include either genetic changes to plants or livestock to increase their resistance or tolerance to pests, or genetic changes to the pest population to reduce its numbers. Plant and livestock genetic pest management strategies include both conventional breeding as well as genetic engineering to increase resistance to pests. The first genetically modified crop was tobacco which was engineered for herbicide resistance. Later the same crop was modified to express genes from *Bacillus thuringiensis* (Bt) that resulted in the plants producing a protein that was toxic to caterpillars (James and Krattiger 1996). The 'sterile insect technique', previously mentioned as a method for insect eradication, is an example of genetic modification to manage a pest population.

2.2.6 REGULATORY CONTROLS

The objective of regulatory pest management is to prevent the introduction and/or spread of pests through various regulatory controls. The primary strategy to exclude pests from entering a particular country is by implementing quarantine procedures. Inspectors work with border agencies to examine agricultural products before entry and limit entrance of non-indigenous pests. Other strategies include:

- Parties must provide export documentation for domestic products if they are to be exported;
- Provide post-entry inspection of quarantined plants;
- Establish programs to eradicate or suppress certain pests; and
- Institute commodity fumigation prior to entry.

These strategies prevent and reduce pests from entering the host country. Countries should consider having such policies to manage the entry of new pest populations and thereby limit pest outbreaks.

2.3 INTEGRATED PEST MANAGEMENT

IPM is the use of an environmentally sustainable combined array of pest-control tactics. It encourages the cultural and natural control of pest populations by anticipating pest problems and managing their numbers while shying away from the use of pesticides (USAID 2009a; UCIPM, n.d.). Successful IPM plans depend on a thorough understanding of pest populations, the associated ecosystem, and the available management tactics. Only with this understanding can strategies be developed that maintain the pest density below economically important levels with minimal perturbation to the ecosystem.

IPM strategies must be tailor-made for specific crop/pest complexes in particular locations. IPM plans can also vary in complexity. At its simplest, an IPM plan may use pesticides based on monitoring a pest population and only treat when the pest density reaches a pre-determined action threshold, or selection of a pesticide that has minimal effect on natural enemies. Much more complex programs which aim to lower pest populations by close examination of the agroecosystem have also been developed.

IPM plans integrate appropriate mitigating factors, environmental concerns, climatic conditions, ecosystem concerns, and appropriate existing management methods (e.g., cultural, mechanical, biological, chemical). Successful IPM plans follow a four-tiered implementation approach:

1. Setting action thresholds: The first step in developing an IPM plan is establishing an "action threshold" of pest damage that is great enough to justify implementing pest control measures (USAID 2009a). The presence of a few pests does not always mean pest control is needed.
2. Monitoring and identifying pests: Developing a deep understanding of the local ecosystem and properly monitoring and identifying pests is a critical part of IPM, as not all insects, weeds, and living organisms require control. Many are not harmful, and some are even beneficial.
3. Prevention: Prevention includes taking steps to ensure that pest populations do not build up to economically damaging levels. Preventive methods can be very effective and cost-efficient and present little to no risk to people or the environment.
4. Identification: Once action thresholds, identification, and monitoring all indicate that pest control is required, and preventive methods are no longer effective or available, control methods can be employed. Control methods are evaluated on effectiveness and relative risk.

Annex B provides an illustrative example of IPM strategy development for the control of European corn borers (ECB) in Ukraine. The example IPM framework provides the risks posed by an ECB infestation, as well as physical, cultural, biological, and chemical control measures. Please note that the IPM strategy for ECB is included as an example only. In practice, IPM strategies recommendations are not made in this guide, and specific pest control measures must be assessed considering activity-specific context.

2.4 PEST MANAGEMENT ACROSS SECTORS

Pest management may be necessary across a wide range of sectors. This SEG focuses on impacts and mitigation measures from pest management operations across the following sectors:

- Construction
- Crop Production
- Livestock Production
- Post-harvest Storage
- Public Health

- Water Treatment and Sanitation

2.4.1 CONSTRUCTION

The construction sector is not always considered to be one that requires pest management. However, the need for the control against pests such as termites, fungus, rodents that may infest constructed buildings and cause structural damage is key to building long-lasting, livable structures.

Pest management techniques used in construction include:

- Using naturally termite-resistant wood or reducing the use of wood in construction;
- Removing termite mounds/hills near premises;
- Rodenticide-baited traps; and
- Protein- or sugar-based traps for insects.

For additional information about pest management in the construction sector, please refer to the following USAID resources:

- The Construction Sector Environmental Guideline;
- The Roads Sector Environmental Guideline; and
- The Global PERSUAP of Termite, Fungus, and Rodent Control in Vertical-Build Construction for ASHA.

2.4.2 CROP PRODUCTION

Pest management plays a large role in the crop production sector. Pest damage to crops can greatly reduce yields, which can significantly impact livelihoods and food security, particularly in developing countries.

Pest management techniques used in crop production include:

- Adjust planting and harvesting periods;
- Crop rotation that breaks crop-pest cycles;
- Select pest-resistant crop varieties;
- Use of herbicides, insecticides, and/or fungicides;
- Introduce natural predators of target pests; and
- Weed and stalk management.

For additional information about pest management in the crop production sector, please refer to the following USAID resources:

- The Crop Production Sector Environmental Guideline;
- The Global Fall Armyworm Management PERSUAP;
- The Desert Locust Surveillance and Control PEA; and
- The BHA Treated Seed PERSUAP.

2.4.3 LIVESTOCK PRODUCTION

The livestock industry across all sizes of production operations (i.e., from small-scale to industrial) is affected by arthropod pests, vertebrate pests, and disease pathogens (including internal parasites) at various scales worldwide, causing significant losses and constraining socio-economic development (Takken, et al. 2018). Effective control of livestock pests enhances the living conditions, health, and well-being of animals, limits disease transmission between animals and humans, and improves the economic viability of livestock production operations. Example pest control methods used in livestock production include:

- Establishment of naturally occurring biological control agents (e.g., natural predators to pasture flies);
- Walk through traps that brush flies from cattle;
- Insecticide ear tags; and
- Sprinkle on insecticide powder.

For additional information about pest management in the livestock sector, please refer to the following USAID resources:

- the Livestock Production Sector Environmental Guideline; and
- the Livestock Pesticide Programmatic Environmental Assessment (PEA) and Global PERSUAP.

2.4.4 POST-HARVEST STORAGE

Pest management strategies are also used to limit damage to stored grains caused by pests such as weevils and grain borers. Damage to stored grains can significantly reduce the economic yield of production operations and/or adversely impact food security (Kumar and Kalita 2017). A 2014 study found that grain storage structures in developing countries are constructed with readily available materials (e.g., grass, mud, wood) and are not well suited to resisting pest infestations. The study estimated losses of almost 60 percent for maize stored in traditional granary/polypropylene bags in Uganda (Costa 2014).

Example pest management strategies used to manage pests in post-harvest grain storage include:

- Ensuring grain storage bins are cleared of older grain, dust, and webs prior to storing new grain;
- Use of non-invasive predatory insects; and
- Phosphine fumigation.

For additional information on phosphine fumigation, please refer to the USAID Phosphine Fumigation PEA.

2.4.5 PUBLIC HEALTH

The Centers for Disease Control and Prevention, the USEPA, and the USDA developed a List of Pests of Significant Public Heath Importance due to the serious threat pests pose to public health. Pests, such as cockroaches, rodents, microbes, and vectors (e.g., ticks, mosquitoes, lice) can spread or trigger serious, sometimes fatal diseases. Zika virus, malaria, Lyme disease, asthma, allergies, and microbial infections are all significant public health problems caused by pests.

Pest management techniques used in crop production include:

- Using insecticide treated nets or clothing;
- Prevent instances of standing water;
- Larviciding;
- Using non-chemical repellents; and
- Infecting pests with bacteria that reduces their ability to transmit diseases.

For additional information about pest management in the livestock sector, please refer to the following USAID resources:

- The Healthcare Waste Sector Environmental Guideline
- The Small Healthcare Facilities Sector Environmental Guideline
- The U.S. President's Malaria Initiative Best Management Practices (BMP) Manual
- The Integrated Vector Management Programs for Malaria Control Programmatic Environmental Assessment (PEA)
- The Global Initial Environmental Examination (IEE) for Long Lasting Insecticidal Nets

2.4.6 WATER TREATMENT/SANITATION

Over 50 percent of the developing world's population suffers from diseases caused by lack of access to water, contaminated water, or poor sanitation (USEPA 2008). Water-related diseases can result from exposure to microorganisms found in the water supply. In order to prevent waterborne diseases, antimicrobials (e.g., chlorine) are added to disinfect water supplies, making it safer for consumption, food preparation, and other uses.

Pest management techniques used in water treatment/sanitation include:

- Aeration;
- Use light traps, electronic traps, or sticky traps;
- Larvicides or adulticides; and
- Ultraviolet Radiation.

For additional sector information, please refer to the Water Supply and Sanitation Sector Environmental Guideline.

3. ENVIRONMENTAL IMPACTS OF PEST MANAGEMENT

Pest management plays a significant role in improving agricultural output, reducing post-harvest losses, preserving infrastructure and controlling disease. However, pest management, especially the use of chemical pesticides, also present risks to the environment. While chemical pesticides protect against pests, their use can negatively affect non-target organisms and habitats, wildlife, livestock, and human health. Given these impacts, it is important to weigh the costs and benefits of each type of pest management practice when determining how pests will be managed.

This section describes the adverse environmental impacts that may result from pesticide use including: toxicity to terrestrial environments, degradation of environmental media, and toxicity to aquatic environments. It is worth noting, that in general risk of adverse environmental impacts from non-chemical pest management techniques is lower than that for chemical interventions, but balancing of risks against benefits should always be considered. This section concludes by describing strategies for mitigating adverse environmental impacts.

There are many different types of pesticides, as determined by chemical composition, specific uses, or target organism or other factor (See Annex 1 for more information about general categories of pesticides). All pesticides contain at least one active ingredient that acts to control the pest. The same active ingredient also determines the toxicity and half-life of the product. The best way to minimize the potential impacts of pesticides on the environment is to familiarize yourself to the pesticide(s) you will be applying. This would include reading the pesticide label for each pesticide and conducting additional literature searches for any known issues associated with the pesticide(s) in question. For more information about general categories of pesticides see Annex A and the earlier section on application considerations.

3.1 TOXICITY TO NON-TARGET TERRESTRIAL ORGANISMS

The global increase in pesticide use has been associated with negative impacts in terrestrial ecosystems and environments around the world. These impacts include reduced soil productivity which results in reduced plant productivity, which in turn negatively impacts all of the organisms further up the food chain. Pesticides can also directly impact animals, such as insects, birds, and mammals, disrupting ecosystem balances and reducing populations.

The following sections highlight key adverse impacts of pesticides and pesticide metabolites to various classes of terrestrial organisms.

3.1.1 PLANTS

Pesticides and pesticide metabolites can negatively impact plants directly (e.g. herbicides) or indirectly through soil degradation, water contamination or loss of pollinators. Herbicides, such as glyphosate, have been shown to negatively impact non-target plants by causing build-up of harmful substances, resulting in an overall disruption of plant function by affecting the photosynthesis process, plant health, and hindering growth (Zaller and Brühl 2019). Certain pesticides alter gemination, the sprouting of a seed, spore or other reproductive body into a new plant or fungal species after a period of dormancy, rates and affect the plants growth and development, resulting in shorter root and shoot lengths (Pathak et al. 2022).

For indirect impacts, as described above, soil and soil functions subtend and support terrestrial ecosystems and agricultural systems by providing necessary nutrients and structure for plant growth. Plant growth requires healthy soils. In systems where pesticides cause soil damage it can lead to yellowing of the plant leaves, leaf curl, oxidative stress, and photosynthesis impairment in non-target plants (Bondareva and Fedorova 2021). For example, plants depend on certain soil microorganisms to transform atmospheric nitrogen into nitrates, a lack of microorganisms can cause a lack of available nutrients for the plants (Gunstone et al. 2021). Seed quality is also affected negatively by the exposure to glyphosate, impacting plant growth (Tudi et al. 2021). As pesticides are adsorbed into soil, they may persist for long periods of time and cause damage to other crops and plants post-harvest due to the contaminated soils (Lozowicka et al. 2015). Therefore, even when originally protected, crops and plants may suffer indirectly from pesticide use (Aktar, Sengupta, and Chowdhury 2009).

As explained in earlier sections, once pesticides enter the water cycle they are distributed throughout the ecosystem. Non-target plants absorb the water with dissolved substances, including pesticides, from the soil. The pesticide residues are then transported through the plant. The absorbed pesticides are a concern because they can then be transported within the plant, potentially reaching various plant tissues, including leaves, stems, and fruits. When these vital parts of the plant become contaminated with pesticides this poses a risk to pollinators that rely on these plants, as will be explained in the section below.

3.1.2 NON-TARGET ARTHROPODS

Arthropods are invertebrate animals including insects, spiders, centipedes and millipedes that play an essential role in ecosystems. Pesticide toxicity of non-target arthropods can both damage ecosystems and result in reduced crop yields. While pesticides of all types pose a potential hazard to arthropods, arthropods are especially sensitive to broad-spectrum insecticide use (Sánchez-Bayo 2021; Gunstone et al. 2021).

There are three types of non-target arthropods that are beneficial to crops, 1) pollinator; 2) predator; or 3) parasite. Pollinators, such as bees and butterflies, are important for food, feed, fiber and fuel production, as some plants rely on pollinators for seed or fruit development. Predatory arthropods like ladybugs and spiders prey on different types common crop pests-species, such as aphids or mites. (Smith, Capinera, and Martini 2021). Parasitic insects, like the Trichogramma wasp, parasitize the eggs of other insects reducing their populations naturally. Just like ladybugs, Trichogramma wasps are widely used globally for pest management to control pest populations as a biological control agent thanks to their naturally occurrence in the wild (Elwakil, Doherty, and Dale 2022). These three types of beneficial arthropods are valuable to have in the ecosystem, especially when farmers are considering implementing an IPM approach.

The increasing use of insecticide and its effect on pollinators has been well documented over the recent decades and has had the effect of an overall reduction of pollinator populations. As described previously, pesticides and pesticide degradation products can migrate from their application area to the environment surrounding treated fields, coating non-target plants and trees. While the quantity of these residual pesticides may be sub-lethal (e.g. not high enough to kill non-target arthropods) they can trigger detoxifying mechanisms in pollinators that are energy-draining and can result in stress and a weakened immunity (Sánchez-Bayo 2021).

For example, behavioral changes expressed in bees through disorientation and productivity decrease have been linked to pesticide residues found in active beehives near agricultural fields (Sharma et al. 2019). Since bees may ingest pesticide residues when feeding on pollen and nectar, pesticide application that coincides with flowering can particularly affect pollinator populations (Zaller and Brühl 2019). An indirect effect of pesticide application is reduced food supply (e.g. pollen and nectar) for beneficial arthropods. If pesticides reduce weed or other non-target plant populations, there are reduced food resources for beneficial arthropods. Application of pesticides can therefore also indirectly lead to pest outbreaks due to disturbance of natural predators (Sánchez-Bayo 2021).

3.1.3 BIOAMPLIFICATION IN ANIMALS

Bioaccumulation is the increased accumulation of toxic pesticides up the food chain (Mahmood et al. 2016). It occurs as a form of secondary poisoning of non-target wildlife, such as foxes and birds, when these animals prey on target pests that have been poisoned by pesticides. Just as some pesticides can dissolve in water and enter the environment through leaching and runoff, other pesticides are fat soluble and can concentrate in animal tissue through the bioaccumulation process. This process causes the dissolved pesticides to be absorbed by the fatty tissue of animals. This can then become a hindrance to the organism's normal functioning by affecting its hormonal and reproductive systems, or cause greater vulnerability to illnesses or cancers over time (Aktar, Sengupta, and Chowdhury 2009; Sharma et al. 2019). Through bioaccumulation, harmful pesticides and pesticide degradation products first ingested by insects are passed through the entire food chain, accumulating at higher and higher concentrations in apex predators. Bioaccumulation threatens rare species and has caused a reduction in biodiversity in terrestrial and aquatic animals and plants (Mahmood et al. 2016).

Anticoagulant rodenticide is an example of a highly toxic pesticide that can accumulate in the food chain from predators eating poisoned mice or rats. Another example of a persistent agricultural pesticide is DDT, which concentrates in avian apex predators that rely on smaller animals or fish for survival (Mahmood et al. 2016).

In addition to natural ecosystems, pesticides can also accumulate in livestock populations. Animal feed, especially for livestock, may contain leftover toxins from crop production or pest management from rangelands, or may result from inappropriately feeding pesticide-treated seeds intended for planting to livestock (Choudhary et al. 2018). Livestock contaminated with pesticides can result in contaminated meat and milk, which can impact humans who consume these products (Akkina and Estberg 2018).

3.2 WATER CONTAMINATION

Pesticide residues and metabolites can enter water through multiple entry points, including volatilization, leaching and runoff. Once these chemicals enter the water cycle, they can be distributed at great distances from their original application site. Pesticide contamination of water can have a wide range of negative impacts with high environmental costs. These include directly impacting organisms through primary consumption (e.g. an organism directly consumes or uptakes the pesticide dissolved in the water), and indirectly impacting organisms through creation of imbalanced ecosystems (e.g. the dissolved pesticide damages soil microbes resulting in reduced plant production impacting availability of bird food or habitat), or secondary consumption of pesticides (e.g., insects consume dissolved pesticides which then impact the birds that consume the insects). For more information on pesticide impacts on aquatic ecosystems see the "Toxicity of Aquatic Environments" section below.

3.3 SOIL DEGREDATION

Soil is a diverse ecosystem comprised of organisms that perform important functions, such as nutrient cycling, soil structure maintenance, carbon transformation and sequestration and the regulation of pests and diseases. Soil and soil functions subtend and support terrestrial ecosystems and agricultural systems by providing necessary nutrients and structure for plant growth. Soil is also the primary reservoir of excess applied pesticides (Gunstone et al. 2021). As described above, pesticides and degradation products can adsorb to soil and potentially negatively impact soil organisms for years after application depending on pesticide degradation rates and toxicity of degradation products. This leads to soil infertility and can exacerbate erosion and reduce soil nutrient retention, leading to higher needs for fertilizer applications, which pose their own hazards for sustainable land usage.

As mentioned, one of the major impacts pesticides and pesticide metabolites can have on soils is damaging soil microbial ecosystems. As many pesticides and pesticide metabolites are toxic to beneficial soil organisms, pesticide contamination can disrupt critical soil ecosystems thus damaging soils and soil productivity. Impacts from pesticides range from increased mortality in soil organisms, to reduced reproduction, growth and cellular function (Gunstone et al. 2021). Soil microbial biodiversity loss leads to a decrease in soil activity needed to form aggregates and soil organic matter to support soil fertility. Insufficient numbers of beneficial soil microorganisms result in nutrient loss, soil degradation and loss of soil fertility, which results in soil erosion, reduced productivity of lands, including agricultural lands, and loss of habitat for terrestrial organisms. For example, glyphosate, a common herbicide, reduces the growth and activity of nitrogen-fixing soil bacteria. As a result, the nitrogen fixation performed by the bacteria is reduced over time impacting plant nutrient availability.

In addition to microbial organisms, pesticides can impact more biologically complex soil dwelling organisms like earthworms and other invertebrates. Invertebrates are responsible for forming soil aggregates by breaking down litter (fallen leaves, twigs and dead plants) and transforming decaying material into plants nutrients. For example, earthworms support healthy soils by burrowing canals, spreading nutrients through the layers of the soil thereby increasing soil porosity, water infiltration and retention. Earthworm activities improve plant root growth which decreases the potential for runoff and soil erosion, and increases topsoil retention. Pesticides have been found to have negative effects on soil invertebrates in 70 percent of cases studied (Gunstone et al. 2021).

3.3 TOXICITY TO AQUATIC ORGANISMS

As described above, pesticides and pesticide break-down products can enter water bodies through leaching, runoff, volatilization, or drift, resulting in negative impacts to aquatic ecosystems. Pesticide pollution has been found to be a leading cause of aquatic population decline, including plants, fish and other aquatic organisms (Virginia Tech and Virginia State University 2009). Standard pesticide use can result in surface water contaminated with insecticides at levels that are frequently above those known to affect fish and aquatic invertebrates (Isenring 2010). Many major riverine ecosystems like the Ganges have shown pesticide contamination in the surface water as well as the riverbed sediments, which can negatively impact and kill water plants.

Water plants are used as habitats by aquatic organisms such as clams and worms that live in the sediments among the roots. Water plants are responsible for most of the dissolved oxygen that sustains the aquatic population. Algal blooms that result from pesticide contaminated water further reduce oxygen levels. The loss of aquatic habitats and the decreased oxygen levels may lead to reduced fish productivity and ultimately cause suffocation of fish. Pesticide-contaminated water can also cause physiological and behavioral changes.

For example, the pesticide residues from chlorpyrifos can cause toxicity in aquatic organisms as a result from oxidative stress enzymes and histological alterations in the vital organs of fish, such as tilapia (Tudi et al. 2021; Mahmood et al. 2016). Bioaccumulation of harmful chemicals from pesticides also occurs in the aquatic populations and further contributes to a decline of aquatic microorganisms, invertebrates, such as prawns and frogs, as well as vertebrates, such as fish and water birds (Mahmood et al. 2016). Some pesticides are known to alter the composition of microbial communities in freshwater, as has been shown in field tests with the herbicide glyphosate, resulting in a reduction of food availability for other aquatic organisms (Isenring 2010). See also other relevant USAID resources: Sector Environmental Guidelines on Wild Caught Fisheries and Aquaculture (2018).

3.4 MITIGATION AND MONITORING OF ENVIRONMENTAL IMPACTS

In addition to IPM practices, other mitigation measures and monitoring considerations can support sustainable pest management methods. Through careful consideration environmental impacts from pest management practices may be minimized. Some mitigation and monitoring efforts can be effective for more than one environmental impact. For example, the implementation of buffer zones to prevent soil and water contamination on adjacent non-target land also creates and protects habitats for potentially impacted pollinators and helps minimize biodiversity loss. At the end of the section, Table 1 shows an overview of the negative impacts of the pest management activities as discussed in earlier chapters and summarizes mitigation measures as well as monitoring options.

3.4.1 MITIGATION MEASURES

Responsible handling of pesticides

Pesticides should only be used after monitoring indicates they are needed according to established guidelines, so that the right pesticides are used with the goal of removing only the target organism. If alternative pest control methods are available, these should be considered first. When pesticides are used, proper handling and disposal of pesticides is essential and storing and mixing should be done at appropriate locations to avoid environmental hazards. Teaching environmental and health safety procedures for responsible handling of pesticides is therefore crucial for understanding the risks associated with these chemicals and how to minimize them. Providing education and training on environmental health and safety procedures reduces the risks for the environment, as well as to human health, and contributes to sustainable agriculture and pest management practices.

Buffer Zones And Wildlife Corridors

Implementation of runoff buffers, such as riparian buffers, catchments or coverups can reduce pesticide runoff and leaching after pesticide spraying. Runoff buffers are composed of strips of vegetation adjacent to streams and wetlands that absorb and filter out pollutants. It reduces pollution of aquatic habitats by reducing transportation of contaminated sediments to nearby surface water. Design, placement, and protection of these buffer zones are crucial factors to determine their effectiveness (USEPA 2005). Riparian buffer zones also support restoration of diversity for riparian plant communities, as well as provide wildlife habitats for beneficial insects, such as pollinators (USDA 2020b). Additionally, these zones act as barriers, reducing the movement of pests and facilitating the presence of natural predators that can control pest population. By providing suitable habitats for beneficial species, buffer zones and wildlife corridors contribute to the natural balance of ecosystems and reduce the reliance on pesticides for pest management.

Integrated Soil Fertility Management (ISFM)

Reduced soil fertility can lead to reduced crop quality or yield due to non-sustainable practices involving chemical pesticides. ISFM practices focus on preventing erosion and other forms of soil productivity loss by managing and sustaining soil fertility as an integral part of a productive farming system. This practice supports minimizing the use of chemical pesticides and instead makes use of other pest-management methods that also help sustain soil fertility, such as cover crops, intercropping and crop rotations, planting legumes and the use of fallows. For further information read the Crop Production Sector Environmental Guidelines on the USAID website.

Habitat conservation

Habitat conservation helps protect and maintain biodiversity, including beneficial organisms such as pollinators, natural predators, and other beneficial insects. These organisms can contribute to natural pest control, reducing the reliance on pesticides. Another vital part of habitat conservation is replanting native vegetation and introducing local plant species (USEPA 2022). Native plants are adapted to the local environment and provide important food and shelter resources for native wildlife, including natural predators of pests and can therefore be a valuable mitigation measure. By incorporating diverse native plant species into habitats, the overall ecological resilience and biodiversity of the area can be enhanced (USEPA 2022). This may also support natural pest control mechanisms and reduce the need for pesticide use. Prohibiting pesticide use on for particular crops which are attractive to pollinators may also mitigate pollinators decline (USEPA 2022).

Application timing restrictions

The timing of pesticide application is of importance for mitigating risks for pollinators as there are certain times in the day or season in which pollinators are more active. This cultural pest control method has the benefit that it helps sustain pollinator populations, pesticide restrictions should consider 1) Blooming stages: Bloom periods attract pollinators, 2) crop-stage: Certain stages of plant growth crops are more attractive to pollinators, 3) time of day: Applying pesticides before dawn or after dusk is beneficial as most pollinators are active during the day (USEPA 2022). It is important to have monitoring in place in case impacts are detected so that implemented measures can be changed accordingly.

Sustainable innovations and technologies

Several sustainable innovations and technologies can be applied to support IPM practices. Integrated Pest Management (IPM) combines various pest control methods, minimizing pesticide usage. Biopesticides, comprising natural agents, offer an environmentally friendly alternative to synthetic pesticides. Precision agriculture employs advanced tools to optimize production and limit pesticide application to specific areas in need. Crop rotation interrupts pest life cycles and enhances soil health, reducing pesticide requirements. Additionally, the adoption of genetically modified crops allows farmers to introduce traits such as pest resistance and enhanced nutritional content, which may improve yield and crop quality.

3.4.2 MONITORING CONSIDERATIONS

Soil And Water Sampling

Mitigation measures for the various causes of soil and water contamination start with identifying the potential sources of contamination, and monitoring soil and (ground)water quality throughout the project activities to help address issues early. Monitoring should include regular testing of soil and water samples for pesticide residues, as well as analysis of ecological indicators such as the health of aquatic organisms. Considerations for monitoring should include determining a baseline of contamination, the timing and frequency of sampling, selection of appropriate sampling locations, and selecting appropriate analytical methods.

Monitoring invasive species

The introduction of natural enemies of pests for biological control may include species that are invasive to the environment. To minimize their potential negative impacts regular monitoring should be conducted to assess the population dynamics and spread of the introduced species. Even better is to use species that are native to the environment. Monitoring should track the presence and abundance of both the targeted pest species and the introduced biological control species. If the introduced species show signs of causing unintended ecological disruptions, action should be taken to mitigate the risks. This includes employing cultural practices that discourage the spread. For example, crop rotations help break the cycle of spread by reducing the resources that favor the invasive species. After invasive species have been removed, restoration and rehabilitation of the affected ecosystems are essential to enhance their resilience and prevent reinvasion, such as replanting native vegetation, restoring habitats.

Habitat monitoring

Regular monitoring of habitats and ecosystems allows for the assessment of impacts of pesticide use. Monitoring can help identify any negative effects on biodiversity and ecosystem health, enabling the implementation of appropriate measures to mitigate those impacts. Adjustments can be made to pesticide application strategies and timing to be less impactful to non-target flora and fauna so that alternatives to pest management methods include more effective and sustainable pest management, such as IPM practices.

TABLE 1. ENVIRONMENTAL IMPACTS, MITIGATION, AND MONITORING

TYPE OF PEST MANAGEMENT ACTIVITY	ENVIRONMENTAL IMPACTS	MITIGATION MEASURES	MONITORING CONSIDERATIONS
Chemical pest control	**Soil contamination** Resulting from pesticide drift, runoff, leaching, adsorption.	Identify potential sources of contamination and monitor throughout activity. Minimize pesticide use. Perform storing and mixing of pesticides at appropriate locations and practice safe pesticide use to minimize spills.	Determine a baseline of contamination and conduct environmental screening regularly to identify new sources of possible contamination. Perform regular testing of soil quality. Monitoring of spray usage to control pesticide application and avoid drift. Teach environmental and health safety procedures for environmentally responsible handling and application of pesticides.

TABLE 1. ENVIRONMENTAL IMPACTS, MITIGATION, AND MONITORING			
TYPE OF PEST MANAGEMENT ACTIVITY	ENVIRONMENTAL IMPACTS	MITIGATION MEASURES	MONITORING CONSIDERATIONS
Chemical pest control	**(Ground) Water contamination** Resulting from pesticide drift, runoff, leaching, adsorption.	Identify potential sources of contamination and monitor throughout activity. Implement runoff control measures and riparian buffers. Control leaching. Control volatilization and spray drift. Minimize the use of chemical pesticides. Prevent runoff by conserving soil moisture. Control rainfall through catchment or coverups on small/medium scale farms to prevent pesticide runoff and leaching after pesticide spraying. Make sure pesticides are stored and mixed in an area away from water sources, or potential flood zone.	Regular testing of water resources for contamination Maintain plan for water quality monitoring and signal any changes in quantity or quality for water used for human consumption. Monitor pollution from irrigation and drainage, including runoff past field borders.
Chemical pest control	**Reduced soil fertility** Resulting from loss of soil microbes leads to a reduction of soil fertility, which may lead to higher dependency on fertilizers, resulting in unsustainable crop yield.	Characterize soils and practice integrated soil fertility management (ISFM). Implement erosion control practices. Use fallow periods to plant grasses, legumes or forbs to sustain soil fertility.	Monitor soil quality. Teach ISFM methods to apply methods that support crop yields and sustain soil fertility long term.
Chemical pest control	**Accumulation of pesticides in the food chain** Resulting from spread of toxic pesticides entering food webs of non-target animals.	Identify alternatives to various toxic pesticides and promote alternative pest management methods. Discourage drinking and swimming in unsafe surface water as well as fishing and hunting wildlife in case of contamination.	Monitor for harmful pesticide contamination in food and (drinking) water.
Chemical pest control *Biological pest control*	**Loss of biodiversity** Resulting from decline in populations of important non-target organisms, such as pollinators.	Conserve land to preserve biodiversity. Promote alternatives to monocropping. Replanting and introducing local species. Minimize pesticides use harmful to local flora and fauna.	Conduct monitoring regularly to identify affected non-target species.

TABLE 1. ENVIRONMENTAL IMPACTS, MITIGATION, AND MONITORING			
TYPE OF PEST MANAGEMENT ACTIVITY	ENVIRONMENTAL IMPACTS	MITIGATION MEASURES	MONITORING CONSIDERATIONS
Biological pest control *Genetic control*	**Introduction of invasive species** Resulting from Biological pest-control methods.	Release natural enemies into target environment as needed. Practices as intercropping provide pollen sources for natural enemies, Select pesticides with minimal effect on natural enemies, or time application to avoid negative effects to natural enemies. Release lab modified species of the pest to decrease their ability to reproduce. Use local species for biological pest control wherever possible.	Monitor spread of invasive species.
Chemical pest control	**Change in animal behavior** Resulting from spread of toxic pesticides entering wildlife habitats and ingestion of toxic pesticides by animals.	Use pesticides that minimize the negative impact on non-target fauna. Identify species sensitive to pesticide used throughout activity. Establish a population baseline of those species and implement measures that avoid spraying during sensitive time (flowering in the case of pollinators). If impacts are detected change implemented measures accordingly.	Monitor change in species populations.
Chemical pest control	**Reduced crop quality** Resulting from a higher dependency on synthetic fertilizers because of a reduction in soil fertility, leading to unsustainable crop yield.	Practice integrated soil fertility management (ISFM). Choose indigenous crop species already adapted to the local agro-ecology and climate.	Monitor soil quality. Teach ISFM methods to apply methods that support crop yields and sustain soil fertility long term.
Chemical pest control	**Pesticide resistance** Resulting from unsustainable pest-management practices that lead to increased pesticide resistance in weeds and insect species.	Minimizing pesticide use Crop rotation Using pesticide mixtures with more than one active ingredient. Use GM crops with pyramid resistance genes or crops that express high toxin levels.	Stay up to date on research and apply relevant sustainable innovations on top of new technologies and developments.

4. COMMUNITY HEALTH IMPACTS OF PEST MANAGEMENT

Pesticides have both direct and indirect impacts on the human body. Direct impacts depend upon exposure time to and concentration of a pesticide, and can affect the skin, eyes, mouth, and respiratory tract. Indirect exposure occurs through consumption of produce grown in pesticide-contaminated soils or waters and can cause chronic diseases by increasing the concentration of toxins inside organs. Within these two exposure pathways, there are three types of pesticide exposure:

(1) **Direct occupational**: applicators who mix and spray pesticides in agricultural fields;

(2) **Direct non-occupational**: rural-resident people who live near agricultural fields and come into contact with pesticides; and

(3) **Indirect**: people distanced from agricultural fields but become exposed to pesticides through agricultural products, the food chain, and contaminated waters (Pathak et al. 2022).

Below are community health considerations in reference to pest management projects that should be carefully considered by Missions and/or IPs, when assessing potential community health impacts of pest management activities.

4.1 ADVERSE COMMUNITY HEALTH IMPACTS OF CHEMICAL PEST MANAGEMENT

4.1.1 DIRECT OCCUPATIONAL PESTICIDE EXPOSURE

In any given community, applicators that come in direct contact with chemical pesticides are at the highest risk of the harmful and hazardous effects pesticides can have on human health. The most common form of exposure pesticide applicators are subjected to is direct occupational, which is the most dangerous exposure route as it can lead to a range of immediate and long-term health effects such as lung disease, cancers, etc. One long-term effect that can stem from direct exposure is altered genomic methylation, which can result in genetic damage (Pathak et al. 2022). Among applicators, the genetic damages from direct occupational exposure can exceed those damages that result from smoking and alcohol consumption (Nascimento et al. 2022).

The most common exposure routes that pesticide applicators experience are through dermal and inhalation routes. Dermal is the most common route of exposure because of contact with the splashing, spills, or spray drift that can result from application methods. Inhalation exposure also occurs via inhalation of large amounts of volatile pesticide components and directly impacts the nose, throat, and lung tissues. Every year, WHO estimates that 355,000 people are unintentionally poisoned and killed from excessive exposure and inappropriate use of toxic pesticides (WHO 2010).

Since direct occupational exposure to pesticides by applicators exhibits the most dangers that come with chemical pest management, strict adherence to label instructions, usage of PPE, and best practice guidelines for pesticide handling should be implemented to limit potential adverse effects. Guidelines regarding PPE usage from the FAO/WHO can be found here: https://apps.who.int/iris/bitstream/handle/10665/330917/9789240000223-eng.pdf.

4.1.2 DIRECT NON-OCCUPATIONAL PESTICIDE EXPOSURE

While applicators experience the most direct and dangerous effects of chemical pest management, communities both close and far from a given pesticide activity can also see health impacts. The two main types of exposure that can affect communities are direct non-occupational and indirect.

PESTICIDE CONTAMINATION

Residents of a community that live within proximity to agricultural fields that use pesticides have direct non-occupational exposure to chemical pesticides. One way that they often experience this type of exposure is passively. Studies show that, over time, rural residents tend to have higher blood concentration of pesticides and increased DNA damage due to pyrethroid metabolites that originate from contaminated air and diets. The most vulnerable populations for this type of exposure are the elderly, women, and children (Pathak et al. 2022). Women exposed to pesticides during pregnancy or breastfeeding can suffer from severe health complications themselves, as well as the fetus or newborn (Asmare et al. 2022).

PESTICIDE SELF-POISONING

A major community health problem that stems from the general use of pesticides is self. An estimated 20 percent of all suicides is attributed to pesticide poisoning, with estimates of 300,000 deaths per year in the Asia-Pacific region alone (WHO 2021a). The most used pesticides for self-poisoning are paraquat, aluminum phosphide, highly toxic organochlorines, highly toxic organophosphorus insecticides, and carbamate insecticides. Because of the highly toxic nature of these pesticides, many deaths occur before patients even reach hospitals. One of the main pressure risk factors for self-poisoning to occur in agricultural communities is acute financial difficulties which stem from crop failure or a less profitable season (WHO and FAO 2019).

Globally, self-poisoning is an under-recognized and under-reported major public health concern which forwards the importance of poison centers and strict regulatory standards (WHO 2021b). While WHO recommends that all countries establish and strengthen their own poison centers, only fewer than half of WHO Member States have at least one poison center (47 percent as of 01 January 2023) (WHO 2021b). Communities with gaps in a presence of poison centers are notably in African, Eastern Mediterranean, and Western Pacific regions.

Adherence to strict regulatory standards and presence of poison centers aids communities in educating and protecting their communities from the harmful misuses of pesticides intended for pest management uses. WHO recommends that national bans of acutely toxic, highly hazardous pesticides are cost-effective in addition to beneficial in limiting the use of harmful chemicals. In addition, poison centers act as sources of expertise on the diagnosis and management of poisoning that can occur from misuse of pesticides. They provide emergency advice to the public, act as health professionals, provide surveillance of chemical exposures, and act as sentinels to detect chemical release.

4.1.3 INDIRECT PESTICIDE EXPOSURE

Pesticide use can cause environmental contamination via exposure to water, soil, air, plants, animals, food, and humans. For example, the soil matrix structure acts as "pesticide storage because of its high capacity to interact" with the active ingredients (Panis et al. 2022). While pesticides can be reduced in soil by means of microbial degradation and soil adsorption, they are still frequently reported as contaminants in drinking water.

Communities who do not live within proximity of chemical pesticide activities may still experience the effects of chemical pesticide use via indirect exposure, and most often, indirect oral exposure. Indirect oral exposure to pesticides occurs through contact or consumption of agricultural products, the food chain, and contaminated waters that originate from an agricultural.

LUNG DISEASE/RESPIRATORY PROBLEMS AND CANCER

The Agricultural Health Study documents health outcomes associated with chronic pesticide exposure, which include increased risk for thyroid dysfunction (including cancer), risk of hematological cancers, altered kidney functions, Parkinson's disease incidence, and evidence of immune disorders (Panis et al. 2022). Human health benchmarks have been proposed by the US EPA to ensure pesticide concentrations in drinking water remain safe and to protect communities against the carcinogenic potential of pesticides present in water and residues (Panis et al. 2022).

Research shows that when chemicals found in pesticides interact with DNA inside a human body, they can induce gene mutations and lead to consequences such as carcinogenesis (Pathak et al. 2022). In one study, it was found that ongoing direct pesticide use for twenty years or greater was associated with a heightened risk for lung cancer (Kim et al. 2022). Long-term direct occupational exposure to pesticides is linked to increased risk of cancer.

BIOACCUMULATION IN FOOD PRODUCTS AND PESTICIDE RESIDUES

Although WHO states that no pesticides "currently authorized for use on food in international trade are genotoxic," extended and repeated exposure to pesticides over time can eventually result in acute poisoning and long-term health effects (WHO 2022). Pesticides can enter the body through foods that have animal origins and are high in lipid content. For instance, organophosphorus pesticide (OPP) and organochlorine pesticide (OCP) residues have been detected in raw animal milk (Sadhana 2015). The general community population is exposed to low levels of pesticide residues through food and water. Food sold or donated (i.e., food aid) should comply with pesticide regulations for given countries, specifically in-line with maximum residue levels (MRLs) set for each country. WHO recommends that customers limit pesticide residue intake from foods by peeling and washing fruits and vegetables before consumption. Cleaning the outer layer of food helps to reduce the pesticide residues ingested as well as protect against foodborne hazards caused by harmful bacteria (WHO 2022).

FAO and WHO jointly work together to conduct risk assessments for pesticide residues on food in the Joint FAO/WHO Meeting on Pesticide Residues (JMPR). The data for these assessments stems from national registrations of pesticides worldwide and scientific studies from peer-reviewed journals. JMPR establishes its own limits for safe intake of pesticide-treated foods to ensure exposure to residue is limited throughout one's lifetime to limit and reduce adverse health effects. Daily intakes are also considered by the Codex Alimentarius Commission to establish MRLs for pesticides on food. For international trade of food, Codex standards are the reference, with standards currently existing for more than 100 pesticides (WHO 2022).

4.2 ADVERSE COMMUNITY HEALTH IMPACTS OF NON-CHEMICAL PEST MANAGEMENT

In USAID activities that only employ non-chemical pest management techniques and do not have to resort to chemical pesticides, the risk to community health is minimal because of the generally non-toxic properties that non-chemical techniques have. When addressing adverse impacts from non-chemical pest management, it is best practice to refer to other sections of this SEG to learn about the more important environmental or social implications that come from non-chemical techniques.

4.3 MITIGATION AND MONITORING OF COMMUNITY HEALTH IMPACTS

Adverse community health impacts may be mitigated through careful considerations of potential mitigation measures and monitoring so that harm to the community due to pest management practices remains limited.

4.3.1 PREVENTING SELF-POISONING

Means restriction is one of the key effective interventions for prevention of self-poisoning as recommended by WHO. Pesticide regulators and registrars on a mission-level can identify pesticides commonly used in fatal self-poisoning incidences and compile a list to best avoid use or access to these harmful pesticides by the community. In addition, regulations to ban the most toxic products, like in many HIC, can be an effective approach to reducing the number of self-poisoning deaths in lower-income countries where such strict restrictions do not exist as readily.

Many international conventions and UN initiatives also aim to reduce reliance of highly hazardous pesticide use and can also be referenced in their approach for which chemicals not to use and plans on how best to reduce risks associated with chemical pest management. These conventions include the Rotterdam and Stockholm Conventions on which more information can be found in the beginning of this SEG (WHO and FAO 2019).

4.3.2 INTEGRATED VECTOR MANAGEMENT

Integrated vector management (IVM) is a decision-making process, similar to IPM, that highlights the optimal resources and courses of action for dealing with vector control issues in community health settings. The ultimate goal of IVM implementation is to prevent transmission of harmful vector-borne diseases such as malaria, dengue, schistosomiasis, etc. Use of IVM can help provide potable and clean drinking water sources in communities that do not have access to widely available resources. Five key elements comprise the IVM framework: (1) advocacy and regulatory control for public health in communities; (2) collaboration with local health sectors for planning and decision-making; (3) integration of both non-chemical and chemical vector control methods; (4) evidence-based decision-making guided by operational research; and (5) development of adequate human resources to promote national and local capacity strengthening. Further IVM resources are available here from WHO: https://www.who.int/teams/control-of-neglected-tropical-diseases/interventions/strategies/vector-control.

Table 2 below lists the negative impacts of the pest management activities as discussed in earlier chapters of this SEG and develops mitigation measures as well as offers monitoring options.

TABLE 2. COMMUNITY HEALTH IMPACTS, MITIGATION, AND MONITORING

COMMUNITY HEALTH IMPACTS	MITIGATION MEASURES	MONITORING CONSIDERATIONS
Pesticide Self-Poisoning.	Means restriction	More poison centers in countries, document cases of pesticide self-poisoning

TABLE 2. COMMUNITY HEALTH IMPACTS, MITIGATION, AND MONITORING		
COMMUNITY HEALTH IMPACTS	MITIGATION MEASURES	MONITORING CONSIDERATIONS
	Banning of hazardous pesticides Raise community awareness of pesticide self-poisoning	International code of conduct on pesticide management
Bioaccumulation in Food Products	Establish Maximum Residue Levels (MRLs) IPM innovation lab Peeling/washing fruits and vegetables	Codex standards for internationally traded food products JMPR limits of pesticide residues International code of conduct on pesticide management
Illness and Cancer Risks	Human health benchmarks Drinking water limits and standards Raise community and health professional of health risks associated with pesticide use	Overseeing bodies (e.g. E.U drinking water directive) Monitor hospital cases of pesticide-induced illness International code of conduct on pesticide management

5. SOCIAL IMPACTS

USAID's visions, policies, and strategies call for a participatory process that safeguards against doing harm to its beneficiaries. This process includes ensuring meaningful stakeholder engagement from government, communities, and individuals to assure that USAID's international development efforts benefit all members of society, particularly marginalized and underrepresented groups and/or people in vulnerable situations.

Stakeholder engagement is critical for ensuring that USAID maintains accountability to program participants by ensuring the active participation of local communities, developing mitigation measures that include participants' voices, as well as ensuring that affected individuals and communities can communicate their concerns through USAID's Accountability Mechanism.[1] Given the importance of stakeholder engagement for fostering a successful project, the project may benefit from sustaining this engagement throughout the entire project life.

Social Impact Risk Initial Screening (SIRS) Tool
Per the June 2024 update to ADS Chapter 201 Program Cycle Operational Policy, USAID design teams must conduct an initial screening of the social impact of their Activities and Programs using the Social Impact Risk Initial Screening and Diagnostic Tools (ADS 201mbf) (USAID 2024a). The Social Impact Risk Initial Screening (SIRS) Tool is intended to help USAID design teams plan for, mitigate, and monitor potential adverse social impacts from USAID Activities and Programs (USAID 2024b). The Tool consists of 10 questions designed to kickstart mandatory analytical thinking about a variety of different potential adverse social impacts and help identify when additional social safeguarding is needed. Additional social safeguarding may include redesigning Activity/Program components or concepts, identifying social impact mitigation measures, or conducting additional analyses, such as a Social Impact Assessment. When filling out the Tool, design teams should only check "no" when they are highly certain that there is no potential for an adverse impact. The complexity of the process for completing the Tool will vary based on the severity of social impacts posed by the Activity/Program.

Just as environmental compliance measures under 22 Code of Federal Regulations (CFR) 216 seeks to avoid, minimize, and mitigate impacts, including with crop production projects, social impacts should be assessed to determine whether there has been a change from baseline conditions for individuals and communities resulting from a USAID project (USAID 1980). Furthermore, there may be pre-existing adverse conditions in a local community prior to a USAID-funded activity, which should be taken into consideration to maximize benefit sharing so that proposed USAID-funded activities minimize unintended social consequences, such as impacts on a person's livelihood, economic activities, traditional vocations, land or property rights, access to natural resources, culture and customs, and health and well-being.

5.1 KEY SOCIAL IMPACTS

This section is organized according to the principles presented in USAID's Voluntary Social Impacts Principles Framework. The Voluntary Social Impact Principles Framework encompasses nine principles for considering and assessing potential social risks and social impacts across USAID programs, projects, and activities. Table 3 summarizes the nine principles. For additional information on the nine Principles

[1] The USAID Social, Economic, and Environmental Accountability Mechanism (SEE-AM) is expected to be formally launched in summer 2024. The SEE-AM offers communities and project participants to report adverse social, economic, or environmental impacts caused by USAID-funded activities. Complaints and questions can be submitted to disclosures@usaid.gov.

see the USAID Voluntary Social Impact Principles Framework. The subsequent sections present an illustrative list of potential social impacts pertaining to crop production projects that Missions and/or Implementing Partners (IPs) should consider.

Table 1: USAID Social Impact Principles

PRINCIPLE		DESCRIPTION
1	Indigenous Peoples	Indigenous Peoples are a distinct cultural, linguistic, and social group with historical continuity, collective attachment to surrounding natural resources, and/or commitment to maintaining ancestral systems. Specific actions are required of USAID programs involving Indigenous Peoples.
2	Cultural Heritage	Cultural heritage is part of every culture and is found all over the world. It includes archaeological sites, historic buildings, artifacts, and natural environments inherited from past generations as well as intangible knowledge and practices. Working in areas with cultural heritage or on cultural heritage projects can have consequences beyond just destruction of an important resource and can also offer potential means of positively engaging with communities.
3	Land Tenure, Displacement, and Resettlement	Land tenure is associated with acquiring and managing rights to land. Land use change may lead to compulsory displacement and resettlement (CDR), and/or the loss of access and/or use of land and natural resources, which should be avoided and minimized to reduce social impacts on affected landholders, tenants, community members, and pastoralists, among other groups. Failure to account for, and respect, the land and resource rights of local community members can cause costly delays, work stoppages, protests, and, in some cases, violence. USAID may face legal actions and suffer financial, brand, or reputational harm.
4	Health, Well-Being, and Safety	Health, Well-being, and Safety is safeguarding against potential physical, psycho-social, and health impacts among project staff, program participants, and communities where AID actions are implemented. Individual USAID actions must account for potential occupational health and safety risks, as well as potential uneven socio-economic gains across affected communities/program participants, to avoid unintended consequences.
5	Working with Security Personnel	Cognizance of the unique challenges involved in engaging security personnel, working with security personnel prioritizes a rights-based approach to ensure respect for, and safety of, individuals and local communities. Without transparent and accountable oversight of rule of law, the risks of potential human rights violations increase.

PRINCIPLE		DESCRIPTION
6	Conflict Dynamics	Attentiveness to the operational context in relation to past and present conflicts as well as sensitivity around the role that a USAID action has in shaping the conflict landscape. Poor understanding of conflict dynamics increases the possibility of contributing to or exacerbating conflict.
7	Inclusive Development	Inclusive development is an equitable development approach built on the understanding that every individual and community, of all diverse identities and experiences, is instrumental in the transformation of their own societies, which means providing them with the opportunity to be included, express their voices, and exercise their rights in activities and public decisions that impact their lives. Inclusion is key to aid effectiveness. Nondiscrimination is the basic foundation of USAID's inclusive development approach.
8	Environmental Justice	Environmental Justice (EJ) is the fair treatment and meaningful engagement throughout the project life cycle of marginalized and underrepresented groups and/or people in vulnerable situations, with respect to environmental and/or health impacts and implementation and enforcement of environmental laws. It includes the protection of marginalized and underrepresented groups that may face enhanced vulnerability due to environmental harms caused by any action or activity. Marginalized and underrepresented groups and/or people in vulnerable situations may include (but are not limited to): Indigenous Peoples, LGBTQI+ persons, persons with disabilities, children and other youth, older persons, women, low-income populations, and all disadvantaged and marginalized communities across race, color, gender, or national origin.
9	Labor	The Labor principle focuses on advancing worker empowerment, rights, and labor standards through programming, policies, and partnerships to advance sustainable development outcomes. USAID recognizes the high risk of labor abuses that may result from programming, and, thus, USAID works to establish and strengthen labor protections (including social protections) that align with internationally recognized worker rights. This principle includes the promotion of safe and healthy work environments; respecting the principles of freedom of association and collective bargaining; the elimination of forced labor and the worst forms of child labor; and the protection from discrimination at work.

5.1.1 LAND USE, LAND TENURE AND ECONOMIC DISPLACEMENT

Land based projects will likely cause land use change, and an inherent component of land use change are imminent changes or impacts to land tenure. Whilst in the context of small-scale pest management activities, they will likely not be necessitating large stretches of land to undertake an activity, it is nevertheless important to be cognizant of the social implications that may come about due to land use change, which may have repercussions to land use and resources access, and implications to land tenure and resource claims and rights, due to land degradation (due to for example soil contamination due to the improper application or use of pesticides) as well as land use change. For example, smallholders, including marginalized and underrepresented groups and/or people in vulnerable situations may be adversely affected by land use change due to land degradation from pesticides. Therefore, these important aspects (land use change and land tenure or resource claims) should be assessed early on during the planning and design phase.

Land tenure is the relationship that individuals and groups of people hold with respect to land and related resources. Land tenure rules define the ways in which property rights to land are allocated, transferred, used, or managed in a particular society. Land tenure issues can be complicated in areas that may not have a formal system of land ownership or of documentation of land ownership. Traditional rights of use (e.g., for hunting and/or gathering) may be allocated at the local level without a legal registration system. These alternate forms of land tenure and land use when assessing impacts, designing mitigation measures, and determining compensation must be considered. These projects should be assessed for the risk of the impingement of use rights.

Land tenure issues may lead to CDR. In the context of pest management projects, there may be a potential social impact of economic displacement, rather than physical displacement or involuntary resettlement due to the smaller footprint of the pest management activities; however, economic displacement may affect local community members. Economic displacement is an impact that should be avoided, minimized, or mitigated. For instance, in pest-management activities, if pesticides deplete crops, business owners and workers may lose revenue since they rely on the profit from crop production. This may lead them to travelling to other locations to gain financial resources for their own and their family's survival. This circumstance known as economic displacement may also occur when a business moves from a valuable location, causing a worker to travel a greater distance to get to his or her place of employment, or an individual or business loses access to natural resources that provided an economic or survival benefit. Please see the footnote.[2]

Displacement can also have social implications by disrupting or dispersing communities, fracturing social networks, or reducing access to important cultural heritage resources and sites. Resettlement to alternative sites can have negative social impacts on both the resettled population and the established community at the new site, with one or both groups subject to discrimination, prejudice, social conflicts, and/or violence.

There may also be physical displacement. When there is the potential for partial or total physical displacement, economic displacement, or resettlement, the social impacts must be assessed and addressed in an Environmental and Social Impact Assessment (ESIA). USAID's Environmental Compliance Procedures (22 CFR 216) identify resettlement as a class of action with a "significant effect" on the environment and therefore requires, as appropriate, either an EA or Environmental Impact Statement (EIS).

USAID has implemented guidelines that cover CDR that may result from USAID programs (USAID 2016a). Given the importance of stakeholder engagement, an important first step is to review the

[2] Please refer to page 17 of the World Bank Guidance Note:
https://documents1.worldbank.org/curated/en/294331530217033360/pdf/ESF-Guidance-Note-5-Land-Acquisition-Restrictions-on-Land-Use-and-Involuntary-Resettlement-English.pdf

Agency's social assessment-related resources, including the Environmental Compliance Factsheet: Stakeholder Engagement in the Environmental and Social Impact Assessment Process (USAID 2016b). Specific guidelines that USAID and its partners should follow to avoid, minimize, and mitigate CDR risks include the following (USAID 2024c):

- Understand the legal and institutional contexts.
- Identify all legitimate landholders and relevant risks.
- Develop a Resettlement Action Plan and a Livelihood Action Plan (LAP) if physical displacement is unavoidable.
- Promote informed and meaningful engagement.
- Improve livelihoods and living standards.
- Provide additional protections for marginalized and underrepresented groups and/or people in vulnerable situations, especially women and Indigenous Peoples.

The USAID CDR guidelines (USAID n.d.-a; 2016c; 2016a) are consistent with leading international standards on land and resource tenure, including IFC Performance Standard 5, Land Acquisition and Involuntary Resettlement (IFC 2012), and Environmental and Social Standard 5 in the World Bank Environmental and Social Framework (IBRD and The World Bank 2017).

Resettlement must consider not only the impacts on displaced people but also the impacts on the communities to which the displaced people are resettled. Failure to address the issues of all stakeholders can lead to many challenges, including adverse impacts on project-affected groups and individuals, delays in project implementation, possible cancellation of the project, protests, conflict, and/or violence.

5.1.2 HEALTH WELL-BEING AND SAFETY

Specific choices around project design and implementation invariably have the potential to influence health, well-being, and safety. Assessing and managing the potential social impacts related to health, well-being, and safety requires a careful and sustained effort. For example, USAID staff and Implementing Partners should also be aware of self-poisoning by intentional ingestion of pesticides. Studies have found that 14-20 percent of global suicides are from self-poisoning with pesticides (Bonvoisin et al. 2020). Another consideration mentioned in the community health section is pest management projects may contaminate local bodies of water, affecting the availability of drinking water for community members. The contamination of drinking water may lead to acute health effects or chronic illnesses such as cancers, birth defects, and reproductive harm. In addition, pesticide exposure related illnesses may disproportionately affect vulnerable groups such as women, children, and the elderly.

Public safety risks may also arise, depending on the pest management project being proposed, which should be taken into consideration. For example, women and girls may often be responsible for fetching drinking water. However, the contamination of surface and/or ground water may lead them to travel to remote and unfamiliar areas to fetch safe drinking water and may unintentionally pose an increased risk of Gender Based Violence (GBV).

5.1.3 CONFLICT DYNAMICS

USAID's projects are often implemented in fragile or conflict-affected environments. USAID's work encompasses investments in conflict prevention and mitigation, stabilization, and peace building, parallel to investments in other sectors. Understanding conflict dynamics and how a pest management project affects or is being affected by these dynamics is an essential component of being conflict aware and conflict sensitive (USAID 2024c). For example, local communities may have a heightened awareness of the distribution of resources, as well as the roles and responsibilities of the people involved in the distribution of those resources, and a proposed pest management project may exacerbate the underlying conflict dynamics. There may be historical grievances that come to light due to proposing a pest management project to benefit one group of people over another, or due to siting and placement of the project, which may exclude one group over another, thus exacerbating local tensions. For instance, competition and other unsafe mechanisms for acquiring pesticides may occur, risking the safety of community members. In addition, as pest management methods could potentially damage resources such as crops and water, competition for those resources may arise. Therefore, conflict dynamics at the site level should be understood during the design phase by means of engaging stakeholders in a participatory approach and assessing conflict dynamics (USAID n.d.-b; 2024c).

5.1.4 ENVIRONMENTAL JUSTICE

Environmental justice (EJ) is the fair treatment and meaningful stakeholder engagement throughout the project life cycle of all project-affected persons, particularly marginalized and underrepresented groups and/or people in vulnerable situations with respect to environmental and/or health impacts, and implementation and enforcement of environmental laws. It includes the protection of potentially marginalized and underrepresented groups that may face enhanced vulnerability due to environmental harms caused by any action or activity. It also includes equitable access to environmental benefits and/or ecosystem services that a project may enhance. Marginalized and underrepresented groups and/or people in vulnerable situations may include (but are not limited to): Indigenous Peoples, LGBTQI+ persons, persons with disabilities, children and other youth, older persons, women, low-income populations, and all disadvantaged and marginalized communities across race, color, gender, or national origin (USAID 2024c).

Meaningful stakeholder engagement entails:

- People from diverse social groups are provided with an opportunity to participate in decisions about activities that may affect their environment, livelihoods, well-being, and/or health;
- The public's contribution can influence the agency's decision;
- Community views, perspectives, and concerns will be considered in the decision-making process; and
- Decision makers will seek out and facilitate the stakeholder engagement process with potentially affected people (USAID 2024c).

Further guidance on EJ is available in the USAID Voluntary Social Impact Principles Framework (USAID 2024) to help assess adverse environmental and social impacts of USAID programs on marginalized and underrepresented groups and/or people in vulnerable situations and to provide guidance to USAID staff and IPs on identifying and stakeholder engagement with marginalized and underrepresented groups and/or people in vulnerable situations.

5.1.5 LABOR

Pest management is a highly labor-intensive sector and hence involves workers. Each project implementer should be aware of the International Labor Organization's (ILO) conventions that the host country has signed.[3] Adherence to ILO's core labor standards is essential. The ILO core labor standards address freedom of association, collective bargaining, abolition of forced labor and the worst forms of child labor, minimum age, equal remuneration, discrimination, and the protection of children and young persons. Even for countries that do not adopt one or more standards, they are fundamental to the protection of the workforce. USAID's Agency-Wide Counter-Trafficking in Persons Code of Conduct has the goal of prohibiting USAID contractors, subcontractors, grantees, and sub-grantees from engaging in trafficking in persons, procuring commercial sex acts, or using forced labor (Alliance 8.7 n.d.; U.S. Department of Labor n.d.; ILO 2011; Rainforest Action Network 2017; Responsible Sourcing Tool n.d.; The White House 2023; United Nations 2023; USAID 2023a).

Furthermore, since pest management projects entail the use of chemicals and workers can be exposed to extreme heat regarding working conditions, workers may be at risk to an array of occupational risks and hazards. Individual projects should ascertain the occupational health and safety risks to workers and design mitigation measures (ILO 2001; The World Bank 2018; ILO n.d.; ILO 1981).

5.2 OTHER SOCIAL CONSIDERATIONS

5.2.1 THE ROLE OF STAKEHOLDER ENGAGEMENT

Stakeholder engagement provides a systematic approach to Missions and Implementing Partners, that will allow for the project proponent to acquire stakeholder's input, information, feedback, local and traditional knowledge, local perspectives, and concerns early on, during the design and planning phase, well before the assessment of social impacts phase (USAID 2022a). Stakeholders may be groups or individuals from the private or public sector, as well as individuals who may have an influence on the outcome of the project or may be considered an affected party. Members of civil society organizations may also be considered such as, local hunter and gatherer groups, local fishermen groups, and small-scale subsistence farmers, for instance. Special attention should be given to vulnerable, marginalized, and underrepresented groups as they may be inequitably affected by a project such as women, children, and older persons.

Stakeholder mapping, engagement, and consultation are key steps in the planning process of pest management projects and will also be crucial in identifying opportunities for the inclusion of marginalized and underrepresented groups and/or people in vulnerable situations (USAID 2016b). Stakeholder engagement should be a broad, inclusive, and continuous process. The benefit of beginning the stakeholder engagement process early on and sustaining it throughout the entire project life cycle is that

[3] Per IFC Performance Standard 2, this Performance Standard recognizes that "the pursuit of economic growth through employment creation and income generation should be accompanied by protection of the fundamental rights of workers and must respect several International Labor Organization (ILO) Conventions, including ILO Convention 87 on Freedom of Association and Protection of the Right to Organize; ILO Convention 98 on the Right to Organize and Collective Bargaining; ILO Convention 29 on Forced Labor; ILO Convention 105 on the Abolition of Forced Labor; ILO Convention 138 on Minimum Age (of Employment); ILO Convention 182 on the Worst Forms of Child Labor; ILO Convention 100 on Equal Remuneration; ILO Convention 111 on Discrimination (Employment and Occupation); UN Convention on the Rights of the Child, Article 32.1; and the UN Convention on the Protection of the Rights of All Migrant Workers and Members of their Families" (IFC 2012).

it may allow for the co-creation[4] of positive benefits, for example identifying mitigation measures regarding the social impacts based on traditional knowledge from local community members, through adaptive management. Information on best practices for stakeholder engagement is available in the USAID document entitled Environmental Compliance Factsheet: Stakeholder Engagement in the Environmental and Social Impact Assessment (ESIA) Process (USAID 2016b).

5.2.2 LOCAL COMMUNITY

When planning and designing pest management projects, the local community in which the project will be embedded should be assessed. This assessment may be addressed prior to assessing potential social impacts by means of undertaking a desktop review of the characteristics of the community, such as demographics; socioeconomic composition; and political, institutional, and legal frameworks, as well as through field visits and stakeholder engagement. Although the particulars of identifying social impacts for pest management projects depends on the site location, and local context, undertaking stakeholder engagement early on is necessary to improve the understanding of how the proposed project may affect the local community. If stakeholders in a local community voice concerns regarding potential negative social impacts due to a proposed project, the social impacts may be assessed, and mitigation and monitoring measures designed. Management measures should be commensurate with the degree of the identified adverse social impacts. In cases where social impacts from project activities are deemed to adversely affect the lands, rights, and livelihoods of individuals and communities, implementation of the project should be reconsidered (i.e., potentially ended). If/when the project is under implementation, the local community is adversely impacted, implementation of the project may need to be curtailed until adequate management measures have been designed and implemented to mitigate the identified impacts.

5.2.3 GENDER EQUALITY

Gender considerations may need to be looked at when planning for and designing pest management projects and during the process of evaluating potential social impacts. Women oftentimes are involved in pest management projects yet do not always benefit from the project equally. Therefore, social impacts are gender differentiated, and can affect men and women in different ways.

Many social impacts are gender differentiated and can affect men and women in different ways. USAID seeks to support gender equality with the following goals: (1) improve the lives of people by advancing gender equality; (2) empower women and girls to participate fully in, and equally benefit from, the development of their societies on the same basis as men; and (3) secure equal economic, social, cultural, civil, and political rights regardless of gender. USAID policy requires that a Gender Analysis "be integrated in strategic planning, project design and approval, procurement processes, and measurement and evaluation" as part of ADS 205: Integrating Gender Equality and Women's Empowerment in USAID's Program Cycle, which seeks to integrate gender and equality into the program cycle (USAID 2023b).

Special attention must be paid to how pest management projects may affect women and girls. Gender Analysis "is a systematic analytical process used to identify, understand, and describe gender differences

[4] USAID defines co-creation as a process that "brings people together to collectively design solutions to specific development challenges. Time limited and participatory, partners, potential implementers, and end-users define a problem collaboratively, identify new and existing solutions, build consensus around action, and refine plans to move forward with program and projects." For additional information see https://www.usaid.gov/co-creation-usaid.

and the relevance of gender roles and power dynamics in a specific context" (USAID 2023c). Such analysis typically involves examining the differential impact of development policies and programs on women and men and may include the collection of sex-disaggregated or gender-sensitive data (USAID 2011). Gender Analysis examines the "different roles, rights, and opportunities of men and women and relations between them. It also identifies disparities, examines why such disparities exist, determines whether they are a potential impediment to achieving results, and looks at how they can be addressed" (USAID 2023c). Furthermore, there may be gender divisions in the decision-making process that may influence how the placement of the project may be proposed.

Disparate gender impacts on pest management projects may involve imbalances in stakeholder input, decision making, employment opportunities, and monetary compensation for project impacts. A Gender Analysis helps to identify gender disparities in the community early on. Because USAID projects require stakeholder engagement and consultation as part of the process of identifying, avoiding, and mitigating adverse social impacts, it is increasingly important to be aware of gender-based barriers to public participation. In these cases, stakeholder engagement and consultations may need to occur in a gender sensitive manner, for instance by having separate venues for men and women. To acquire input and feedback from women, a combination of methods may be undertaken (such as interviews and focus groups). For, instance semi-structured interviews or women-only focus groups may be conducted with women in a safe space such as an individuals' home or place of worship. Providing a space in which to obtain women's perspectives may shed light on a potential gender division in decision making and consultation, and in turn could impact siting and benefit sharing.

Furthermore, it is important to assess gender considerations to avoid the potential to exacerbate underlying conditions, beliefs or value systems that perpetuate Gender Based Violence (GBV). GBV should be avoided as this is a significant social impact. USAID has resources to evaluate the potential for GBV and how to address this social issue (USAID n.d.).

Moreover, there are several guidance documents regarding gender considerations, that are available on behalf of USAID.[5]

5.3 SUMMARY TABLE OF SOCIAL IMPACTS, MITIGATION MEASURES AND MONITORING MEASURES

The social impacts discussed in Table 3 are for illustrative purposes only and do not provide an exhaustive list because the social impacts identified for solid waste projects and activities will depend on the site location and the specifics of a proposed project, as well as the local context, among other factors. The mitigation and monitoring measures also are described in the subsections below and are not an exhaustive list.

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[5] For additional guidance regarding gender considerations, see the following: https://www.usaid.gov/sites/default/files/2022-05/GenderEqualityPolicy_2.pdf; https://www.usaid.gov/sites/default/files/2022-05/USAID_GenderEquality_Policy_MT_WEB_single_508.pdf; https://www.usaid.gov/what-we-do/gender-equality-and-womens-empowerment/usaid-websites-related-gender-resources; https://www.usaid.gov/engendering-industries/gender-equality-guides/policies

TABLE 3. SOCIAL IMPACTS, MITIGATION, AND MONITORING		
SOCIAL IMPACTS	MITIGATION MEASURES	MONITORING CONSIDERATIONS
Labor Farmworkers may experience illnesses or injuries from pesticide exposure. Direct contact with pesticides can cause irritation to skin, eyes, mouth, and respiratory tract. Reactions from such exposures can cause headache, sneezing, irritations, vomiting, and skin rashes. Long term illnesses include reduction in fertility, respiratory illnesses and more (Pathak et al. 2022). See Community Health section for additional information on the health impacts from pesticide exposure. Occupational health and unfair labor practices are heightened when national occupational labor standards are poorly developed or enforced for pesticide exposure prevention.	Establish a stakeholder engagement plan (SEP) during the planning and the design phase to acquire feedback and sustain stakeholder engagement throughout the project life cycle. Follow Guidance as per ILO Convention 155 (ILO 1981). Address Occupational and Community Health and Safety in the Pre-implementation environmental and social impact assessment (ESIA) processes. The ESIA process should specifically address occupational and community safety and health risks presented by supported activities—for example those presented by use of pesticides. Such analysis should specifically (1) consider the risks presented to more vulnerable members of the community (such as children, women, and individuals with weakened immune systems); and (2) identify and follow any host country laws and regulations and/or international occupational health and safety standards that apply. Mitigation design, with reference to the previously stated occupational safety and health issues, should then address said risks. Conduct safety trainings for workers regarding correct PPE use, pesticide application methods, dangers associated with pesticide exposure and other topics related to pesticide application safety Identify any host country laws and regulations and/or international laws or regulations regarding labor safety	Review and update the SEP on a periodic basis Document and report the number of chemical exposures, accidents, and incidents and review periodically Keep records of trainings on labor safety and of numbers of people who attended.
Land use and tenure Land degradation from pest management activities may lead to land conversion as landowners may clear other areas due to pesticide damage to their original land. This	Conduct stakeholder engagement during planning and design phase to understand local land tenure insecurity and determine whether impacts of insecure tenure may be a concern in the context of pest	Review and update the SEP on a periodic basis Periodically review the reports on land use and land tenure changes and stakeholders impacted.

TABLE 3. SOCIAL IMPACTS, MITIGATION, AND MONITORING		
SOCIAL IMPACTS	MITIGATION MEASURES	MONITORING CONSIDERATIONS
may dispossess land from tenant smallholders. Due to loss of land ownership, smallholders may be more likely to clear other areas, for example of pristine forests, which may contribute to deforestation, to acquire new pastures or land to grow feed.[6] Some communities, including marginalized and underrepresented groups and/or people ion vulnerable situations may lose access to the land due to land conversion, affecting their ability to graze animals, gather fuel wood, etc. In some cases, it may lead to landlessness, inability to access jobs, food insecurity, impoverishment, social conflict, and violence.	management activities Establish a Stakeholder Engagement Plan (SEP) for continued community consultation If land tenure is a concern, conduct mitigation strategies such as supporting smallholders in obtaining formal land title and formalizing informal land usage rights. Keep a log of all potential land tenure use and tenure changes and the stakeholders it may be impacting in a report Consider alternatives in the design phases to avoid and minimize impacts to marginalized and underrepresented groups and/or people in vulnerable situations. Include participatory identification and mapping of areas important to marginalized and underrepresented groups and/or people in vulnerable situations for hunting, gathering, and/or agricultural activities in the Stakeholder Engagement Plan.	Undertake ongoing stakeholder engagement.[7]
Gender Equality Water contamination from pesticides for crop production may lead to women traveling to unfamiliar locations to fetch drinking water. This may risk their safety, leading to an increase in GBV.	Draft a Stakeholder Engagement Plan (SEP) early on in the project life cycle and sustain throughout the project Review USAID's Gender Equality and Female Empowerment Policy (USAID 2023b) Establish women led community protection groups to ensure that individuals feel safe traveling to areas that they depend upon. Establish a Grievance Redress Mechanism (GRM).	Periodically review and update the SEP and for the pest management activity periodically and integrate feedback from women and girls on an ongoing basis

[6] For more information on social issues related to deforestation, see the Forestry SEG, accessible at https://www.usaid.gov/environmental-procedures/sectoral-environmental-social-best-practices/sector-environmental-guidelines-resources.

[7] For more information on monitoring considerations related to land use and tenure, see the Crop Production, Forestry, and Dryland Agriculture SEGs, accessible at https://www.usaid.gov/environmental-procedures/sectoral-environmental-social-best-practices/sector-environmental-guidelines-resources.

TABLE 3. SOCIAL IMPACTS, MITIGATION, AND MONITORING		
SOCIAL IMPACTS	MITIGATION MEASURES	MONITORING CONSIDERATIONS
Health Well-Being and Safety Local communities may be exposed to pesticides through runoff due to agricultural production. Children may have access to pesticides leading to accidental poisoning. Local communities to the pest management project may be exposed to pesticide contaminated water. Water contamination can lead to pesticide-related illnesses including hormone imbalance, reproductive issues, carcinogenic exposure, and reduced intelligence towards children under the age of five (Syafrudin et al. 2021). Children and the elderly may be more vulnerable to contracting such illnesses. Pesticide drift or overspray from pesticide application can negatively affect nearby communities. For example, children that attend schools near agricultural fields may be exposed to pesticides due to the proximity of pesticide spraying. Health effects include skin and eye irritation.	Engage in Safer Pesticide Use[8] Draft a Stakeholder Engagement Plan (SEP) early on during the project life cycle and sustain throughout the project. Educate community members and farm workers on pesticide, related illnesses and preventable measures. Community leaders can engage and educate the community members Undertake a mapping of pest management projects located near neighborhoods, schools, clinics and other areas heavily occupied by community members. Avoid conducting pest management activities near highly populated areas Build capacity for community health services and health education Promote integrated pest management	Periodically review and update the SEP and ensure participation of older people, and of children that are accompanied by their parent or legal guardian to better understand how they are being impacted and to monitor the mitigation of the impacts that may be causing the illnesses. Keep a log of the number of stakeholders that have been treated for skin irritation at the local clinic. Keep a log of the number of farm workers that have attended the capacity training workshops for correct application of pesticide use.
Conflict Dynamics A project may unintentionally cause conflict in the local community regarding for instance, the loss of land tenure. Smallholders including marginalized and underrepresented groups and/or people in vulnerable situations may lose ownership of land to others affected by land degradation from pesticide use. This may lead to conflict regarding land ownership. Reduction in availability of drinking water due to pesticide contamination may lead to competition for water resources.	Undertake a Conflict Dynamics Assessment Undertake stakeholder engagement at the beginning of the project life cycle and establish a Stakeholder Engagement Plan (SEP) Consult with community leaders, government officials, members of civil society, women's groups, church groups, NGO's and CBO's (among other stakeholders) to understand existing conflicts and tensions. Establish a Grievance Redress Mechanism (GRM).	Review and update the SEP on a periodic basis. Conduct stakeholder engagement on an on-going basis, through different mixed methods approach such as village meetings or community surveys prior to and throughout project implementation. Review and update the SEP on a periodic basis. Revisit the GRM.

[8] For more information on Safer Pesticide Use, see the USAID PERSUAP Template, accessible at https://www.usaid.gov/environmental-procedures/environmental-compliance-esdm-program-cycle/environmental-documentation/persuap.

TABLE 3. SOCIAL IMPACTS, MITIGATION, AND MONITORING		
SOCIAL IMPACTS	MITIGATION MEASURES	MONITORING CONSIDERATIONS
Environmental Justice Marginalized and underrepresented groups and/or people in vulnerable situations may disproportionately be affected by pesticide contamination and exposure. Smallholder farm workers are particularly vulnerable due to how they apply pesticides and the conditions in which they apply pesticides (Isgren and Andersson 2020). Few smallholders receive training on how to apply pesticides or understanding pesticide labels. Also, proper equipment and PPE may be too expensive for smallholders to afford (Isgren and Andersson 2020). marginalized and underrepresented groups and/or people in vulnerable situations may experience disproportionately high levels of exposure to pesticides by way of pesticide drift.	Conduct stakeholder engagement at the beginning of the project life cycle and ascertain that protections to vulnerable groups are upheld to ensure environmental justice. Train farm workers on taking appropriate precautions during pesticide spraying (e.g., wearing personal protective equipment), and using proper equipment to apply pesticides. Consider alternatives to substitute pesticide use Compare demographic and geographic data to ensure that pest management projects are sited such that marginalized and underrepresented groups and/or people in vulnerable situations are not exposed to pesticide drift	Review and update the Stakeholder Engagement Plan (SEP) periodically. Review demographic and geographic data for significant changes in community makeup. Keep a log of the number of stakeholders that have been treated for pesticide related illnesses at the local clinic. Keep a log of the number of farm workers that have attended the capacity training workshops for correct application of pesticide use.

6. CLIMATE CHANGE AND PEST MANAGEMENT

Pest management is highly climate dependent. Disruptions to traditional weather patterns can result in changing pest distribution and severity, and landscapes degraded by extreme weather events are more vulnerable to pests. Pests are already affecting global crops and food security. As much as 40 percent of global food supply is currently lost due to pests (Heeb and Jenner 2017). Under climate change, this threat on food supply/security is anticipated to increase as the potential for pest damage increases. Other crop stressors (e.g., increasing temperatures and extreme weather; pollution), occurring simultaneously to these pest stressors, can further strain crop quantity and quality.

An ecosystem's **vulnerability** to climate change impacts is the propensity or predisposition to which it may be adversely affected by or unable to cope with a changing climate (USAID 2022b; IPCC 2018). There are various factors that play a role in crops' vulnerability to pests under climate change, such as pest management strategies (e.g., biological control, synthetic pesticides). Vulnerability is a function of exposure, sensitivity, and adaptive capacity. Therefore, project managers working in pest management and with the agricultural sector communities who are heavily dependent on natural resources for food, medicine, fuel, and income need to provide guidance on measures that reduce **sensitivity** (i.e., the degree to which ecosystems and species react to and respond to climate stressors) and increase the **adaptive capacity** (i.e., the ability of ecosystems and species to adjust to potential adverse effects of climate change, to take advantage of opportunities, or to respond to consequences (USAID 2022b)) of biodiverse ecosystems. Successful projects must also plan for **exposure** (i.e., the extent to which ecosystems and species are exposed to climate change impacts) to a changed climate over the coming decades.cu

Further detailed information on options for climate change mitigation and adaptation in pest management activities is detailed below.

TABLE 4. KEY DEFINITIONS FOR CLIMATE CHANGE AND PEST MANAGEMENT

TERM	DEFINITION
Adaptation	The process of adjusting in response to actual or expected climate change and its effects, in order to manage potential adverse climate change-related impacts or benefit from opportunities (USAID 2022b; IPCC 2018)
Resilience	The ability to mitigate, adapt to, and recover from climate-related adverse impacts in a manner that reduces chronic vulnerability and facilitates inclusive growth (USAID 2022b).
Climate Change Mitigation	The reduction or prevention of greenhouse gas emissions or enhancement of greenhouse gas sinks (USAID 2022b; IPCC 2018).
Direct Climate Impact	The specific hazard outcomes of climate change, such as increased temperatures, precipitation variability, and extreme events such as storms, floods, drought, and wildfires.

Indirect Climate Impact	The outcomes resulting from communities' or ecosystems' responses to the direct climate change hazards - for example, increased disease, vegetation change, and decreased reservoir levels.
Risk	The potential for climate-related adverse outcomes, resulting from vulnerability, exposure, and the likelihood of the hazard to occur (IPCC 2018).
Hazard	The potential for an event to occur that may cause injury, loss of life, or other health impacts in addition to the loss or damage of infrastructure, livelihoods, and ecosystems or environmental resources (IPCC 2018).

6.1 CLIMATE CHANGE IMPACTS ON PEST MANAGEMENT ACTIVITIES

Generally, future challenges with pests under climate change are expected to be greater and more unpredictable (Gregory et al. 2009). Pest management will become increasingly complex as the species, timing, range, and intensity of pest populations shifts under climate change (Subedi 2023). In the agricultural sector, this unpredictability may result in the failure of some crop protection strategies, particularly as pests add to the crop stress imposed by heightened temperatures, extreme precipitation, drought, and other direct impacts of climate change. The most significant impacts of climate change on pest management include:

- **Increased temperatures** can result in a shift in the distribution of pest species, including invasive species and diseases (Heeb, Jenner, and Cock 2019). For some regions, rising temperatures may drive pest population growth, as pests shift toward geographic regions for which they are better suited. Warmer temperatures can accelerate mosquito development and increase their breeding rates. Globally, a pattern of increasing latitudinal and altitudinal range of crop pests is expected. This pattern may be driven either through direct climate-related impacts on the pests themselves, or on the availability of host crops (Gregory et al. 2009; Barzman et al. 2015).

  Meanwhile, increasing temperatures may decrease the effectiveness of pest management strategies (Ma et al. 2021). Increased temperatures and sunlight exposure may increase volatilization and accelerate degradation of chemical pesticides leading to reduce effectiveness (Delcour, Spanoghe, and Uyttendaele 2014).

- **Precipitation variability,** including both extreme precipitation and drought, can lead to significant pest habitat loss but can also be beneficial to certain pests (Heeb, Jenner, and Cock 2019). Changing moisture content may increase disease prevalence and pest population size. More frequent and severe rainfalls events (e.g., heavy rainfall, floods, hurricanes) create stagnant water pools, ideal breeding grounds for mosquitoes. Simultaneously, pest control methods may be less effective. For instance, droughts can reduce populations of beneficial insects due to impacts on pollinators and pest infestations (Sutherst et al. 2011). Meanwhile, crops and livestock suffering from water stress are increasingly vulnerable to pests (Heeb, Jenner, and Cock 2019).

- The projected **increase in frequency and intensity of extreme events** – floods, storms, landslides, wildfires, etc. – can be a substantial risk to ecosystems and agriculture, and the relevant infrastructure and workers for pest management. Habitats or species populations can be damaged or completely destroyed as a result of these events, and ecosystems disturbed by extreme events tend to be more vulnerable to pests – both native and invasive species (Masters and Norgrove 2010). For example, invasive species, particularly fast-growing ones, may take over highly disturbed landscapes after a weather-related disaster such as a wildfire or storm. Storms and strong winds can also transport disease and pests from one location to another (Heeb, Jenner, and Cock 2019). Although extreme weather events can be detrimental to pests (e.g., extreme heat can kill off pests), ecosystems may become more susceptible to pests under these changing conditions.

- **Increasing carbon dioxide** levels may lead to increased crop yields but also some increase in pest incidence (Heeb, Jenner, and Cock 2019; Heeb and Jenner 2017; Coakley, Scherm, and Chakraborty 1999). For example, elevated CO2 and temperature have been shown to increase metabolism and food consumption of cotton bollworm larvae, which may increase damage to crop yields (Akbar et al. 2016). A study of elevated CO2 on multiple generations of Asian corn borer showed increased larval food intake which could lead to greater damage to host plants (Xie et al. 2015). Elevated CO2 may also change plant physiology, with reduced nutritional quality of plant tissues causing an increase in consumption by insect herbivores (Ngumbi 2021).

- **Changes in land use and crop management** can significantly affect pest populations, potentially even more so than the direct effects of climate change (Heeb, Jenner, and Cock 2019). Climate change can reduce crop yields and agricultural productivity, requiring populations to supplement their supply with new resources. Although ecosystems are inherently dynamic, the speed of climate change may already be exceeding their natural adaptive capacity to moderate damages or cope with the consequences of such changes. As a result, some species ranges or distributions are shifting, and individual species are being affected by pest infestations and invasive species. Community displacement and/or migration may even result when climate change hazards lead to a change in natural resource use that alters a landscape and the presence of pests.

6.2 BUILDING RESILIENCE AND ADAPTING TO CLIMATE CHANGE IN PEST MANAGEMENT ACTIVITIES

The incorporation of climate smart pest management (CPSM) strategies can help protect ecosystem services and habitats against pests. It is important to consider the potential for indirect effects of pest management to ensure that local communities and Indigenous Peoples are not displaced or otherwise adversely impacted.

Integrating climate adaptation and mitigation in pest management, such as through CSPM, can directly increase ecosystem and community resilience, as well as food security (Heeb, Jenner, and Cock 2019). Examples of CSPM measures include:

- Forecast (model) pest populations and monitor and identify pest species and prevalence.

- Adjust inputs (e.g., use of biological or synthetic pesticides) to address target pests as part of an IPM strategy.
- Provide climate information such as anticipated changes in pest prevalence and seasonality caused by climate change.
- Develop and implement a biosecurity action plan to prevent the introduction or spread of invasive pests or other contaminants.
- Raise awareness at the local level for the recognition of pest threats. Act early when threats are identified, only as part of an IPM strategy.

In the crop production sector, CSPM can simultaneously contribute to both improved agricultural productivity and yield, and resilience and GHG mitigation (e.g., increasing the crops' carbon assimilation), in a range of ways (Kern et al. 2012). For example, practices that maximize plant diversity and soil organic matter, such as conservation agriculture, contribute to the sequestration of carbon while also increasing plants' resilience to pests (Altieri and Nicholls 2003).

The pest management program design process should consider the potential and near- and long-term changes to climate conditions and local weather patterns. Climate change impacts (e.g., increased temperatures) can result in the shifting geographic suitability and distribution of some native and invasive pest species. Pest management is critical for sustaining human health and well-being, for example by supporting food security, public health, and resilience to climate change impacts.

Climate Risk Management (CRM) offers a method through which project designers and implementers can screen activities for climate risks and develop responses to address risks and build resilience. Measures to develop comprehensive pest management programs can boost resilience to climate change impacts. Studies can also be conducted on the relationship between climate change and pest management to further understanding of climate impacts in specific regions. Finally, engaging local communities is critical to ensuring that climate adaptation is aligned with improved food security, human health, and livelihood protection.

Table 5 summarizes climate hazards posed to pest management projects and the direct and indirect impacts from them and provides mitigation measures to address the risks.

TABLE 5. CLIMATE CHANGE IMPACTS ON PEST MANAGEMENT ACTIVITIES

CLIMATE HAZARDS (VARY BY REGION)	DIRECT IMPACTS	INDIRECT IMPACTS	POSSIBLE CLIMATE RISK MITIGATION MEASURES
Increasing Temperatures	Increased prevalence and distribution of pests (incl. invasive species) resulting in increased crop loss and biodiversity stressors. Increased incidence and severity of diseases caused by pathogens.	Shifts in the types of crops that populations can grow. Changes in patterns of forest and natural resource use, crop yield, and food insecurity (as a result of declining agricultural yields or livestock viability).	Work with communities to conduct capacity building on climate-smart pest management, as part of climate-smart agriculture. Community training about local pests and actions to take.

TABLE 5. CLIMATE CHANGE IMPACTS ON PEST MANAGEMENT ACTIVITIES			
CLIMATE HAZARDS (VARY BY REGION)	DIRECT IMPACTS	INDIRECT IMPACTS	POSSIBLE CLIMATE RISK MITIGATION MEASURES
	Reduced effectiveness of pesticides. Increased occupational health hazards for outdoor workers. Disrupted temperature-sensitive species, resulting in increased vulnerability of crops to pests. Increased pesticide toxicity, as water temperatures warm.	Changes in the quality of ecosystem services provided. Increased applications of pesticides and fungicides (as pest populations increase), which can lead negative external effects on the environment and human health. Community displacement and/or migration.	Work with communities to create and implement a local biosecurity plan. Livelihood diversification to reduce stressors on food supply. Implement heightened monitoring of invasive pest species and increased management measures as needed. Select more heat-resistant crops (and train communities on how to select species) in order to reduce additional stress on crops.
Changes in Precipitation (i.e., excessive or insufficient water availability, including drought)	Increased prevalence of disease and increased pest populations (incl. plant pathogens) under warm and humid conditions. Leaching of pesticide runoff into water resources. Decreased populations of beneficial insects due to droughts, with knock-on effects on pollination and pest infestations.	Compounding stressors. Water-stressed crops are more vulnerable to pests. Shifts in seasonality, viability, and productivity of crops, which in turn could line up with the timing of harmful pests and result in crop loss and livelihood/income loss and food insecurity. Community displacement and/or migration.	Select crops that are more drought- or flood-resistant (and train communities on how to select species) in order to reduce additional stress on crops. Grow crops and animals using more water-resilient production methods to limit water stress. Develop integrated watershed management informed by climate change projections to improve groundwater availability (to reduce water stress of crops). Reduce other crop stressors (e.g., pollution).
Increased Incidence and Magnitude of Extreme Weather Events (i.e., floods, storms, landslides, fires, high winds, etc.)	Increased susceptibility of disturbed ecosystems to pest invasions (native and nonnative) following an extreme weather event. Increased unpredictability of some crop protection	Additional stress to underlying socio-economic and health status of communities (reduce food security, adaptive capacity, and resilience), resulting in increased resource use.	Develop community-based early warning systems that can alert communities of an extreme event, including forest fire monitoring, prevention, and control systems.

TABLE 5. CLIMATE CHANGE IMPACTS ON PEST MANAGEMENT ACTIVITIES			
CLIMATE HAZARDS (VARY BY REGION)	DIRECT IMPACTS	INDIRECT IMPACTS	POSSIBLE CLIMATE RISK MITIGATION MEASURES
	strategies, as extreme weather events can influence the interactions between crops and pests in ways that are difficult to predict. Extended range of pest populations, as a result of strong air currents in storms transporting disease agents and pests from overwintering areas to other areas. Damage to crops and livestock.	Population displacement and/or migration.	Establish community education and capacity building for emergency preparedness and response. Develop and implement a biosecurity plan to implement following an event that disrupts an ecosystem. Reduce other crop stressors. Develop prevention or management plans for each of the potential extreme events.
Elevated levels of carbon dioxide	Increased crop yield due to greater plant growth and increased water-use efficiency. These increases can partially offset losses (maize and rice) or fully offset losses (wheat and soybeans) due to higher temperatures and drier conditions. However, these findings do not account for impacts on crop nutrition, or pests (Hille 2016). Physiology of insect pests has been shown to be positively or negatively impacted at various stages of development. Overall, consumption rates of pests increase, heightening the risk to crops.	Changes in crop nutrition may in turn spur greater consumption by pests.	Reduce GHG emissions and / or enhance removals to minimize elevation of CO2 levels

6.3 PEST MANAGEMENT IMPACTS ON CLIMATE CHANGE

Pest management is critical to ecosystem health and the agriculture sector, although pesticides and pest management activities may in turn contribute to climate change. The amount of GHG emissions from pest management varies significantly based on the type of pest management strategy practiced.

Non-chemical pest management strategies constitute a negligible share of greenhouse gas emissions, and pesticide use is the main form of pest control used. Pesticide production and use generates greenhouse gases throughout its lifecycle – production, storage, shipment, application, and breakdown of the chemicals (USAID 2009a). This section, therefore, focuses on the impacts of chemical pesticides on climate change.

- Emissions from **pesticide production** are due to the use of fossil fuels, both as a feedstock (often petroleum or natural gas) and as an energy source in their manufacture (Helsel 2019). It is very difficult to quantify the GHG emissions from pesticide production because producers are not required to provide complete information about product ingredients (Center for International Environmental Law (CIEL) 2022; Cox and Surgan 2006). These data gaps make it difficult to truly understand the upstream emissions related to pesticide use (USGS 2023).

- **Storage of pesticides** such as stockpiles of obsolete pesticides that have expired or that are no longer legal to use can also emit GHGs, as can disposal methods common in the Global South such as burning (USGS 2023). However, current research omits this source of emissions (USGS 2023).

- **Transportation** of pesticides may result in GHG emissions from fossil use as well. Reducing transportation, and the use of raw materials with high embedded levels of GHGs will lower emissions.

- **Pesticide application** also emits GHGs. The application method matters since the use of tractors fueled by diesel will be far more GHG intensive than a smallholder hand-spraying their fields. When applied in the field, some pesticide interactions increase net emissions. For example, applying the fumigant chloropicrin impacted soil microorganisms, increasing the production of nitrous oxide in soils seven-fold (Spokas and Wang 2003).

  Applying pesticides also produces ground-level ozone, which absorbs radiation and acts as a GHG. Ozone is formed when pesticides emit volatile organic compounds that volatilize into gases that react with nitrogen oxides and ultraviolet rays (Martin 2013). Studies show that up to 90 percent of pesticides applied may volatilize within a few days and increased temperatures are anticipated to result in more pesticide volatilization (USGS 2023). According to the USDA, ground-level ozone is more damaging to plants than all other air pollutants combined (USGS 2023). In croplands, increasing ozone levels can significantly decrease both yield and carbon sequestration (Felzer et al. 2007).

- **Pesticide degradation** or transformation – the process by which pesticides break down in the environment – changes the molecular structure of a pesticide. This process can take place even before the pesticide is applied, while it is being stored (Somasundaram and Coats 1991). Most pesticides that are applied eventually degrade into materials such as carbon dioxide, ammonia, water, mineral salts, and humic substances which may further degrade into GHGs (Somasundaram and Coats 1991).

Full consideration of GHG emissions would include pesticides' role in increasing emissions from agricultural soil by negatively impacting soil health and function. For example, pesticides have been shown to harm soil invertebrates which sequester soil carbon (Gunstone et al. 2021) and damage mycorrhizal fungi (Aktar, Sengupta, and Chowdhury 2009) that enhance plant nutrient uptake and conserve soil organic matter (Hepperly 2007).

Despite their negative impact on climate change and the substantial hazards they pose to human health and the environment, as previously noted, researchers have estimated that crop losses would double without the use of pesticides (Saravi and Shokrzadeh 2011). Indeed, pesticide use may increase the number of times each year a crop can be grown on the same land, which is particularly important in countries that face food shortages (WHO Fact Sheet 2022). Successful pest management can also reduce indirect GHG emissions by avoiding the need to convert additional land for agriculture (Hughes et al. 2011). Land use change, especially the conversion of forests for agricultural production, is a leading driver of deforestation.

6.4 REDUCING GREENHOUSE GAS EMISSIONS IN PEST MANAGEMENT PROGRAMMING

Given the diversity of pest management tactics, including vast local and indigenous agricultural knowledge, location specificity, and the challenge of climate change-induced disruptions, a practical way for program designers, managers, and implementing partners to mitigate the GHG impacts of a pest management program is to prioritize approaches that lower emissions and enhance removals.

GHG emissions can be reduced using pest management methods and strategies such as (USAID 2009a):

- **Reducing pesticide use**. Ceasing overapplication (excessive amounts or numbers of applications), ensuring that application is within the pesticide's degradation time frame and coincides with when the pest is present, and avoiding application when adverse weather conditions are likely to disperse the pesticide will decrease use. Such efforts will support pesticide effectiveness. Minimizing the use of farm machinery that burns fossil fuels and selectively applying pesticide only when an action threshold is reached, such as a certain pest density, will also reduce GHG emissions. Coupling an action threshold with biological measures leveraging natural pest enemies has been shown to reduce pesticide use. Coupling fungicide use with resistant cultivars to control foliar disease has been shown to reduce the GHG emission intensity of each unit of winter wheat produced (Berry, Kindred, and Paveley 2008).

- The **cultural pest control** "push-pull" approach described above uses knowledge of the pest species' preferences and dislikes to simultaneously attract stemborer moths to the edge of the field while repelling them from maize by intercropping a legume. There would be GHG emissions associated with producing, transporting, and planting the non-maize plants but would avoid pesticide related GHGs. Most of the additional carbon dioxide captured by the perimeter and intercropped plants would be released once the plants decompose (Ontl and Schulte, n.d.) but the legume's ability to supply nitrogen typically fosters plant productivity

(Marquard et al. 2009) and increases soil carbon sequestration capacity (Diekow et al. 2005) . To the extent that this reduces the need for fertilizer, emissions from inputs of synthetic fertilizer, animal manure, or other potential emission sources would be reduced.

- **Mechanical methods** that physically prevent access to or remove pests from plants such as using a greenhouse to bar pests from entry, or the use of sticky traps, would not generate GHG emissions through their use. From a lifecycle GHG accounting perspective, emissions from the production and transport of construction materials and supplies, and their disposal, would be included. Methods that produce a certain temperature or humidity level or sound to make the environment less hospitable to pests such as using fans to aerate grain to reduce humidity and deter pests and mold is costly from an energy standpoint (Feed & Grain 2020). However, GHG emissions could be avoided if the fans were powered by renewable energy.

The GHG emissions from **biological pest control** such as mass-producing natural predators or developing strains of bacteria to hamper reproduction, would be concentrated upstream of field deployment. The same would be true for **genetic control methods** such as propagating sterile or genetically incompatible pests, and the use of **natural chemicals** such as attractants, repellents, sterilants, or growth inhibitors. The emissions magnitude would likely depend on factors specific to the

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Overall, the climate change impact of pest management can be reduced by using practices that maximize plant diversity and soil organic matter. For example, planting cover crops provides habitat for beneficial species and can be more effective at pest control than insecticide use while reducing soil erosion and nutrient loss and enhancing soil health (Gill 2022). Crop rotation avoids the build-up of pest populations by replacing host plants with other plants that are not susceptible to the same pest. This also avoids the large build-up of disease pathogens that survive from year to year. Planting native species reduces pest outbreaks because they have co-evolved with native pests and can take advantage of natural predators. Using biochar – a soil amendment derived from agricultural and other organic waste – helps suppress plant pathogens and insect pests, improve soil fertility, increase plant response to soil pathogens, and improve habitat for beneficial soil microbes. It is utilized to sequester carbon in soil, and if produced from agricultural wase, it reduces the burning of crop residues, a major source of agricultural GHG emissions.

Many of these methods are associated with IPM but are not exclusive to it. Climate-smart agriculture, of which CSPM is a part, goes further in defining an approach to focus IPM methods on adapting to climate-induced change and recognizing the potential of pest management to mitigate climate change. It aims to reorient entire agricultural systems to support development and food security in a changing climate by providing focused pest management guidance. It identifies support needed from research and extension services such as pest risk forecasting and climate information and projection and describes an enabling environment with key roles for the public and private sectors, such as policies and incentives and financial services. CSPM guidance for producers covers both continuous, long-term and proactive practices that build resilience of the farm and surrounding landscape, i.e., climate and pest monitoring, pest prevention, and agroecosystem management. It also includes occasional, short-term, reactive practices to control pests, namely cultural, mechanical, biological, and chemical control methods (Heeb, Jenner, and Cock 2019).

rearing facility, laboratory, or production facility, such as its heating and cooling efficiency and distance from the field.

See Table 6 below for a summary of GHG emissions with pest management activities and associated mitigation measures.

TABLE 6. GHG EMISSIONS ASSOCIATED WITH PEST MANAGEMENT ACTIVITIES

TYPE OF PEST MANAGEMENT ACTIVITY	GHG EMISSIONS SOURCES	GHG EMISSIONS REDUCTION AND SEQUESTRATION ENHANCEMENT OPPORTUNITIES
Pesticide use	Pesticides contribute to climate change throughout their production, transport, and application. During the manufacturing process, carbon dioxide, methane, and nitrous oxide are emitted. Pesticide application produces ground-level ozone and can impact soil microorganisms and in a way that increases the production of nitrous oxide in soils. Using farm machinery that burns fossil fuels to apply pesticides also generates emissions. Pesticides degrade into carbon dioxide, ammonia and other substances. This results in emissions of CO2 and ammonia (NH3). NH3 can be converted to nitrous oxide when deposited in soil. Pesticide waste such as from stockpiles of obsolete pesticides and disposal methods such as burning emits GHGs.	Replace pesticides with other forms of pest control. Reduce pesticide use by establishing action thresholds, combined with biological or other control methods. Support practices that reduce carbon loss, increase carbon input, or both such as planting cover crops. Use climate-smart pest management strategies, such as biological methods (e.g., increasing beneficial insect populations that are natural enemies to pests); mulching; mechanical (i.e., manual) removal of weeds and other pests. Deploy Indigenous and local farming knowledge to expand the arsenal of location-specific pest management tactics. Reduce avoidable yield losses and rationally use agricultural inputs, which reduces GHG emissions intensity per unit of food produced.
Integrated Pest Management and Climate Smart Pest Management	Lifecycle emissions associated with cultural, mechanical, biological, chemical pest control methods such as producing, transporting, and	Consider how to lower emissions from production facilities and laboratories, e.g., work with local ones to minimize transportation GHG emissions, and encourage facilities to be

TABLE 6. GHG EMISSIONS ASSOCIATED WITH PEST MANAGEMENT ACTIVITIES		
	disposing of plants, insects, chemicals, and other materials.	energy efficient and to use renewable energy if possible. Prioritize use of native plant species and legumes that are effective at managing pests. Employ proactive pest prevention practices that maximize plant diversity and soil organic matter such as using cover crops, crop rotation, native species, and biochar.

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ANNEX A: PESTICIDE CONSIDERATIONS

WHEN TO CONSIDER USING PESTICIDES

Safer pesticide use promotes the principle that all options of pest management should be considered, tested, and integrated into strategies for sustainable and environmentally sound crop production. Pesticides are considered a tool, especially in short-term or emergency situations. However, only when less ecologically disruptive methods are unavailable, should pesticides be considered. The wide variation of pest management methods available enables farmers to use or not use pesticides for pest management. Within the practice of IPM, a long-term view with pest solutions being a combination of methods is preferred over the reactive solutions of a short-term view.

The most important factor to consider is the health and safety of those using the pesticides. The use of protective equipment does not necessarily mean that pesticides are safely being used. Depending on the geological location of the farm and the scale of the production, protective equipment might not be used properly. When safety measures are applied poorly, users could allow pesticides to accumulate in clothing and masks when not washed between uses. Improper use of pesticides can have unintended consequences for the health of the user and the environment.

PESTICIDE TRANSPORT AND STORAGE

To avoid unnecessary health and environmental risks, safe handling principles should be followed when transporting pesticides. Before transport the pesticides should be placed in another container or bag, secured and tightly sealed before departure to prevent spillage. Pesticides should never be transported with persons or animals or where they could come into contact with groceries, livestock feed, seed or other products, as they might become contaminated. Before departure, the transporting surface should be checked for any nails, bolts, screws or other sharp objects that could damage the pesticide container. During transport the pesticides should be kept where people are the least likely to be exposed to them, away from any passengers. Upon arrival the pesticides should be stored at the destination where the pesticides will be used. If that is not possible, close to the destination.

A management system should be used to record the date of arrival at the storage facility, date when the pesticide is used, and how long the pesticide stays in storage. Pesticides can have different storage requirements and need to be tested periodically to ensure that the active ingredient is as described on the label and that formulation concentration is correct. This information should be posted and be known by management staff. New staff should be informed of the transport and storage guidelines.

A good storage facility would be fenced (thorn-branch will do if other materials are unavailable or too expensive) and offer a covered area for the pesticides. Before the rainy season, pesticides must be moved to the crop protection service's base, as transporting the pesticides can become more difficult when the weather conditions change. If no village storage is available, farmers may decide to store pesticides on their farms. They should be storing pesticides in accordance with the principles in this chapter. A facility that stores pesticides should:

- be secure against illegal entries, as well as children and livestock, and locked when not in use;
- be constructed in a site not exposed to flooding during rainy season;

- be isolated from dwellings, to avoid fire, leakage and water contamination;
- be supplied with water, to clean spills and fight fires;
- be well ventilated (aerated) to avoid concentration of toxic fumes;
- have a current inventory list of pesticide stocks;
- have protection gear such as suits, boots, gloves, goggles and breathing masks;
- have a first aid kit with antidotes; and be serviced by trained personnel familiar with measures to take in cases of poisoning.

The following considerations when storing pesticides are of vital importance:

- The pesticides must be kept dry; if they get wet, they lose their power to control pests. Therefore, the roof should be waterproof (zinc sheeting is good), and pesticides should be placed on a shelf or pallet—never directly on the floor or ground.
- Plants should not be allowed to grow around the storage area, because they will attract domestic animals to feed. Animals can be poisoned by eating plants that have been contaminated with pesticides.

PESTICIDE DISPOSAL

Empty pesticide containers must be destroyed and should not be reused, as that could pose extreme danger to the surrounding people or the environment. Consulting the pesticide label on the container or the manufacturer's representative is advised, as different pesticides may have specific recommendations regarding container cleanup and disposal. Even after thorough cleaning the empty containers are still not safe to use for other purposes. It is best practice to break any glass containers and puncture any plastic or metal containers. Containers should then be buried in an isolated area, at least 50 cm below ground surface (USAID 2009b).

1. Below are general guidelines to help with cleaning and disposal of pesticide containers. The following steps are to be taken, followed by one of basic methods that is most applicable to the situation and available resources. Turn container upside down and allow to drain into the spray tank for at least 30 seconds.
2. Add water to the container and rotate it well to wet all surfaces.
3. Drain it again into the spray tank as an additional dilutant.

Triple Rinse Method: Add a measured amount of water or other specified dilutant so the container is one-fifth to one-fourth full. Rinse containers thoroughly before pouring it into a tank. Allow to drain for 30 seconds. Repeat three times. The water rinsate (rinsewater) can be reused to mix with or dilute more of the same pesticides, or it can be sprayed on the target crop.

Pesticide Neutralization Method: Pesticide Neutralization Method: Empty organophosphate and carbamate containers can be neutralized by washing with alkaline substances, though the wash water and rinsate are still dangerous.

For large containers (200-liter barrels) the following procedure is recommended. Use proportionally less material for smaller containers:

1. Add 20 liters of water, 250 milliliters of detergent, and one kilogram of flake lye or sodium hydroxide.

2. Close the barrel and rotate to wet all surfaces.
3. Let stand for 15 minutes.
4. Drain completely and rinse twice with water. The rinsate should be drained into a shallow pit in the ground located far away from wells, surface water or inhabited areas.

OBSOLETE PESTICIDES

Obsolete pesticides are those that are no longer authorized for use because of expiration, degradation of product, labeling or packaging, or banned status as per country standards. Major problem with obsolete pesticides is that they are not properly stored and, in some cases, vulnerable groups such as children have access to them. Use of them is to be highly discouraged since chemical compounds degrade more dangerously over time and thus, proper disposal techniques should be addressed as well as utilizing Obsolete Pesticide Centers that specifically deal with hazardous waste of unused pesticides. (USAID 2009b)

ILLEGAL PESTICIDES

Illegal pesticides, also referred to as fraudulent pesticides, include those that are counterfeit, fake, unauthorized, or obsolete. Counterfeit pesticides are illegal copies of a branded, legitimate pesticide. They may have high quality packaging and labeling making it very difficult to differentiate them from a legal product. Fake pesticides may contain water colored with molasses, talcum powder or diluted or outdated pesticide, often have poor packaging and can be more easily distinguished from the real thing. Unauthorized pesticides are those which are sold in a country in which they are not authorized for use. Obsolete pesticides are those which are no longer authorized for use in a country due to degradation of product itself or deterioration of labeling or packaging.

Illegal pesticides are a growing worldwide problem, with 15% of products in global trade thought to be illegal. The issue is particularly acute in developing countries where it is estimated that 30% of pesticides are illegal (UNICRI 2016). China and India are by far the largest producers of counterfeit pesticides globally, together accounting for 50% of counterfeit pesticides (Bayoumi 2021). In Africa, most production of illegal pesticides occurs in Egypt, West Africa, Uganda, and Tanzania (Guyer 2017). Other countries involved in illegal pesticide manufacture include Malaysia, Indonesia, Turkey and Ukraine (FCEC 2015).

A major driver of trade of illegal pesticides is the high profit margin associated with this criminal activity, and demand for low cost products. Developing, testing and registering a new pesticide costs an average of $286 million and takes an average of 11 years (McDougall 2016). According to the Federation of Indian Chambers of Commerce and Industry (FICCI 2015), the margins on illegal pesticides can be as high as 25-30%, compared to 3-5% for legitimate products. Farmers may knowingly choose counterfeit products simply because they are much less expensive than the genuine product.

Impacts of illegal pesticides

- The health of applicators of illegal pesticides (farmers, ranchers, vector management personnel) is endangered. Illegal products have not gone through the registration process and may contain unknown toxic impurities.

- The products may not provide protection against the target pest(s) and therefore farmers or other users will suffer losses due to the lack of efficacy of the product. Additionally, the illegal products may cause harm to a crop or livestock.
- Residues of unknown and untested substances may compromise the health of consumers of crops treated with illegal pesticides. Moreover, residues may affect the marketability of crops for export.
- Harm to the environment. The products are untested for environmental safety and can contain highly toxic impurities. Unregulated use can compromise the quality of ground water and surface water, can negatively affect natural habitats of local flora and fauna, and can leave residues in soil that could be detrimental to subsequent crops.
- Illegal pesticides defraud governments through lost taxes from the sale of genuine products.
- Finally, illegal pesticides negatively affect the profits of companies that produce legally registered products.

PESTICIDE RESISTANCE

Pest resistance to pesticides is increasingly common as pesticide usage increases. In 2022, it was estimated that 586 arthropod species (insects and their relatives) worldwide had resistance to at least one insecticide (Sparks and Nauen 2015), and at least 267 weeds are resistance to herbicides (Heap 2023). Resistance occurs when a few individuals in a population are resistant to a particular pesticide. When that pesticide is applied to the population, most individuals are killed but those with the resistance trait survive and reproduce, passing the trait along to their offspring. Over time, a larger proportion of the population is represented by resistant individuals. Resistance is managed by minimizing pesticide use, rotation of pesticides and using a mixture of pesticides rather than relying on a sole active ingredient.

GM crops are not immune from resistance problems, particularly those relying on a single gene. As of 2016, there were 16 cases of insect resistance to crops engineered with genes from Bacillus thuringiensis (Bt) (Tabashnik and Carrière 2017). A primary strategy to combat the development of resistance is to 'pyramid' resistance genes, by adding two or more Bt genes that produce different toxins into a crop. A second strategy, referred to as 'high dose – refuge strategy', requires the engineered crop to express high levels of a toxin, and planting a susceptible crop nearby. Resistant insects developing in the Bt crop will be able to mate with susceptible individuals that have developed in the refuge crop, thus depressing the chances for matings between resistant individuals.

MIGRATION FROM TARGET AREAS TO NON-TARGET AREAs

It is estimated that less than 0.1% of pesticides applied reach their target organism, meaning that approximately 99.9% of pesticides applied remain in the environment (Pimentel 1995). Once pesticides are applied, they can migrate from their application area through a range of processes, such as sticking to the soil (adsorption), or entering the water cycle through leaching, vaporizing/volatilization, and surface water runoff (See Figure 4). These processes can lead to the movement of pesticides to non-target areas – areas where the pesticide application is not intended and may cause damage to non-target organisms. Depending upon the local environmental conditions and the specific pesticide applied, pesticides can remain active in the environment for a few hours up to decades until they degrade into biproducts, which may be more or less toxic than the original pesticide (National Pesticide Information

Center (NPIC) 2015). As described in further detail below, pesticide contamination in the environment can negatively impact aquatic and terrestrial ecosystems, kill crops, and harm humans.

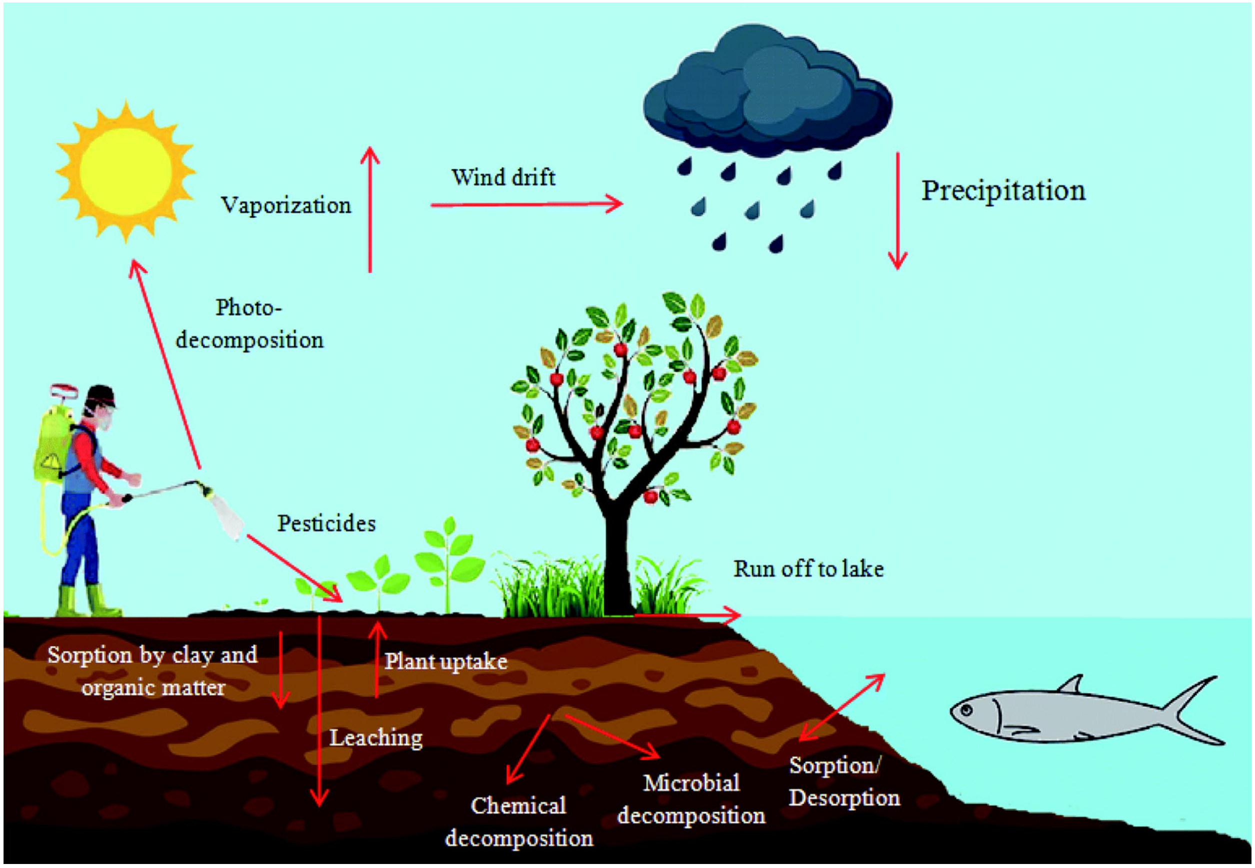

Figure 4. Schematic view of pesticides in an environment (Pirsaheb and Moradi 2020)

Volatilization/Vaporization

The major pathway for pesticide migration from target areas is through volatilization or vaporization (e.g. when a solid or liquid pesticide becomes a gas) (Tudi et al. 2021; USGS 2023). Pesticides that have been volatilized and become airborne can be carried from their treated surfaces to non-target destinations via air currents. There are multiple pathways through which pesticides can be volatilized or vaporized. The first is based on environmental conditions where higher vapor pressure, temperature or air movement, as well as a low relative humidity increase pesticide volatilization rates (Connell 2005). The second is through plants, where pesticides dissolved inside the plant can be volatilized through plant transpiration, as plants release water vapor from their leaves into the air. Pesticide droplets can become vaporized during application, commonly called "spray drift". In some countries pesticides may be applied via Unmanned Aerial Vehicles (UAV) at low volumes. Although there are benefits to this pesticide delivery method, it also results in spray drift, which can affect areas adjacent to agricultural fields.

Regardless of the pathway to volatilization, once pesticides are vaporized, they can be carried far from their original application location through wind, or they can enter the water cycle and be distributed through precipitation. For example, when air currents pick up volatilized pesticides, they can land on surface water, entering the water cycle, or land in terrestrial environments, causing environmental pollution (Tudi et al. 2021). Pesticides in atmospheric water can be returned to the ground from rain, or volatilized pesticides can be deposited back to the ground via dry deposition. Surface water, including lakes, streams, rivers, reservoirs and estuaries, act as small captive sinks and are therefore vulnerable to accumulation of pesticides from volatilization (Rajmohan, Chandrasekaran, and Varjani 2019).

Surface Runoff

Runoff is another major pathway for pesticide contamination of surface water (see Figure 5). Runoff occurs when there is more water than can be absorbed by the soil, creating an excess of surface water which runs off the field (Tudi et al. 2021; Delcour, Spanoghe, and Uyttendaele 2014). Surface water can be contaminated with pesticides through multiple pathways including, leaching from treated fields, mixing and washing sites, and waste disposal areas. Once pesticide residues leach into groundwater, they can spread throughout the water cycle potentially resulting in wide distribution (see Figure 5 for pesticide movement through the water cycle). Examples of pesticide distribution of surface run off through the water cycle include seepage through soil, and runoff into streams, ponds, lakes and wells, negatively impacting plants, humans and wildlife. Polluted surface water may also be transported over long distances contaminating irrigation water, drinking water for livestock and humans and recreational water. For environmental impacts of runoff see the "Environmental Impacts of Pest Management" section.

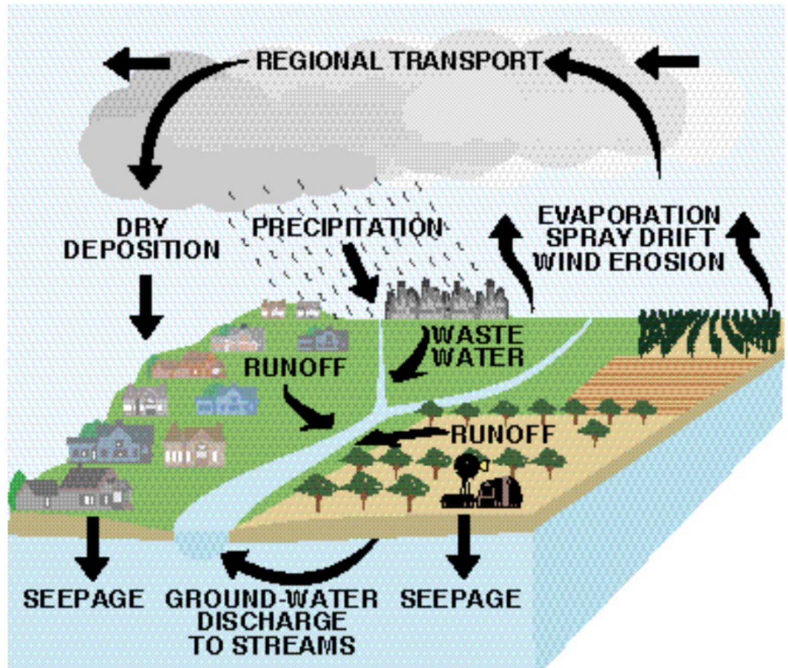

Figure 5. Pathways of pesticide movement in the hydrologic cycle. From https://pubs.usgs.gov/fs/1995/0152/fs15295_hydrologic.html

Leaching

Pesticides applied to target areas can migrate in water through the soil (also called leaching) resulting in groundwater pollution. The key environmental factor influencing the potential of leaching of pesticides into the soil is precipitation, as it further increases downward leaching of pesticides groundwater (Tudi et al. 2021). Other factors that influence pesticide leaching rates include soil texture, soil permeability, pesticide solubility and pesticide degradation rates (Tudi et al. 2021; Bošković et al. 2020). Specifically, sandy soils with high levels of permeability result in faster leaching rates and highly soluble pesticides with slow degradation rates result in higher pesticide concentrations in soil leachate. For environmental impacts of leaching see the "Environmental Impacts of Pest Management" section.

SOIL ADSORPTION

Pesticides applied over soils, such as herbicide application on weeds, also results in herbicide application on the soil under the weeds. This can result in severe soil pollution through adsorption, a process where pesticides essentially stick to soil particles (Xue et al. 2006). Agricultural soils, particularly those that are rich in organic matter and clay, are particularly prone to adsorption due to their greater particle surface area (Bošković et al. 2020). Dry soils also absorb more pesticides than wet soils. In addition to contaminating soils, wind erosion of soils can result in pesticide contaminated soils being distributed into waterways and other terrestrial environments. For environmental impacts of soil adsorption see the "Environmental Impacts of Pest Management" section.

Degradation Pathways And Metabolites

Once applied, pesticides begin to break down (also called degrade) into smaller molecules known as metabolites. Degradation can occur through multiple pathways including chemical (processes which do not include living organisms) or biochemical (processes which do include living organisms). Pesticide degradation rates depend on four key factors, 1) the chemical composition of the specific pesticide used; 2) environmental conditions, such as temperature, humidity, sunlight and soil PH; 3) the local ecosystem, including soil and soil bacteria and fugus composition; and 4) the interaction between factors one through three (Pathak et al. 2022).

In terms of chemical composition, some pesticides are more persistent than others. The degradation rate of pesticides is called the half-life, the time in which it takes for half of pesticide to degrade. (See also npic.orst.edu/factsheets/half-life.html for more information) Generally speaking, a more complex chemical structure will degrade slower than those with a simpler structure (Pathak et al. 2022). The interaction between chemical composition and environmental conditions can also affect degradation rates; some pesticides degrade more rapidly under warm and moist conditions, while others may remain more stable under certain PH levels. Similarly, some pesticides are degraded more quickly by specific soil microbes than others (Huang et al. 2018).

Much like the pesticide itself, pesticide degradation products vary in persistence and toxicity. Generally speaking, metabolites are typically more water-soluble and less toxic than the original pesticide. Degradation products may have little to no toxicity (Eerd et al. 2003). However, some pesticides, like chlorpyrifos, degrade into a more mobile and toxic metabolite than the original pesticide itself (Tudi et al. 2021). Also, like pesticides, metabolites can be transported through the environment via adsorption, leaching, volatilization, or surface runoff, which can result in negative environmental impacts (Pathak et al. 2022).

ANNEX B: STRATEGY FOR INTEGRATED PEST MANAGEMENT (IPM) PLAN DEVELOPMENT

This Annex is intended to provide Implementing Partners (IPs) and program participants with a foundation for the development of an activity-level Integrated Pest Management (IPM) scheme including present key steps for implementing an IPM strategy and an illustrative example of IPM strategy development. IPs are encouraged to use this document as a resource when developing an IPM strategy based on local conditions.

The document defines IPM and provides a stepwise approach to developing an IPM plan, including an example of how each step can be performed to develop an IPM strategy to manage a European corn borer (ECB) infestation.

The example IPM framework provides the risks posed by ECB, as well as physical, cultural, biological, and chemical control measures. Please note that the IPM strategy for ECB is included as an example only. In practice, IPM strategies recommendations are not made in this guide, and specific pest control measures must be assessed considering activity-specific context.

IPM focuses on long-term prevention of pests and their damage. It is USAID policy to apply the principles of IPM to every activity that involves or influences pesticide procurement or use (USAID 2009a). Control methods found to be effective and that pose lower risk to human health and the environment should always be selected first. Synthetic pesticides should only be used as a last resort.

DEFINITION AND STEPWISE APPROACH

IPM is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices (USEPA 2023a). IPM is not a single pest control method but rather involves integrating multiple control methods (e.g., non-chemical and chemical)[9] based on site-specific information obtained through inspection, monitoring, and reporting. IPM takes advantage of all appropriate pest management strategies (i.e., monitoring methods, preventive methods, and control methods) and considers pesticide application after non-chemical measures have been implemented and have not yielded positive pest control results.

Consequently, every IPM program should be designed considering the pest prevention goals and eradication needs of the situation (USEPA 2023b). Pesticide use in USAID Activities should only be done as part of an IPM program.

Successful IPM programs follow a four-tiered implementation approach:

1. **Establish Action Thresholds**
   The first step in developing an IPM plan is establishing an "action threshold" of pest damage that is great enough to justify implementing pest control measures (USAID 2009a). The presence of a few pests does not always mean pest control is needed.

   When establishing an action threshold, the following should be considered:
   - Is the amount of pest damage or pest presence posing an economic threat?
   - Has the level at which pests become a health hazard been reached?
   - Action thresholds should be quantitative. For example, thresholds can be based on:
     - Average number of pests captured each week
     - Percent of leaves or plants damaged or infested based on visual inspection (UC IPM 2021)

[9] Non-chemical control measures include, but are not limited to, clean plowing and adjusting planting and harvest time. Chemical control measures include, but are not limited to, lowering water pH and applying pesticides.

Pest control measures should not be implemented before the action threshold is reached.

Box A1 below provides an example of how an action threshold can be developed for ECB.

BOX A1. ESTABLISHING ACTION THRESHOLDS FOR ECB

In this scenario, action thresholds are based on achieving 95 to 100 percent of harvested corn product that is clear of pest damage.

Potential action thresholds include:

- **Prior to the growth of tassels and through the emergence of green tassels:** If 15 percent or more of corn plants show recent damage or contain one or more ECB caterpillars, the action threshold has been reached, and pest control measures should be implemented.
- **During the formation of corn silk:** If traps capture more than twelve ECB moths per week during silking, more than one week from harvest, the action threshold has been reached, and pest control measures should be implemented (Hazzard, Brown and Westgate 2008).

2. Monitor and Identify Pests

Not all pests require control. Many pests are not harmful, and some are even beneficial. In conjunction with action thresholds, correct pest identification is key to:

- Determine the best preventive measures
- Prevent the elimination of beneficial organisms
- Reduce the unnecessary or incorrect use of pesticides

Monitoring pest populations is important to determine if an action threshold has been reached, preventing the use of control methods when they are not needed (USEPA 2023a). IPM plans should be updated in response to monitoring results.

If an action threshold has been reached and control measures have been implemented, the pest infestation should be monitored to determine whether levels of pest prevalence and damage have fallen below the action threshold and control measures can cease.

Box A2 below provides example monitoring strategies for ECB.

BOX A2. MONITOR AND IDENTIFY EUROPEAN CORN BORER

The portion of the corn plant scouted for ECB varies prior to tassel emergence and after tassels have emerged. Monitoring strategies for these phases of corn growth are as follows:

- **Prior to the growth of tassels and through the emergence of green tassels:**
    - Stop at five spots in the field, pull 20 whorls, look for the characteristic "shot hole" leaf feeding damage and larvae in the whorl, and count any live larvae found when unrolling the whorl.
    - Calculate the percentage of plants damaged and/or infested. For example, 27 plants damaged and/or infested among the 100 plants (20 plants × 5 spots) means that 27 percent of the stand is affected.
    - Compare percent of damaged plans
- **During the formation of corn silk:** Check traps for more than twelve ECB moths per week during silking, more than one week from harvest to check whether the action threshold has been reached (Hazzard, Brown and Westgate 2008).

3. Prevention

Prevention – removing conditions that attract pests – is an IPM program's first line of defense. Prevention includes taking steps to ensure that pest populations do not build up to economically damaging levels.

Preventive methods can be very effective and cost-efficient and present little to no risk to people or the environment (USEPA 2023a).

Among others, preventive actions include:

- Selecting pest-resistant varieties
- Strategic planting and crop rotation
- Water management and optimization of plant nutrition

Box A3 below provides examples of preventative measures for ECB.

BOX A3. EUROPEAN CORN BORER PREVENTION

Weed Control

- Keep cornfields relatively free of dense weed, where moths seek shelter during the daylight hours.

Resistant Varieties

- ECB can be managed with *Bacillus thuringiensis* (Bt) corn hybrids. These genetically modified corn hybrids contain a gene derived from a naturally occurring bacterium, Bacillus thuringiensis, which produces a protein that is toxic to ECB (Purdue University Extension 2017).

Please refer to TABLE A1. INTEGRATED PEST MANAGEMENT FRAMEWORK FOR EUROPEAN CORN BORER for additional preventative measures.

4. **Control**

Once monitoring indicates that the action threshold has been reached and preventive methods are no longer effective or available, control methods can be employed. Control methods are evaluated on effectiveness and relative risk.

- Choose effective, less risky pest controls first:
  - Mechanical control, such as trapping or weeding
  - Highly targeted chemicals, such as pheromones to disrupt pest mating
- If less risky controls are not effective, additional pest control methods can be employed, such as targeted spraying of pesticides (USEPA 2023a).
- If using pesticides, least toxic pesticides should be selected for use first, and only PERSUAP approved pesticides may be used in USAID activities.
- Any pesticides used must be approved for the intended application (e.g., outdoor use), according to the pesticide label.
- Rotation of modes of action (i.e., class of pesticide) should be considered to avoid development of pest resistance.

Box A4 below includes example preventative measures for ECB.

BOX A4. EUROPEAN CORN BORER CONTROL

Physical Control

- Stalk Management: Primary tillage such as chisel plowing or moldboard plowing in the fall can reduce overwintering populations.
- Soil and moisture conservation must be considered.

Cultural Practices

- Planting Time: early planting of resistant hybrids will result in minimum infestation.
- Early Harvesting: early harvesting will effectively reduce yield losses resulting from broken and lodged plants and dropped ears (Iowa State University Extension 1989).

Biological Agents

- The ECB is attacked by many natural enemies throughout its life.
- In non-outbreak situations, it is important to not apply chemical control measures unless the action threshold is reached so that the populations of beneficial insects will not be affected (Manitoba Agriculture 2018).

Pesticide Treatment

- Insecticides should only be applied when action thresholds have been surpassed.
- Broadcast spraying of non-specific pesticides is a last resort.

Included below is an example IPM framework for ECB that summaries and expands on the example IPM components in Boxes A1-A4 above. The strategy includes an overview of the pest, a description of crop damage caused by the pest, and a summary table (Table A1) of monitoring methods, and preventative and control measures. The list of active ingredients (AIs) included in the table is an example of AIs that could be used to allow for pesticide class rotation. This framework is solely intended to serve as an example, and PERSUAP requirements and activity-specific context must be considered when developing an IPM framework.

EXAMPLE IPM PLAN: EUROPEAN CORN BORER IN UKRAINE

PEST OVERVIEW

European corn borers (Ostrinia nubilalis Hbn.) feed on all types of corn and attack and damage hundreds of other economically important crops (e.g., millet, sorghum, soybean) (Purdue University Extension 2017). Broken tassels, collapsed stalks, feeding signs on leaves, and borings in stalks and ears are signs of the presence of ECB larvae (Eaton and Maccini 2016).

The ECB goes through complete metamorphosis and has four distinct life stages: egg, larva (borer or caterpillar), pupa, and adult (moth) (Rice and Hodgson 2017). There are two generations of ECB per year in Ukraine (Melnichuk, et al. 2022).

The ECB survives winter by entering a resting metabolic state, as mature larva in cornstalks, corn cobs, corn, residue, or weed stems. Development resumes when ambient temperatures exceed 10°C and moths emerge in early June. ECB moths lay their eggs on the underside of corn leaves, along the midrib. Egg masses are white and flat with individual eggs overlapping like fish scales (Rice and Hodgson 2017). Eggs hatch into larvae that feed on leaves, making "shot hole" damage pattern on corn leaves. Larvae initially feed on leaves and eventually bore into stalks. Mature larvae pupate in the cavities, and some emerge as adult moths to start the second generation in August (Eaton and Maccini 2016).

PEST DAMAGE

The ECB is a major maize pest in Ukraine. Between 0.5 million ha and 0.7 million (12 to 15 percent of the crop) is estimated to be annually affected that cause economic damage (Brookes 2015). Feeding by ECB larvae causes direct, physiological losses when stalk tunnels disrupt the movement of water and nutrients within the plant. Corn borer feeding can also produce indirect losses by providing entry points for ear and stalk pathogens. The tunnels in stalks and ear shanks create harvest losses due to stalk lodging and ear drop (University of Minnesota Extension 2020).

TABLE A2. INTEGRATED PEST MANAGEMENT FRAMEWORK FOR EUROPEAN CORN BORER

MONITORING METHODS:

- Regularly survey and scout pests, natural enemies, damaged crops, and life cycle of pests.
- Know when ECB flight begins, reaches a peak, and ends in a given field to implement appropriate control measures.
- Determine the necessity for implementing controls and implement controls based on monitoring results.

NON-CHEMICAL PREVENTIVE METHODS:	NON-PESTICIDE CONTROL METHODS:	KEY ELEMENTS OF PESTICIDE TREATMENT[a,b]:	
		APPLICATION METHODS:	ACTIVE INGREDIENTS
Monitoring and scouting ● Effective preventive measures require an investment in monitoring: ○ Use traps (blacklight or pheromone-baited) to monitor ECB moth flights[c]. ○ Catches of adults in traps should initiate intensive weekly scouting for egg masses and for the signs of early damage from larvae (e.g., "shot holes" on leaves of maize)[d]. ○ Once the corn has reached the sixth-leaf stage, fields should be scouted weekly for the next two to four weeks to detect first-generation ECB infestations[e]. **Preventive practices** ● Keep fields free of weeds[f]. ● Fields with chronic ECB problems can be planted with the genetically modified *Bacillus thuringiensis* (Bt) hybrids, along with the corresponding refuge. ● Rotate crops in the field year after year. If crops cannot be rotated, consider a rotation of Bt traits to avoid resistance development[g]. ● If soil erosion is not a problem, remove overwintering larvae by removing crop debris in the fall and early spring[f].	**Physical** ● Place row covers shortly after crop emergence[f]. ● When harvesting, cut stalks as close to the ground and as early as possible. ● Plowing and stalk shredding. **Cultural** ● Planting time ○ Non-Bt plants should not be planted first or last. ● Early harvest ○ Early harvesting effectively reduces yield loss from lodged plants and dropped ears. **Biological[h]** ● Maintaining plant diversity in and around the fields to attract natural enemies. ● Release parasitic wasps (e.g. *Trichogramma ostriniaee, Trichogramma brassicae*) that attack the egg stage[c]. ● Release predators, such as minute pirate bugs and twelve spotted ladybeetles that prey on ECB eggs and young larvae[i].	**Critical periods[f]** ● Late whorl stage ○ When tassels just become visible down inside the whorl ○ Aim sprays into the whorl ● Fresh silk stage ○ Aim sprays at the silks **Action thresholds[j]** ● Based on an economic yield goal of 95 to 100 percent clean corn at harvest. ● Spray if more than 15 percent of plants have one or more larvae present or show fresh feeding damage[c]. **Foliar treatment options** ● Ideal time: just before or during tassel emergence but before silking[c]. ● Refer to product labels for proper use rates and spray timings. ● Scout again within a week after the first spray[c]. ● Be aware of the number of allowed applications of the product(s) being used per season. **Application equipment** ● Drop nozzles ● Small acreage ○ Backpack mist blower ● Moderate to large acreage Tractor-mounted boom sprayer	**Bioinsecticides** ● *Bacillus thuringiensis* ● *Beauvaria Bassania* **Chemical Insecticides** ● Acetamiprid ● Bifenthrin

[a] Pesticide controls should only be considered and pursued when other IPM measures have been applied and the prevalence of European corn borer is increasing and/or remains above the determined action thresholds. Pesticide controls may only be used if proposed pesticides have been analyzed in a manner consistent with 22 Code of Federal Regulations (CFR) Part 216 "Pesticide Procedures," and their proposed procurement and/or use has been subsequently reviewed and approved by USAID for the proposed uses. Pesticide classes (e.g., pyrethroids) should be rotated to avoid pest resistance.

[b] Pesticides must be applied (e.g., outdoor use, application method) according to pesticide label and using appropriate equipment.

[c] Organic Insect Management in Sweet Corn (Hazzard and Westgate 2005)

[d] Pest of Economic Importance in Ukraine Integrated Pest Management Manual (FAO 2021)

[e] European Corn Borer: A Multiple-Crop Pest in Missouri (Boyd, Bailey and Rice 2022)

[f] European Corn Borer Pest Fact Sheet 17 (Eaton and Maccini 2016)

[g] European Corn Borer (A. Eaton 2009)

[h] Biological controls refer to the use of natural predators, parasites, pathogens, and/or competitors to control pests (UC IPM 2021).

[i] Crop Profile for Corn in Michigan (Johnson 2002)

[j] Using IPM in the Field - Sweet Corn Insect Management Field Scouting Guide (Hazzard, Brown and Westgate 2008)

[h] European Corn Borers (Purdue University Extension 2017).

ANNEX C: PEST MANAGEMENT POLICIES, PROCEDURES, AND FRAMEWORKS

USAID PROCEDURES, POLICIES, AND FRAMEWORKS

REG 216 (22 CFR 216) – USAID'S ENVIRONMENTAL PROCEDURES[10]

- **USAID Environmental Procedures -** Automated Directives System (ADS) 204 – How to apply 22 CFR 216 to the USAID assistance process (USAID 2020a)
- **Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP)** (USAID, n.d.-b)
    - "PERSUAPS are the protocol and document for addressing 22 CFR 216.3(b)(1)(i) of USAID's Pesticide Procedures, which requires that the IEE, EA, or EIS for any activity for which "assistance for pesticide procurement, or use, or both" is anticipated "include a separate section evaluating the economic, social and environmental risks and benefits of the planned pesticide use..." and specifies the 12 analytical factors that must be considered in this evaluation."
    - "Upon approval of the PERSUAP, the pesticide support activities covered by the PERSUAP are approved, subject to the following conditions: (1) only pesticides approved by the PERSUAP are supported; (2) support for these pesticides is limited to specific uses and geographies approved; and (3) enumerated safer use and IPM conditions are implemented and enforced. The pesticides approved and the attendant conditions all flow from the 12-factor analysis required by the regulation."
- **Environmental Impact Assessment (EIA)** (USAID, n.d.-b)
    - "The EIA tool is a guide for the implementation of environmental and social impact assessment. It is a simple checklist that takes you through the process and asks a series of questions that prompt you to examine if a specific resource, such as water, habitat or air or even communities and land tenure will be impacted by the project/activity. Annex A is the specific checklist. If you answer yes or "don't know" more analysis or baseline data is likely needed."
- **Initial Environmental Examinations (IEE)** (USAID, n.d.-b)
    - a "first review of the reasonably foreseeable effects of a proposed action on the environment. Its function is to provide a brief statement of the factual basis for a Threshold Decision as to whether an EA or an EIS will be required."
- **Requests for Categorical Exclusion (RCE)** (USAID, n.d.-b)
    - "The RCE is used when all proposed actions are eligible for categorical exclusion per 22 CFR 216.2(c). Such actions both belong (1) to the classes of actions enumerated in 22 CFR 216.2(c)(2) and do not individually or cumulatively have foreseeable significant [adverse] effect on the environment"
- **Environmental Assessment (EA)** (USAID, n.d.-b)
    - An EA is a detailed study of the reasonably foreseeable significant effects, both beneficial and adverse, of a proposed action on the environment of a foreign country or countries . USAID EAs must meet the requirements of 22 CFR 216.6.
- **Environmental Mitigation and Monitoring Plan (EMMP)**(USAID, n.d.-b)

[10] Reg. 216 (22 CFR 216) | Basic Page | U.S. Agency for International Development (usaid.gov)

    - "An EMMP translates IEE or EA conditions into specific mitigation measures (if the conditions are general); sets out indicators/criteria for monitoring the implementation and effectiveness of mitigation measures; and establishes timing and responsible parties. EMMPs are required almost universally by USAID EAs and by IEEs when one or more action covered by the IEE receives a Negative Determination with Conditions."
- **Climate Risk Management (CRM)** (USAID, n.d.-a)
    - Climate risk management (CRM) is required for nearly all USAID strategies, projects, and activities. USAID's CRM toolkit provides links to supporting resources, such as regional and country risk profiles, USAID's CRM tool (including the energy and infrastructure annex), real-world examples, and online trainings, and explains how to do CRM.
- **Environment and Natural Resource Management Framework** (USAID 2019)
- **Safeguard Requirements for Parks and Protected Areas** (Social)
- **Promoting the Rights of Indigenous People's Policy (PRO-IP)** (Social) (USAID 2020b)

INTERNATIONAL POLICIES, AGREEMENTS, AND FRAMEWORKS

FAO AND WHO PESTICIDE ASPECTS JOINT MEETINGS

- The Joint Meeting on Pesticide Management (FAO, n.d.-a)
  The FAO and WHO Joint Meetings on Pesticide Management (JMPM) Memorandum of Understanding was signed in 2007. It was an agreement between the WHO and FAO on cooperation in a joint programme for the sound management of pesticides. Joint technical meetings, in which the strengthening of areas within pesticide management are discussed, are held once per year.
- The Joint Meeting on Pesticide Specifications (FAO, n.d.-c)
  The FAO and WHO Joint Meeting on Pesticide Specifications (JMPS) is a statutory body of FAO whose Panel Members are experts on Vector Biology and Control, appointed by WHO. The primary function of the JMPS exists to make recommendations to the FAO and/or WHO on the adoption, extension, modification, or withdrawal of specifications, as well as to develop guidance and procedures in establishing pesticide specifications and equivalence determination which has also its relevance to the registration and quality control of pesticide in national or regional authorities.
- The Joint Meeting on Pesticide Residues (FAO, n.d.-b)
  The FAO and WHO Joint Meeting on Pesticide Residues (JMPR) is an expert ad hoc body administered jointly by FAO and WHO with the purpose of harmonizing the requirements and the risk assessments on pesticide residues. It provides independent scientific expert advice to its specialist Committee on Pesticide Residues as well as to FAO, WHO and member countries. It also provides advice to the Codex Alimentarius Commission (CAC), a collection of standards guidelines and codes of practice to protect consumer health and ensure fair practices in the food trade.

The International Code of Conduct

The International Code of Conduct on pesticide management provides a comprehensive framework that guides government regulators, the private sector, civil society, and other stakeholders on best practices in managing pesticides throughout their lifecycle. It covers every aspect of pesticide management from production to disposal (FAO and WHO 2014). Objectives of this Code include:

- Establishing voluntary standards of conduct.
- Addressing governments, international organizations, industries that use or have an interest in pesticides, pesticide users and public-interest groups.
- Assisting in determining acceptable practices within the context of national legislation.
- Achieving necessary and acceptable use of pesticides without significant adverse effects on human and animal health and/or the environment.
- Addressing the need for cooperative effort between governments of pesticide exporting and importing countries to promote practices that minimize potential health and environmental risks associated with pesticides, while ensuring effective use.
- Recognizing training at all appropriate levels is an essential requirement in implementing and observing its provisions. Entities addressed by the code should give high priority to relevant training and capacity building activities related to each Article of the Code.
- Proposing standards that encourage:

THE ROTTERDAM CONVENTION

The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade is an international treaty to promote shared responsibility and cooperative efforts by the participating countries regarding international trade in hazardous chemicals. The participating countries seek to protect human health and the environment from potential harm and contribute to the environmentally sound use of hazardous chemicals and pesticides. The treaty facilitates this by establishing a list of covered chemicals and the corresponding safety information. Parties seeking to export a chemical on that list are required to first establish that the intended importing country has consented to the import (FAO, n.d.-e). The Convention has 161 member parties. The United States is not a member and participates in the Convention as an observer. The Rotterdam Convention has been effective as of February 2004 (UNEP 2010).

The Stockholm Convention

The Stockholm Convention on Persistent Organic Pollutants is an international treaty that aims to protect human health and the environment from the chemicals known as persistent organic pollutants (POPs) that are toxic to humans and wildlife. POPs have the potential to remain intact in the environment for longer periods and even accumulate in the fatty tissue of living organisms as they become globally distributed in the environment. The treaty regulates 29 POPs of which some are known pesticides. The Stockholm Convention requires its parties to adopt a range of control measures to reduce and, if possible, eliminate the release of POPs. The Convention has 186 member parties. The United States is not a member. The Stockholm Convention has been effective as of May 2004 (UNIDO 2022).

THE BASEL CONVENTION

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal is an international treaty that aims to protect human health and the environment against the adverse effects of hazardous wastes by controlling the international trade in hazardous wastes and certain other wastes. The treaty further aims to reduce hazardous waste and to promote environmentally sound waste management. The Convention has 188 member parties. Although the United States is not a member, there are bilateral agreements in place with the United States and separately Canada, Costa Rica, Malaysia, and the Philippines. The Basel Convention has been effective as of 1992. (U.S. Department of State, n.d.)

THE INTERNATIONAL PLANT PROTECTION CONVENTION

Overseen by the FAO and the UN, the International Plant Protection Convention (IPPC) is an international treaty that aims to protect the world's plants and plant products from the spread and introduction of pests, promoting safe trade. The Convention provides a framework and a forum for international cooperation, harmonization, and technical exchange between contracting parties. It's main tool to achieve its goals is the introduction of the International Standards for Phytosanitary Measures (ISPMs). There are currently 183 countries taking part in the Convention (FAO, n.d.-d).

PESTICIDE REGULATION IN DEVELOPING COUNTRIES

In many developing countries, there is a lack of proper pesticide control legislation including a lack of an approval/registration process for pesticides, lack of regulation on working conditions, and lack of post-registration monitoring. Part of the problem is attributed to the minimal capacity to advise on and enforce national laws and codes of conduct.

Governments should introduce legislation for the regulation of pesticides, their marketing, and use. such legislation should establish regulatory mechanisms such as permits for pesticide users and establish pesticide registration methods in which each pesticide product is registered before it is made available for use. The legislation should allow for re-evaluation and create a re-registration procedure to ensure that measures can be taken if new information on pesticides indicate that regulatory action is needed.