Environmental, Health, and Safety Guidelines for Annual Crop Production

Introduction

1. The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These industry sector EHS Guidelines are designed to be used together with the General EHS Guidelines document, which provides guidance to users on common EHS issues potentially applicable to all industry sectors. For complex projects, use of multiple industry sector guidelines may be necessary. A complete list of industry sector guidelines can be found at: www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines www.ifc.org/ehsguidelines.

2. The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities crop production areas by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities farming systems may involve the establishment of site-specific targets, with an appropriate timetable for achieving them.

3. The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment in which site-specific variables such as host country context, assimilative capacity of the environment, and other project factors are taken into account. The applicability of specific technical recommendations should be based on the professional opinion of qualified and experienced persons.

4. When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are appropriate, in view of specific project circumstances, a full and detailed

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1 Defined as the exercise of professional skill, diligence, prudence, and foresight that would be reasonably expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally. The circumstances that skilled and experienced professionals may find when evaluating the range of pollution prevention and control techniques available to a project may include, but are not limited to, varying levels of environmental degradation and environmental assimilative capacity, as well as varying levels of financial and technical feasibility.
justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

**Applicability**

5. The EHS Guidelines for Annual Crop Production include information relevant to large-scale, commercial production, harvesting, post harvesting processing and storage of the main annual crops, including cereals, pulses, roots and tubers, oil-bearing crops, fiber crops, vegetables, and fodder crops, located in both temperate, subtropical, and tropical regions. It does not include the processing of raw materials into semi-finished and finished products. Perennial crop production is addressed in the EHS Guidelines for Perennial Crop Production. Annex A contains a full description of industry activities for this sector. Plantation crops are addressed in the EHS Guidelines for Plantation Crop Production. Information applicable to the processing of crops is presented in the EHS Guidelines for Food and Beverage Processing. This document has the following sections:

This document is organized in the following manner:

- Section 1.0 — Industry-Specific Impacts and Management
- Section 2.0 — Performance Indicators and Monitoring
- Section 3.0 — References and Additional Sources
- Annex A — General Description of Industry Activities
- Annex B — Water Consumption
1.0 Industry-Specific Impacts and Management

6. The following section provides a summary of EHS issues associated with annual crop production, along with recommendations for their management. Additional guidance on EHS issues that may be common across industry sectors is presented in the General EHS Guidelines.

7. Farm management plans often serve as an underlying framework for the management of environmental and social risks and impacts for annual crop production. A farm management plan would normally cover, among other things, the risks and issues presented in this document.

1.1 Environment

8. Environmental issues in annual crop production primarily include the following:

- Soil Conservation and Management
- Nutrient Management
- Crop Residue and Solid Waste Management
- Water Management
- Pest Management
- Use and Management of Pesticides
- Fertilizers
- Biodiversity and Ecosystems
- Genetically Modified Crops (GM Crops)
- Energy Use
- Air Quality
- Greenhouse Gas (GHG) Emissions

Soil Conservation and Management

7.9. Physical and chemical degradation of soils may result from unsuitable management techniques, such as use of inappropriate machinery or earthworks associated with annual crop production may include the following: preparation and infrastructure development. Chemical degradation of soil may result from insufficient or inappropriate use of mineral fertilizers, failure to recycle nutrients contained in crop residues, and failure to correct changes in soil pH that result from long-term use of nitrogen fertilizers and excessive use of poor-quality water, resulting in salinization.

- Stress on water resources
10. Loss of biodiversity

Soil erosion may result from poor crop cover after land preparation and lack of soil conservation structures on sloping land planted with annual crops. Soil loss prevention practices include appropriate use of the following techniques:

- Practice reduced and zero tillage (often known as “low till” or “no till”), as well as direct seeding and planting, to minimize damage to soil structure, conserve soil organic matter, and reduce soil erosion. Consider contour and strip planting, terracing, intercropping with trees, and grass barriers in sloping areas.
- Minimize soil compaction, damage, or disturbance by using appropriate land preparation machinery at the right time of year.
- Consider a crop rotation program to maintain the soil coverage during the year.
- Manage soil organic matter by returning crop residues or adding compost and manures whenever available and economically viable.
- Plan soil preparation when weather conditions pose the lowest risk of causing environmental damage.
- Consider erosion management practices (e.g., contour and strip planting, terracing, discontinuous trenching, intercropping with trees, and grass barriers) in sloping areas.
- Draw up mitigation plans for planting or harvest operations that must take place during unsuitable periods.
- Plan and control the flow of water from access roads to avoid erosion from the roads’ diverted water. Use flow control weirs and diversion canals to reduce erosion in areas with field drainage.
- Restrict the width of roads to the minimum that will provide the means for efficient and safe transport.

11. The following approaches are recommended to maintain soil productivity over the long term:

- Cultivate crops that are
  - Crop residues and other solid waste
  - Atmospheric emissions

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Stress on Water Resources

1. Water management for annual crop production should aim to optimize crop yield, while conserving the quantity and quality of water resources. Surface or groundwater resources used for irrigation should be managed in accordance with the principles of Integrated Water Management consistent with the following recommendations:

- Determine the quantity and quality of water needed for crop production;
- Evaluate the capacity of groundwater or surface water resources and collaborate with national or regional institutions to ensure that the project considers existing or emerging plans for water management and monitoring;
- Select crops compatible with water availability;
- Maximize the use of available precipitation (“rain harvesting”), where feasible, by:
  - Reducing runoff by methods such as conservation tillage, terraces, and raised ridges that follow the land contour
  - Diverting water within the catchment area toward the crops themselves by diverting spate flow from wadis, directing runoff with low walls, and diverting flow toward crops from roads and paths to store water in the soil and reduce the effect of short dry spells
  - Storing runoff from rainy periods for use during dry spells by using tanks, ponds, cisterns, and earth dams
- Implementing irrigation water conservation measures including:
  - Reduce evaporation by avoiding midday irrigation and using trickle or drip irrigation techniques (if practical), or using ‘under canopy’ rather than overhead sprinkling
  - Reduce seepage losses in channels by lining them or using closed conduits
  - Control weeds on inter-row strips and keep them dry
  - Avoid over and under irrigation to decrease potential for soil salinization
  - Maintain border vegetation in canals and drainage systems
  - Maintain a water management logbook that records precipitation, rainfall, and evaporation, as well as time and amounts of water applied, in order to develop an understanding of long-term trends in water use

Soil Erosion and Loss of Productive Capacity

2. Soil degradation may result from poor management especially due to excessive use of machinery and over-intensive farming practices. Soil erosion may be enhanced by heavy rainfalls, storms, and steep or long slopes, and may contribute to subsequent sedimentation of surface water bodies. Soils should be managed so as to
prevention or minimization of loss of productive capacity and sedimentation of surface waters. Soil loss prevention practices include:

- Practice Integrated Nutrient Management (INM) to avoid nutrient depletion or accumulation;
  - Use crops suited or adapted to the local climate and soil conditions, and adopt good agronomic practices to optimize crop productivity.
  - Collect meteorological data on precipitation, evapotranspiration, temperature, and sunlight, then use this information to inform and guide agronomic management techniques.
  - Use soil maps and soil survey results to determine crop suitability and appropriate soil management practices.
  - Develop and implement a soil monitoring and management plan that includes soil and terrain mapping and erosion risk identification.
  - Conduct regular surveys to monitor soil structure and chemistry in order to identify areas where remedial action is required.
  - Recycle and/or incorporate organic materials (e.g., crop residues, compost, and manures) to replenish soil organic matter and improve soil water-holding capacity whenever available and economically viable.
  - Minimize the use of pesticides by implementing a pest and disease early-warning system, by using biological pest and disease control methods, and by implementing control measures before outbreaks require large-scale control.
  - Follow good practice irrigation guidance to avoid negative impacts on soil productivity.

- Nutrient Management in areas with steep slopes, carefully consider planting zones and the direction of planting in relation to land contours to avoid erosion caused by precipitation or irrigation:
  - Use stone barriers, vegetative cross-slope barriers, terraces, or drainage and diversion canals to prevent wind and water erosion.
  - Use appropriate machinery to avoid soil compaction caused by excessively heavy equipment.
  - Avoid the use of overly saline water for irrigation to prevent salinization.

4 More information can be found, for example, in the 2000 FAO Guideline on Integrated Soil and Nutrient Management and Conservation for Farmer Field Schools.
5 Food and Agriculture Organization (FAO), Good Agricultural Practices Principles, (2007). Among others, good practices include those that select cultivars and varieties on an understanding of their characteristics, including response to sowing or planting time, productivity, quality, market acceptability and nutritional value, disease and stress resistance, edaphic and climatic adaptability, and response to fertilizers and agrochemicals; that maximize the biological benefits of weed control by competition, by mechanical, biological and herbicide options, by provision of non-host crops to minimize disease; that apply fertilizers—organic and inorganic—in a balanced fashion, with appropriate methods and equipment and at adequate intervals to replace nutrients extracted by harvest or lost during production, and that maximize the benefits to soil and nutrient stability by recycling crop and other organic residues.
6 See FAO (1992), chapter 4 of The Use of Saline Waters for Crop Production, for a discussion of the suitability of water for irrigation purposes.
- Use plant cover or intercrops and shelterbelts to reduce erosion from wind and heavy rain;
- Increase the organic matter content in the soil by applying organic matter such as crop residues, compost, and manure to protect the soil physically from sun, rain, and wind and to feed soil biota. The potential for spreading of pests should be considered before implementing this practice;
- Consider adding lime to soil to compensate for acidification, caused by acid deposition and fertilizers, and to maintain stable pH levels;
- Assess potential impacts of waste materials such as manure and sludge to soils and water resources due to the presence of contaminants (e.g., heavy metals, nitrogen, phosphorus, and diseases-causing agents) prior to use for soil enhancement.

**Pesticide Use**

The primary aim of pest management should be not to eradicate all organisms, but to manage pests and diseases that may negatively affect production of annual crops so that they remain at a level that is under an economically and environmentally damaging threshold. Pesticides should be managed to avoid their migration into off-site land or water environments by establishing their use as part of an Integrated Pest Management (IPM) strategy and as documented in a Pesticide Management Plan (PMP). The following stages should be considered when designing and implementing an IPM strategy, giving preference to alternative pest management strategies, with the use of synthetic chemical pesticides as a last option.

3. **Nutrient** management strategies, with the use of synthetic chemical pesticides as a last option.

**Alternatives to Pesticide Application**

4. Where feasible, the following alternatives to pesticides should be considered:

- Provide those responsible for deciding on pesticides application with training in pest identification, weed identification, and field scouting;
- Rotate crops to reduce the presence of pests and weeds in the soil ecosystem;
- Use pest-resistant crop varieties;
- Use mechanical weed control and / or thermal weeding;
- Support and use beneficial organisms, such as insects, birds, mites, and microbial agents, to perform biological control of pests;
- Protect natural enemies of pests by providing a favorable habitat, such as bushes for nesting sites and other original vegetation that can house pest predators;
- Use animals to graze areas and manage plant coverage;
- Use mechanical controls such as traps, barriers, light, and sound to kill, relocate, or repel pests.

**Pesticide Application**

5. If pesticide application is warranted, users should take the following precautions:
- Train personnel to apply pesticides and ensure that personnel have received applicable certifications or equivalent training where such certifications are not required;\(^7\)\(^8\)

- Review the manufacturer’s directions on maximum recommended dosage or treatment as well as published reports on using the reduced rate of pesticide application without loss of effect (such as DAAS 2000), and apply the minimum effective dose;

- Apply pesticides based on criteria such as field observations, weather data, time of treatment, and dosage, and maintain a pesticide logbook to record such information;

- Avoid the use of pesticides that fall under the World Health Organization Recommended Classification of Pesticides by Hazard Classes 1a and 1b;

- Avoid the use of pesticides that fall under the World Health Organization Recommended Classification of Pesticides by Hazard Class II if the project host country lacks restrictions on distribution and use of these chemicals, or if they are likely to be accessible to personnel without proper training, equipment, and facilities to handle, store, apply, and dispose of these products properly;

- Avoid the use of pesticides listed in Annexes A and B of the Stockholm Convention, except under the conditions noted in the convention and those subject to international bans or phaseouts;\(^9\)\(^10\)

- Use only pesticides that are manufactured under license and registered and approved by the appropriate authority and in accordance with the Food and Agriculture Organization’s (FAO’s) International Code of Conduct on the Distribution and Use of Pesticides;\(^11\)

- Use only pesticides that are labeled in accordance with international standards and norms, such as the FAO’s Revised Guidelines for Good Labeling Practice for Pesticides;\(^12\)

- Select application technologies and practices designed to reduce unintentional drift or runoff only as indicated in an IPM program, and under controlled conditions;

- Maintain and calibrate pesticide application equipment in accordance with manufacturer’s recommendations. Use application equipment that is registered in the country of use;\(^13\)

- Establish untreated buffer zones or strips along water sources, rivers, streams, ponds, lakes, and ditches to help protect water resources.

- Avoid use of pesticides that have been linked to localized environmental problems and threats.

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\(^7\) Examples of certification schemes are provided by the US EPA (2006), which classifies pesticides as either “unclassified” or “restricted” and requires workers that apply unclassified pesticides to be trained according to the Worker Protection Standard (40 CFR Part 170) for Agricultural Pesticides. It further requires restricted pesticides to be applied by or in the presence of a certified pesticide applicator.

\(^8\) Additional information on pesticide hazard classification is provided in WHO (2005).


\(^10\) For example, the phaseout of methyl bromide by the year 2015 under the Montreal Protocol on Ozone Depleting Substances.

\(^11\) FAO (2002a).

\(^12\) FAO (2002b).

\(^13\) Refer to host country standards for registration and certification requirements for new pesticide application equipment. Further information on registration and certification schemes is provided in FAO (2001).
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Pesticide Handling and Storage

6. Contamination of soils, groundwater, or surface water resources, due to accidental spills during transfer, mixing, and storage of pesticides should be prevented by following the hazardous materials storage and handling recommendations presented in the General EHS Guidelines. Additional recommendations include the following:

- Store pesticides in their original packaging, in a dedicated, dry, cool, frost-free, and well aerated location that can be locked and properly identified with signs, with access limited to authorized people. No human or animal food may be stored in this location. The store room should also be designed with spill containment measures and sited in consideration of potential for contamination of soil and water resources;
- Mixing and transfer of pesticides should be undertaken by trained personnel in ventilated and well lit areas, using containers designed and dedicated for this purpose;
- Containers should not be used for any other purpose (e.g. drinking water). Contaminated containers should be handled as hazardous waste, and should be treated accordingly. Disposal of containers contaminated with pesticides should be done in a manner consistent with FAO guidelines and with manufacturer’s directions;
- Purchase and store no more pesticide than needed and rotate stock using a “first-in, first-out” principle so that pesticides do not become obsolete. Additionally, the use of obsolete pesticides should be avoided under all circumstances. A management plan that includes measures for the containment, storage and ultimate destruction of all obsolete stocks should be prepared in accordance to guidelines by FAO and consistent with country commitments under the Stockholm, Rotterdam and Basel Conventions;
- Collect rinse water from equipment cleaning for reuse (such as for the dilution of identical pesticides to concentrations used for application);
- Ensure that protective clothing worn during pesticide application is either cleaned or disposed of in an environmentally responsible manner;
- Implement groundwater supply wellhead setbacks for pesticide application and storage;
- Maintain records of pesticide use and effectiveness.

Eutrophication of Aquatic Environments

8.12. Nutrient Management strategies should aim to maintain and/or improve soil fertility and optimize crop yield while maintaining and improving the soil nutrient status. These strategies should be implemented as part of an INM approach that aims to prevent, reduce, or control minimizing off-site environmental impact (e.g., contamination of

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14 FAO (2002a)
15 See FAO Guidelines for the Disposal of Waste Pesticides and Pesticide Containers.
16 See FAO (1996).
17 See the FAO publication on pesticide storage and stock control manual: FAO Pesticide Disposal Series No. 3 (1996).
groundwater resources and eutrophication of surface water resources from surface runoff and leaching of excess crop nutrients. The periods of greatest risk for runoff and leaching may be during and immediately after spreading if). Consider the nutrients are not incorporated into the soil, and during heavy rains that cause rapid runoff. following practices:

7. The following steps should be considered when designing and implementing an INM strategy including evaluating the need for crop nutrient application, following a recommended crop nutrient and post-nutrient application plan, and handling and storage of crop nutrients.

Evaluating the Need for Crop Nutrient Application

8. Consider the following to evaluate the need for, and reduce the use of, crop nutrients:

- Balance nutrient application according to INM recommendations, including the use of reduced or no soil tillage, green manures, cover crops, or mulching techniques, nutrient recycling, one-pass to maintain soil preparation and sowing, taking into account the potential for increased pesticide consumption;
- Use crop rotation methods to enable cultivation of leguminous plants with nitrogen fixation capabilities;
- Use plants to cover the soil, especially during a fallow period and in wet regions, to reduce the loss of nutrients;
- Incorporate organic waste materials into soils rather than burning;
- Avoid excess fertilization by analyzing soil before the growing season to estimate how much additional plant nutrient will be needed for the crop to be produced. Evaluate the need for crop nutrient application through test plot observations;
- Assess soil acidity, which is important for achieving maximum uptake of phosphates;
- Provide farm operators with training in INM following published principles and agricultural practice manuals.**

Crop Nutrient Application

9. If the application of crop nutrients is warranted, the following recommended actions to reduce environmental impacts should be considered:

- Apply replenish soil organic matter, such as manure, to replace chemical fertilizers to the extent practical;
- Incorporate manure into the soil and capture and/or apply between growing crops to improve plant utilization of nutrients and thereby reduce nutrient loss and contamination. Do not apply solid or liquid manure directly onto grazing areas or edible crops. In areas with intensive livestock breeding, be aware that agricultural crop lands are often used to dispose of

** See FAO (2000).
manure with the risk of over-fertilization; conserve moisture.

- Apply "fertigation" in horticulture, in which small amounts of fertilizer added to irrigation water may be applied. This requires detailed management and is mostly used in greenhouse production applications.

- Plan a crop rotation program to incorporate nitrogen-fixing legume crop plants and cover crops in the cropping cycle.
- Draw up balanced fertilizer programs for each soil management unit based on mapped fertility results, history of crop performance, soil and leaf analysis, and crop assessment.
- Assess EHS risks associated with the nutrient management plan and mitigating strategies to minimize potential adverse EHS impacts.
- Time the application of crop nutrients using meteorological information to maximize uptake and minimize nutrient runoff or volatilization.
- Assess soil pH periodically and apply soil amendments (e.g., agricultural lime) to correct changes in soil pH, as required, to ensure that nutrients are available for plant uptake.
- Conduct periodical soil analysis to detect changes in soil fertility, inform decisions on fertilizer application rates, and avoid, where feasible, application during or close to precipitation events: unsustainable nutrient depletion and over-fertilization.

- Use

Establish and respect setbacks from watercourses—including appropriate technical equipment for spraying manure;

- Establish buffer zones, strips, or other "no-treatment" areas along water sources, rivers, streams, ponds, lakes, and ditches—to act as a filter to catch potential nutrient runoff from the land;

- Select and maintain fertilizer application equipment to ensure desired application rates are used and overbroadcasting of solid fertilizers as well as overspraying of liquid fertilizers are minimized.
- Implement INM nutrient planning, monitoring, and documentation, which may include the use of a fertilizer logbook to record the following information:
  - Dates of purchase, dates of use, amount of fertilizer and nutrient used per field / hectare (kg/ha), purpose of use, and weather conditions during application; crop growth stage.
  - Rates of nutrient weather conditions before, during, and after application.
  - Methods used to minimize nutrient loss (e.g., incorporation into the soil, split applications, irrigation after application).
- Provide farm operators with training in nutrient management following published principles and agricultural practice manuals.20
- Ensure that all personnel are trained in and use appropriate management procedures for the storage, handling, and application of all types of fertilizers, including organic wastes.

Personal Protective Equipment (PPE) should be used according to the Safety Data Sheets (SDS) of the product or according to a risk assessment of the fertilizer product. SDS should be available at each management unit.

**Crop Residue and Solid Waste Management**

9.13. In all annual cropping systems, residues (leaf material, roots, and other plant parts) can be recycled beneficially to improve soil organic matter and soil structure, as well as to reduce soil loss. These residues are valuable sources of organic matter and carbon and can lead to the extended release of nutrients during the development (growth stage) phase of the next crop cycle. Prevention and control strategies for potential risks and impacts include the following:

- Develop and implement a residue management plan in combination with results from nutrient management research and planning.
- Recycle residues and other organic materials by leaving the materials on site or through composting (and spreading).
- Consider the potential for harboring and spreading pests and diseases before implementing this practice.
- Consider using crop residues for other beneficial purposes—such as animal feed, bedding, or thatching—when leaving residues in the field is neither practical nor appropriate.
- In cases where crop residues are in excess of those needed for nutrient management, consider using them as a thermal energy source for agriculture processing or for the generation of heat and/or power. Relatively high atmospheric emissions (such as of particulate matter and carbon monoxide (CO)) are possible when using crop residues for thermal combustion; as such, their handling, storage, and processing may present risks of fire, such as from the spontaneous combustion of improperly stored damp residues or the explosion of combustible dust. Strategies to prevent and control risks and impacts include:
  - In the planning phase, obtain physical and chemical data on the fuel and implement advice from a qualified specialist.
  - Undertake tests with the “new” residual biomass fuel prior to introducing it, and demonstrate that expert advice and feedback have been followed.
  - Adopt management practices in line with General EHS Guidelines in managing risks for fire and explosion.
- Avoid using harmful residual chemicals at end of crop life when preparing for removal.
14. Non-crop wastes or hazardous wastes from the production systems (e.g., pesticide containers, waste pesticides, and packaging) often have the potential to contribute to adverse health, safety, or environmental impacts. Considerations for the prevention and control of potential impacts from these wastes include:

- Ensure all packaging for pesticides and herbicides is collected from the field after use and properly stored until final disposal.
- Do not burn packaging, plastics, or other solid waste. Dispose of this waste in designated waste disposal facilities or by recycling. Manage solid waste in accordance with the General EHS Guidelines.
- Consider large container and/or bulk systems for fuels, oils, fertilizers, and chemicals to reduce the volume of waste containers.
- Examine alternative product formulations and packaging (e.g., biodegradable material).
- Manage expired and unwanted pesticides as hazardous wastes in accordance with the General EHS Guidelines and Food and Agriculture Organization (FAO) Guidelines for the Management of Small Quantities of Unwanted and Obsolete Pesticides.\(^{21,22}\)

**Water Management**

15. Water management for annual crop production should aim to conserve the quantity and quality of water resources while optimizing crop yield. Surface or groundwater resources used for irrigation should be managed in accordance with the principles of Integrated Resource Water Management,\(^{23}\) consistent with the following recommendations:

- Determine rain or water irrigation requirements of the crop, based on internationally recognized guidelines, while recognizing seasonal variations and regional norms. When irrigation is practiced, develop an appropriate irrigation plan and schedule, and monitor consumption and compare regularly with these targets.
- Maintain soil structure and soil organic matter. Use of crop residues and mulches will assist in maintaining soil organic matter levels, retaining soil humidity, and reducing surface evaporation.
- Where applicable, maximize the retention of rainwater through appropriate “rain harvesting” techniques, which may include:
  - Diverting water flow from roads and paths toward crops, thus storing water in the soil and reducing the effect of short dry spells.


\(^{22}\) In the event that disposal of pesticides involves overseas shipments, the project must ensure compliance with the country’s commitments under the Stockholm, Rotterdam, and Basel Conventions.

\(^{23}\) Global Water Partnership.
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· Storing runoff from rainy periods for use during dry spells by using tanks, ponds, cisterns, and earth dams.
· Maintaining protective vegetation in canals and drainage systems to reduce canal bank scouring and slow runoff.

- When irrigation is used, implement irrigation water conservation techniques, such as:
  · Whenever feasible, adopt water-efficient irrigation systems, such as micro-sparing, drippers, and fertigation.
  · Consider the soil infiltration capacity to select the best irrigation system and avoid the runoff of water.
  · Ensure regular maintenance of the irrigation system, as well as that of its associated channels and infrastructure.
  · Maintain a water management logbook that records the time and quantity of rainfall evaporation, as well as the amount of irrigation applied and soil moisture levels (%), in order to verify both that irrigation is being used according to crop need and to develop an understanding of long-term trends in water use.
  · Reduce evaporation by avoiding irrigation during periods when evaporation is elevated (e.g., in periods of higher temperatures, reduced humidity, or high winds). Use trickle or drip irrigation techniques, if practical.
  · Reduce evapotranspiration by using shelterbelts and windbreaks.
  · Reduce seepage losses in supply channels by lining them or using closed pipes.
  · Consider collecting storm water through catchments.
  · Employ a cutback furrow irrigation technique, slowing or stopping irrigation water well before the water reaches the end of the furrow and discharges to the environment.
  · If herbicides are used, ensure they are applied at the appropriate time of year to most effectively control undesirable vegetation and reduce its water consumption.

- The following measures are recommended to prevent and control the contamination of water sources:
  · Avoid over-irrigation, which may result in the leaching of nutrients and contaminants.
  · Ensure appropriate soil moisture by active monitoring of soil humidity.
  · Establish and respect setbacks and buffer zones in riparian areas. Buffer widths should be based on the specific risk, land management regime, and slope of the area.

16. Sediments may become a significant pollutant due to their physical and chemical properties. Suspended sediments in surface water carry pollutants such as pesticides, nutrients, and trace metals, affecting water quality. Sediment loading reduces storage and flow capacities of streams, lakes, and reservoirs; may adversely affect
water supplies; and increases the risk of flooding. Soil loss prevention practices are presented in the "Soil Conservation and Management" section.

**Pest Management**

- Maintenance schedule of application equipment to ensure efficient dosage.

**Handling and Storage of Crop Nutrients**

17. The primary aim of pest management should not be to eradicate all organisms, but to manage "pests," including insect pests, diseases, and weeds that may negatively affect annual crops so that they remain at levels beneath an economically damaging threshold. Pests should be managed through a process of integrated pest management (IPM) that combines chemical and non-chemical approaches to minimize pest impact, while also minimizing the impact of such measures on the environment. Pesticides should be used only to the extent necessary under an IPM and integrated vector management (IVM) approach, and only after other pest management practices have either failed or proven inefficient. The following steps should be considered and documented in an integrated pest/vector management plan:

- Identify the main pests affecting crops in the region, assess the risks to the operation, and determine whether a strategy and capacity are in place to control them.
- Where possible, apply early-warning mechanisms for pests and diseases (i.e., pest and disease forecasting techniques).
- Select resistant varieties and use the cultural and biological control of pests, diseases, and weeds to minimize dependence on pesticide (chemical) control options. An effective IPM regime should:
  - Identify and assess pests, threshold levels, and control options (including those listed below), as well as risks associated with these control options.
  - Rotate crops to reduce the presence of insects, disease, or weeds in the soil or crop ecosystems.
  - Support beneficial bio-control organisms—such as insects, birds, mites, and microbial agents—to perform biological control of pests (e.g., by providing a favorable habitat, such as bushes for nesting sites and other original vegetation that can house pest predators and parasites).
  - Favor manual, mechanical weed control and/or selective weeding.

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24 Integrated pest management (IPM) refers to a mix of farmer-driven, ecologically based pest control practices that seeks to reduce reliance on synthetic chemical pesticides. It involves: (a) managing pests (keeping them below economically damaging levels) rather than seeking to eradicate them; (b) relying, to the extent possible, on nonchemical measures to keep pest populations low; and (c) selecting and applying pesticides, when they have to be used, in a way that minimizes adverse effects on beneficial organisms, humans, and the environment.
o Consider using mechanical controls—such as traps, barriers, light, and sound—to kill, relocate, or repel pests.

o Use pesticides to complement these approaches, not replace them.

o Prior to procuring any pesticide, assess the nature and degree of associated risks and effectiveness, taking into account the proposed use and the intended users.

**Pesticides Use and Management**

18. Where pesticide use is warranted, in order to prevent, reduce, or control the potential contamination of soils, groundwater, or surface water resources caused by accidental spills during the transfer, mixing, and storage, crop nutrients and application of pesticides, they should be stored and handled and applied in a manner consistent with the recommendations for hazardous materials management presented in the General EHS Guidelines.

19. A pesticide management plan (PMP) that includes procedures for the selection, procurement, storage, handling, and ultimate destruction of all out-of-date stocks should be prepared in accordance with FAO guidelines and should be consistent with country commitments under the Stockholm, Rotterdam, and Basel Conventions. The PMP prescribes the type of pesticides to be used, as well as the purpose of their use, and outlines best practice for the procurement and storage of all pesticides. Personnel must have appropriate training—including certification, where relevant—to handle and apply pesticides safely. In particular:

- Ensure that any pesticides used are manufactured, formulated, packaged, labeled, handled, stored, disposed of, and applied according to the FAO’s International Code of Conduct on Pesticide Management.

- Do not purchase, store, use, or trade pesticides that fall under the World Health Organization’s (WHO) Recommended Classification of Pesticides by Hazard Classes 1a (extremely hazardous) and 1b (highly hazardous), or Annexes A and B of the Stockholm Convention.

- Do not use pesticides listed in WHO Hazard Class II (moderately hazardous), unless the project has appropriate controls established with respect to the manufacture, procurement, or distribution and/or use of these chemicals. These chemicals should not be accessible to personnel without proper training.

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25 [http://chm.pops.int/](http://chm.pops.int/)

26 [http://www.pic.int/](http://www.pic.int/)

27 [http://www.basel.int/](http://www.basel.int/)


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training, equipment, and facilities in which to handle, store, apply, and dispose of these products properly.

- Preferentially, use selective pesticides with low environmental impact quotient (EIQ) where appropriate, rather than broad-spectrum products, to minimize impacts on non-target species.

Storage

- Store all pesticides in a lockable, bunded container or store that has sufficient space in which to capture any spills without contaminating the environment. Stores should be set away from water sources, residential and built-up areas, as well as livestock and food storage areas.
- Procure spill kits and institute suitable control measures in case of accidental spillage.
- Store all pesticides in their original, labeled containers, and ensure that storage instructions are followed.
- Keep a register of all pesticides procured, recording when they were received, the amount used, the amount remaining in store, and their location.
- Keep SDS at appropriate locations in storage facilities.
- Warehouses must have appropriate ventilation, secondary containment, and emergency showers and kits.

Handling

- Operators must read, understand, and follow product label directions for safe mixing, application, and disposal; use trained personnel for critical operations (e.g., mixing, transfers, filling tanks, and application).
- Insist that correct PPE (e.g., gloves, overalls, eye protection) for each exposure route \(^{31}\) listed in the SDS be worn at all times when handling and applying pesticides.
- Mandate that any mixing and filling of pesticide tanks occur in a designated filling area.
  - This should be set away from watercourses and drains.
  - If on concrete, water should be collected in a separate sump and disposed of as a hazardous waste.
  - Ensure that spills are cleaned up immediately using appropriate spill kits; spills should not be washed away into watercourses or drains.

Application

- Give preference to the application method with the lowest EHS risk.

\(^{31}\) Possible routes of exposure are skin contact, eye contact, inhalation (respiratory system), and ingestion (swallowing).
Select pesticide application technologies and practices designed to minimize off-site movement or runoff (e.g., low-drift nozzles, using the largest droplet size and lowest pressure that are suitable for the product).

Establish buffer zones around watercourses, residential and built-up neighborhoods, as well as livestock and food storage areas.

For the aerial application of pesticides, the boundaries of target areas should be clearly demarcated and all possible nearby communities, livestock, and rivers should be identified in the flight plan. The aerial application of pesticides should not be conducted where there is potential for contamination of organic or otherwise certifiable production.

Ensure that all equipment is in good condition and properly calibrated to apply the correct dosage.

Insist that applications occur under suitable weather conditions; avoid wet weather and windy conditions.

Disposal

In addition, fertilizers should be stored

Any unused dilute pesticide that cannot be applied to the crop—along with rinse water, and out-of-date or no-longer approved pesticides—should be disposed of as a hazardous waste, as per FAO guidelines.

Empty pesticide containers, foil seals, and lids should be triple rinsed, and washings used in the pesticide tank should be sprayed back onto the field or disposed of as hazardous waste in a manner consistent with FAO guidelines and according to the manufacturer's directions. Containers should be stored safely and securely under cover prior to their safe disposal; they should not be used for other purposes.

Fertilizers

Store fertilizers in their original packaging and in a dedicated location that can be locked and properly identified with signs, and with access to which is limited to authorized persons.

Ensure that SDS and inventories are available at fertilizer storage facilities and available to first responders when necessary.

Only purchase and store minimal fertilizer requirements, and use older fertilizers first.

Keep fertilizer stores separate from pesticides and machinery (e.g., fuels, ignition, or heat sources).

Know and understand each crop's fertilizer requirements and only apply what is required, when it is required, to minimize losses to the environment.

Implement a suitable training program for personnel that are transporting, handling, loading, storing, and applying fertilizers.
Biodiversity Impacts and Ecosystems

10. If not properly managed, modern, intensive, conventional cultivation methods may lead to adverse impacts on biodiversity. The main ecosystem threats that should be managed at the farm level may include the following:

Loss of Genetic Resources and Variability

11. Personnel in charge of annual crop production operations should be aware of the biodiversity issues at the farm level (also termed agricultural biodiversity), as well as more general biodiversity issues in the area where the farm is located. The following actions should be taken to maintain farm-level agricultural biodiversity:

- Where possible, maximize reuse of residue from the previous crop on the soil surface. The potential for spreading of pests should be considered before implementing this practice;
- Reduce soil preparation to maintain the structure of soil ecosystems (e.g., promote low-till and no-till strategies);
- Utilize field borders to provide wildlife corridors around fields used for annual crop production;
- Provide buffer zones on farmland bordering wildland of specific environmental and research interest;
- Regularly monitor soil health, for example, by determining the population of soil macrofauna bioindicator species such as the earthworm population;

20. Use certified crop seeds that do... Annual crop production has the potential to have a direct and indirect impact on biodiversity and ecosystems. Key direct impacts relate to habitat conversion or degradation, water usage, pollution, introduction of invasive species, inappropriate cultivation techniques, and quality and or availability of priority ecosystem services. Indirect impacts relate to in-migration, and induced changes to access for traditional land uses (including hunting, fishing, and recreation). Impacts and associated mitigation activities related to biodiversity and ecosystems are primarily specific to the crops, techniques, and existing land use context at any specific site.

21. Impact avoidance should be the goal. Appropriate site selection, including expansion planning, is the single most important impact-avoidance measure available to annual crop production. Early screening can improve macro-level project site selection so as to avoid selecting areas with high biodiversity values, such as critical or natural habitat, areas with high conservation values (HCV), those modified habitats that contain significant biodiversity value (such as previously abandoned farmland that has subsequently developed into secondary forest), or provisioning or regulating ecosystem services. Such screening can help with the scoping of priorities for further assessment, if complete avoidance is not possible, thus reducing unnecessary biodiversity and/or ecosystem impacts and costs in the future. Screening should be conducted to identify species and sites of

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importance within the broader region or landscape. Tools, such as the Integrated Biodiversity Assessment Tool (IBAT),\(^{33}\) can facilitate access to key international data sets. Sites of local, regional, and international importance\(^{34}\) may include: nationally and internationally protected areas, Important Bird Areas (IBA), Key Biodiversity Areas (KBAs), Alliance for Zero Extinction (AZE) areas, Ramsar Sites (Wetlands of International Importance), along with known congregatory sites and unique or threatened ecosystems.

22. Screening should consider any existing spatial data and landscape mapping as part of the literature review and desktop analysis. Key sources for biodiversity or ecosystem information include Strategic Environmental Assessments (SEA), National Biodiversity Strategies and Action Plans (NBSAP),\(^{35}\) relevant sector plans (including those that may be impacted, such as eco-tourism or fisheries), and conservation plans.

23. Conversion of existing critical, natural, or HCV habitats into agriculture should be avoided wherever possible and planting on modified habitats or degraded lands should be promoted. This should be informed by an assessment of existing modified habitats or degraded lands suitable for crop production or restoration, to reduce risks and costs associated with biodiversity impacts or further reduction of ecosystem services.

24. The farm-level management plan should be informed by an assessment of biodiversity values of importance, including species, sites, and habitats. This should, at a minimum, consider the farm management unit; in cases of higher risk, however, expected landscape connectivity or wildlife movement issues should consider a broader landscape unit based on the specific needs of biodiversity values in question. Very large management units, particularly where conversion or planting will be managed in smaller sub-units (e.g., multiple compartments or a phased approach), may not find a single comprehensive assessment to be practically feasible. In such cases, a desktop assessment, including analysis of satellite data supported by targeted groundtruthing, can be used to scope areas of potentially modified, natural, and critical habitat, as well as to identify potential set-asides and restoration areas that could mitigate possible impacts on biodiversity values across the full management unit. Groundtruthing can be practically implemented at the level of smaller sub-units (e.g., refining existing set-asides or establishing new ones). Annual crops subject to international standards and certification systems now routinely employ tools to identify, delimit, and manage areas of HCV.\(^{36}\) Such areas should be clearly established on maps and within management plans. It is important that the conversion or planting schedule for these sub-units allows sufficient time (one to two years) to allow for assessment, analysis, and the development of an appropriate management plan based on this information.


25. Some biodiversity values will require on-site management to maintain viability on-site and within the larger landscape. These include maintaining, establishing, or restoring corridors (e.g., riparian areas, movement corridors for wildlife), set-asides (e.g., important breeding or feeding sites), and buffer zones (e.g., to minimize off-site disturbance to neighboring riparian areas and wetlands, protected areas, and other important sites). The number, extent, and location of these areas should be informed by the assessment process and not simply by the prevalence of areas in which development is not feasible (e.g., steep slopes). Active management (e.g., access control, hunting reduction, and enrichment planting with indigenous species) and monitoring may be required in some situations to maintain required biodiversity values.

26. Developers should seek to avoid the introduction of invasive species, as well as control and reduce their further spread. This includes sourcing planting material (e.g., seeds, tube stock) from reliable suppliers who can provide evidence of purity.

- Developers should use planting material that does not contain seeds from invasive alien species and that comply with the information on the packaging regarding seed diameter and species;
- Ensure protection of the natural enemies of pests by providing favorable habitats, such as hedges, nesting sites, and original vegetation, to house pest predators; and
- Promote the use of organic agricultural practices to the extent feasible.37

42. The following actions should be taken to help maintain regional biodiversity:

- Before converting land to annual crop production, survey the project area to identify, categorize, and delineate natural and modified habitat types and ascertain their biodiversity value at the regional or national level;
- Ensure that any natural or modified habitat to be converted to annual crop production does not contain critical habitat, including known habitat of critically endangered or endangered species, or important wildlife breeding, feeding, and staging areas;
- Be aware of the presence of critically endangered or endangered species in the areas already used for annual crop production and consider them during management processes;

40.27. Provide for minimum disturbance to surrounding areas when harvesting or gathering crops complies with local quarantine and hygiene regulations, implementing machinery cleaning programs when moving between fields to remove soil and seeds that may carry invasive or alien species.

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37 For further guidance on organic agriculture, see IFOAM (2005).
Genetically-Modified Organisms (GMOs), Invasive Species, and Pests

11.28. A genetically modified organism (GMO) is defined as a living organism that possesses a novel combination of genetic material obtained through the use of genetic engineering technology. Environmental concerns related to the introduction of GMO crops may include transfer of introduced genes to other species (possibly weedy or invasive), unanticipated impact on beneficial insects, or increased pest resistance. Another concern related to the introduction or export of plants should be addressed and plant products is the potential for introduction of pests—appropriate research conducted to demonstrate that human and environmental risks (if any) are acceptable.

12.29. The introduction of GMO annual crops should be assessed and conducted in compliance with the host country's regulatory framework for such introductions. If such a regulatory framework does not exist in the host country, the potential impacts and risks—applicability of the Cartagena Protocol on Biosafety—should be assessed, paying specific attention verified and used to scientifically evaluate the potential for impacts and risks related to a specific crop's introduction, including its invasive behavior potential, and identifying—appropriate mitigation measures. The potential for introduction—next steps in the risk assessment are to evaluate the likelihood of pests such events occurring, the consequences if they should occur, and whether the overall risks (i.e., likelihood and consequence) are acceptable or manageable.

Crop Residues and Other Solid Waste

13. The largest volume of residues in crop production is crop residues themselves, although the waste with the most significant impact is often related to pesticide containers and obsolete, expired pesticides. Prevention and control of potential impacts from the generation of these wastes includes the following:

- Recycle crop residues and other organic materials by leaving the materials in the fields, plowing, and / or composting. The potential for spreading of pests should be considered before implementing this practice;

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39 Ibid.
- Reuse crop residues as a thermal energy fuel in bioenergy facilities, as a substrate in fermentation facilities, and as feedstock in biorefineries;
- Clean (e.g., triple rinse technique) and dispose of (e.g., through crushing, shredding, or return to suppliers) pesticide packaging and containers to ensure that they are not subsequently used as containers for food or drinking water; rinsing solutions should be recovered for reuse as diluting agents, or stored for eventual disposal, as per FAO Guideline;
- Manage expired and unwanted pesticides as hazardous wastes in accordance with the General EHS Guidelines and FAO Guidelines for the management of unwanted and expired pesticides.

Atmospheric Emissions

Energy Use

30. Energy is used in annual crop production for site preparation, cultivation, management, irrigation, harvesting, transport, lighting, heating, cooling, and ventilation. Recommendations to reduce energy use and increase efficiency are presented in the General EHS Guidelines. Additional recommended strategies include:

- Select energy-efficient machinery and equipment (e.g., tractors, ventilation systems, drying and storage systems, cooling devices) and consider on-board fuel-use monitors.
- Consider implementing training programs to make operators aware of energy-efficient practices when using machinery (e.g., switching off engines when waiting to load) and when driving.

31. Irrigation energy use can be significant; the following techniques are recommended for efficient use of energy in irrigation systems:

- Develop an irrigation plan that is appropriate for climate, season, soil conditions, plant materials, and grading. This plan should include optimum scheduling, monitoring, and recording systems so that energy usage and efficiencies can be examined. An irrigation logbook or database should be maintained so that quantitative measures are recorded (e.g., kWh electricity per cubic meter applied, fuel usage as liter per cubic meter applied).
- Regularly maintain the irrigation system and associated infrastructure, such as supply channels and water storage.
- Select efficient pumps.

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42 FAO (2002c).
43 FAO (2002c)
44 FAO (1999).
45 In case that disposal of pesticides involves overseas shipments, project must ensure compliance with country’s commitments under Stockholm, Rotterdam and Basel Conventions.
Ensure properly matched pumps, systems, and power sources by keeping a good record of the amount of water pumped and the energy used to ensure suitability.

**Air Quality**

13.32 Atmospheric emissions are primarily associated with emissions of fuel combustion by-products—including carbon dioxide (CO₂), sulfur dioxide (SO₂), nitrogen oxide (NOₓ), and particulate matter (PM)—resulting from the operation of mechanized equipment or from combustion by-products from the disposal or destruction of crop residues. Dioxins and furans may be present in residues if crops have been treated with chlorinated pesticides. Greenhouses gas (GHG) emissions, including nitrous oxide (N₂O), methane (CH₄), and ammonia (NH₃), may result from the use of fertilizers or from soil conditions associated with certain crops such as rice. Ammonia and nitrous oxide are volatilized under high wind and elevated temperature conditions, or processing by-products. The impacts of these pollutants depend on the local context, including the proximity to communities, sensitivity of ecosystems, concentrations of the pollutant, topography, and meteorology. Air-quality issues, including management of mechanized farm equipment, should be managed according to recommendations in the General EHS Guidelines for mobile and stationary sources. Specific recommendations for annual crop production to prevent and control air emissions are:

14. Recommended prevention and control measures include the following:

- Manage emissions from mechanized farm equipment according to recommendations in the General EHS Guidelines for mobile and stationary sources;
- Where feasible, use biofuels instead of fossil energy to reduce net GHG emissions;
- Adopt reduced tillage options to increase the carbon storage capacity of soils;
- Favor solar drying techniques for crops that require drying;
- Reduce particulate matter emissions by avoiding burning straw and other organic material in the field and by maintaining organic matter to protect soil against wind erosion during and after soil preparation activities;
- Avoid open burning for land preparation, weed control, and post-harvest treatments. Evaluate controlled burning in energy production facilities to extract thermal energy for beneficial use. Where burning is unavoidable, potential impacts should be identified and weather conditions monitored to schedule burning in an effort to minimize impacts.
- Prohibit burning of pesticide-treated agricultural wastes and by-products (e.g., pesticide containers) to avoid unintended emissions of persistent organic pollutants (POPs) which may arise from open burning of pesticide-treated agricultural wastes avoiding such practices.
Reduce ammonia and nitrous oxide emissions by:

- Reducing ammonia and nitrate concentration in soil;
- Applying denitrification inhibitors;
- Enhancing soil aeration; and
- Enhancing soil incorporation of ammonia and urea fertilizers and manure using techniques such as manure injection, placement of fertilizers at adequate depth beneath soil, use of supergranules in flooded rice fields, among others.

- Adopt IPM strategies to avoid and reduce use of pesticides and associated drift.
- Monitor and minimize ammonia emissions resulting from nitrogen fertilizer and manure use. Note certain types of nitrogen fertilizer have higher ammonia emissions associated with their use than others. Consider incorporating fertilizer at planting to minimize ammonia emissions.
- Reduce the risk of fire by reducing the build-up of potential groundcover fuel sources and controlling weeds and invasive species. Where controlled burns of residues are necessary, ensure optimal conditions for the low risk of spread and low impact on existing air quality.
- Evaluate the substitution of no- or low-emission energy sources for combustion methods. Ensure proper maintenance and operation of combustion equipment (irrigation engines, boilers, tractor engines, heaters, etc.) and consider replacing old units or retrofitting air emission controls.
- Modify field operations where possible (e.g., reducing the number of in-field passes with machinery, reduced tillage operations, or improved logistics to minimize travel distances).
- Modify timing of operations, where possible, to coincide with favorable atmospheric conditions and reduced risk of air pollution.
- Establish cover crops where possible; retain residues, and reduce tillage intensity to avoid dust and soil degradation due to wind erosion. Where water supplies are ample, water application to cropped areas and access roads may reduce the risk of airborne dust.
- Establish natural wind barriers—such as vegetative field borders, hedgerows, herbaceous wind barriers, and tree/shrub establishment—to intercept airborne particulate matter and droplets, which may also include contaminants.

**Greenhouse Gas (GHG) Emissions**

33. Annual crop production produces GHG emissions, including methane, nitrous oxide, and carbon dioxide from different stages in the production cycle. Carbon is also stored in the crop’s residual biomass above and below ground, as well as in the soil ecosystem. The primary source of GHG emissions during site preparation for annual crops will be carbon dioxide associated with land use change. During the production phase, emissions are NOx.

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46 Roy et al. (2006)
from fertilizer use, methane from paddy fields, and CO₂ from on-farm fuel and electricity use. Emissions from fertilizer come from both the manufacture of the product and from the application of the product to the crop, with both activities resulting in NOₓ emissions, which have a high global warming potential. These emissions should be managed through resource-efficient farming.

34. The following are recommended measures for minimizing GHG emissions from crop production:

- Identify sources of on-farm GHG emissions and establish a GHG management plan that includes methods of mitigating emissions and a monitoring program.
- Follow the nutrient management plan to ensure that the nutrient balance is right for maximum crop uptake, the quantity of nitrogen matches crop needs, and the timing of application coincides with active growth stages.
- Consider using a fertilizer recommendation system to help with planning.
- Where available, use abated nitrogen fertilizers, which have lower GHG emissions associated with their manufacture, or use nitrification or urease inhibitors, which reduce soil emissions.
- Reduce fossil energy use by adopting energy-efficient production and management practices.
- Where feasible, consider using renewable energy (e.g., solar, wind, biofuel) for crop drying or to power irrigation pumps.
- Drain water from wetland rice soils during the growing season to reduce methane emissions.

35. The loss of stored carbon in the land occurs primarily during harvest and farm establishment. Land use changes, such as converting grassland or forest to crop production areas, are responsible for the release of GHG emissions in the form of CO₂. If the existing vegetation is burned as part of site preparation activities for the new land use, both methane and NOₓ will be emitted during the combustion process, in addition to CO₂.

36. When converting land, the potential impact on GHG emissions should be assessed and measures implemented to reduce and mitigate this impact.

37. The following activities and strategies can prevent and control GHG emissions:

- Avoid conversion of high-carbon stock areas, such as natural forest and peatlands/wetlands.

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47 Most of the world’s rice grows in inundated conditions, which leads both to high methane emissions and to large demands for irrigation water. As in wetlands generally, flooding rice fields blocks oxygen penetration into the soil, which allows bacteria that produce methane to thrive. Paddy rice methane generates roughly 500 million tons of emissions of carbon dioxide equivalent per year (1.5 percent of total global greenhouse gas emissions (GHGs)).

Avoid open burning of biomass during site preparation, field operations, and post-harvest.
Highlight Protect soils from the loss of organic matter by implementing good soil conservation management practices.
Increase soil organic carbon stocks through land management techniques.
Maintain and rehabilitate degraded areas and vegetative buffer zones to increase carbon stocks.

1.2 Occupational Health and Safety

In developing suitable plans for mitigating environmental, health, and safety risks associated with all annual crops, the hierarchy of controls should be followed as a means to limit workplace risk. Occupational health and safety (OHS) issues associated with annual crop production include the following:

- Physical hazards
- Confined space entry
- Chemical hazards

- Risk of fire and explosion
- Physical hazards
  - Operational and workplace hazards
  - Machinery and vehicles
  - Confined and restricted space entry
  - Exposure to organic dust

- Risk of fire and explosion
  - Combustible dust and silo safety

- Biological hazards
- Chemical hazards

Physical Hazards

Operational and Workplace Hazards

Operational hazards include:

- Slips, trips, and falls (inadequate workplace) resulting in sprains, strains, and fractures;
- Ergonomics hazards from manual handling, lifting weights, or repetitive movements;
- Sharp and moving objects in the workplace (e.g., foot injuries from thorns on oil palm fronds and fruit);
- Over-exposure to noise, vibration, and extreme or adverse weather conditions.

49 http://www.cdc.gov/niosh/topics/cdibanding/.
40. Occupational safety and health impacts and controls relating to safe work practices during routine operations are discussed in the General EHS Guidelines. Potential risks within annual crop production include biological hazards, wounds from equipment or sharp objects, extreme/adverse weather, and manual handling. Exposure to vibration and noise from equipment operation, as well as exposure to extremes of weather—including sustained exposure to the sun or cold—can be harmful. Typical problems include hypo- or hyperthermia, dehydration, UV damage to skin or eyes, and heat or cold exhaustion cases. These risks should be managed according to the General EHS Guidelines. Vibration from machinery may affect the whole body and can cause chronic backache or hip and knee pain and can additionally lead to spinal, gastro-intestinal, and urinary tract problems. Noise and vibration from hand-held equipment (such as chainsaws, brush cutters, or strimmers) can cause hand/arm problems or hearing loss.

Machinery and Vehicles

41. Accidents may occur in connection with the use of machines and vehicles, including worker transportation, farm tractors, harvesting machinery, and a variety of other machines on the farm. In addition, operators may be at risk used on farms. These may include vehicle collisions; vehicle and machinery roll-overs; uncontrolled movement resulting in personal injury (e.g., crushing by moving vehicles); damage or loss of assets, injury, entrapment, or death due to faulty or unguarded equipment and machinery (e.g., moving parts and pinch points on machinery and vehicles); entrapment due to unplanned starting, activation, or engagement of equipment (e.g., rollers); or injury during inspection or repair of vehicles (e.g., vehicle lift not secured while personnel working underneath).

42. Most fatal accidents are associated with the noise of operating, crushing by vehicles or equipment. In annual crop production, common accidents include becoming wrapped around rotating shafts (power take-offs), falls from height (from vehicles or trailers), being run over by tractors and trailers or other large mobile equipment, or being hit by flying objects ejected from machines, especially in the more confined spaces of farm buildings, or exertion of work, which can be physically demanding and is often compounded by the presence of repetitive motion. Occupational safety and health impacts and controls relating to equipment and vehicle operation and repair are discussed in the General EHS Guidelines.

Confined Spaces and Restricted Space Entry

Occupational health and safety hazards associated with confined and restricted spaces on farms (e.g., manure pits, processing bins and silos, grain product storage bins, water tanks, or inadequately

50 ILO 2011.
ventilated buildings), areas treated with pesticides, etc.) include the risk of asphyxiation, primarily explosions due to the accumulation of methane—gas, dust, or fumes (e.g., residual petroleum fumes), and entrapment or enclosure within the confined space. Serious injury or fatality can result from inadequate preparation when entering a confined space or in attempting a rescue from a confined space. Entry into all confined spaces should be restricted and should be subject to permitted supervision by properly trained persons, as described in the General EHS Guidelines.

**Chemical hazards**

**Exposure to pesticides**

15. Occupational health and safety impacts associated with pesticides are similar to those for other hazardous substances, and their prevention and control are discussed in the General EHS Guidelines. Potential exposures to pesticides include dermal contact (e.g., in storage rooms or from leaking containers) restricted areas should be clearly marked and inhalation during their preparation, storage, and application. The effect of such impacts may be increased by climatic conditions, such as wind, which may increase the chance of unintended drift, or high temperatures, which may be a deterrent to the use of personal protective equipment (PPE) by the operator. Recommendations specific to annual crop production include the following:

16.43. Train clearly conveyed to personnel to apply pesticides and ensure that personnel have received the necessary certifications,51 or equivalent training where such certifications are not required; contractors.

- Respect post-treatment intervals to avoid operator exposure during reentry to crops with residues of pesticides;
- Respect preharvest intervals to avoid operator exposure to pesticide residues on products during harvesting;
- Ensure hygiene practices are followed (in accordance to FAO and PMP) to avoid exposure of family members to pesticides residues.

**Exposure to Organic Dust**

17.44. Threshing, handling, and storage of grain generate potentially high concentrations of organic dust, including particles from grain, fungi, and bacteria, as well as inorganic material. Many agricultural jobs can expose workers to dust, including, for example, cleaning silos, dryers, and grain hoppers, and threshing and milling feed

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51 The US EPA classifies pesticides as either “unclassified” or “restricted.” All workers that apply unclassified pesticides must be trained according to the Worker Protection Standard (40 CFR Part 170) for Agricultural Pesticides. Restricted pesticides must be applied by or in the presence of a certified pesticide applicator. For more information, see http://www.epa.gov/pesticides/health/worker.htm
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grain. Acute toxic alveolitis, otherwise known as organic dust toxic syndrome, can accompany brief, occasional exposures to heavy concentrations of organic dust in an agricultural environment. Some dust—especially dust from moldy forage, grain, or hay—carries antigens that can cause severe irritation to the respiratory tract. Breathing dust from moldy feed materials can result in a permanent lung condition commonly known as “Farmer’s lung”.

Occupational health and safety impacts associated with nuisance dust in agricultural settings are similar to those for other industries and their prevention and control are discussed in the General EHS Guidelines. In addition, recommendations for dust control specific to annual crop production include the following:

- Implement dust exposure limits (e.g., a limit of 10 milligrams per cubic meter for inhalable particles (without the need for Respiratory Protective Equipment)).
- Use local air extraction devices at dust-generating equipment, such as tipping pits, elevators, open conveyors, hoppers, silos, dryers, and scales;
- Do not use compressed air or steam for cleaning.
- Equip tractors, loaders, or combined harvesters (threshing machines) with a cab and ventilator, suitable filtration/ventilation.
- Store only dry grain (and dry, well-cured forages and hay) to reduce microorganism growth.

Risk of Fire and Explosion

Grain storage elevators present a risk of explosion given the presence of powdered grain and the potential for explosive atmospheres. Potential ignition sources for the grain dust may include the mechanical malfunction or deterioration of concentrators, including seizing of roller bearings. Among the recommended methods for prevention of explosions in grain storage facilities are the prevention of accumulation of grain dust through maintenance and repair of dust control systems and the maintenance of grain elevator equipment.

Fire safety should be managed according to the General EHS Guidelines. Additional sector-specific risks include fires resulting from the combustion of stored oil or crop residues, which can lead to a loss of property or

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52 Threshold Limit Value (TLV®) occupational exposure guidelines published by the American Conference of Governmental Industrial Hygienists (ACGIH).
53 Additional information on the prevention of grain elevator explosion hazards is provided by the United States National Fire Prevention Association (www.nfpa.org)
cause possible injury to or fatality of project workers. National or international safety standards should be used in the design, operation, and maintenance of facilities, where applicable.54

47. Management plans and operating procedures should include comprehensive strategies for the prevention, detection, and suppression of fires within plantation perimeters and adjacent properties, including:

- Description of primary detection methods, tools, and protocols;
- Ability to communicate with field staff, contractors, and communities;
- Measures for reducing fuel loading;
- Means to access and contain fires within plantation premises;
- Proper placement of appropriate fire suppression equipment; and
- Training of staff, contractors, and communities in fire prevention and suppression actions.

Combustible Dust and Silo Safety

48. The following measures are recommended as a means of preventing and controlling fires and explosions from combustible dust:55

- Use recognized international standards in design and operation.56
- Classify areas according to respective hazard classes following practices and requirements found in recognized international standards57 and deploy intrinsically safe electrical circuits and anti-explosion electrical devices (including lighting).
- Develop and implement a comprehensive maintenance program to avoid dust build-up. Compressed air should not be used for cleaning dust due to the risk of raising the dust level in the atmosphere; all maintenance equipment, especially welding sets and other electrically driven tools, should be regularly inspected and approved for use.
- Avoid heat sources from friction by adopting appropriate practices or technologies.


57 U.S. National Electrical Code.
- Control static electricity. For example, elevator belts should be constructed of anti-static material or have anti-static properties; during pneumatic transfer of combustible substance, ensure electrical bonding and grounding of tanker vehicles to prevent static electricity.
- Provide proper grounding and lightning protection for silos following internationally recognized standards.
- Control access to areas with a high risk of explosion, e.g., limit access to qualified personnel only.
- Ensure the tipping area is completely enclosed and that the design and maintenance of the grid in the tipping area prevent stones and metal from entering.
- Separate heating systems and surfaces from dust.
- Deploy dust suppression/control systems in silo elevators and conveyor belts to avoid dust accumulation in grain transferring areas; e.g., in tipping areas, a dust control system should be used, ideally installed below the grid and above the receiving hopper.
- Ensure that emergency plans and procedures are developed and understood by staff. Install suitable detection equipment in silos, such as temperature sensor cables and gas detectors. Spark/heat detectors should be connected to an extinguishing system installed in transport systems (belt conveyors, dust extraction systems, etc.) to reduce the risk of ignition.
- Establish a suitable extinguishing operation (e.g., water, foam, inert gas, powder) based on the silo construction and bulk material stored. The silo should be prepared with connections or openings suitable for the planned method and silo construction; e.g., pipe systems and connections should be located at the top of the silo wall if the roof is not considered sufficiently strong to withstand an explosion.
- Consider a separate emergency discharge system (i.e., a separate conveyor at the silo outlet) to a safe place outside the silo to reduce the risk of fire spreading inside the plant and ensure that firefighting equipment is present. If ordinary transport systems are to be used for emergency discharge, consider chain and screw conveyors to avoid generating heat from friction.
- Consider a fixed-gas fire extinguishing system, adapted to the diameter and construction of the silo, to enable a quick and appropriate response to fire.
- Ensure vessels or tanks have sufficient emergency venting capacity to relieve excessive internal pressure in the event of fire; if the silo is contained within a plant, evacuate gases outside.

**Biological Hazards**

49. Occupational health and safety hazards associated with crop production may include contact with venomous animals, such as stinging insects, spiders, scorpions, snakes, disease vectors (e.g., mosquitoes, ticks), and with certain wild mammals (e.g., tigers, wild pigs). Recommended mitigation measures include:
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- Wear appropriate protective clothing, such as a long-sleeved shirt, long pants, hat, gloves, and boots.
- Inspect and shake out any clothing, shoes, or equipment (including PPE) before use.
- Remove or reduce tall grasses, debris, and rubble from around the outdoor work areas.
- Control water accumulation.
- Use insect repellent.
- On-site first-aid equipment (including, for example, antivenom serum) and trained personnel should be available, as well as procedures for emergency evacuation.
- Use observation and sighting records so workers know areas where there are dangerous animals. Install fencing and other exclusion methods for larger animals and use armed guards/spotters to protect workers from large animals (e.g., elephants, tigers, wild boar).

Chemical Hazards

Exposure to Hazardous Products, including Pesticides and Herbicides

50. Occupational health and safety hazards associated with pesticides are similar to those for other hazardous substances, and their prevention and control are discussed in the General EHS Guidelines. Potential exposures to pesticides include:

- Dermal contact (e.g., in storage rooms or from leaking containers or splashes/spillage) during preparation, mixing, and application;
- Inhalation during preparation, mixing, and application; and in storage rooms;
- Ingestion by swallowing the pesticide or contaminated foodstuffs.

51. The effect of such impacts may increase due to climatic conditions, such as wind (which may increase the chance of contaminant drift), elevated temperatures, or high humidity (which may be a deterrent to the use of PPE by the operator, thereby increasing the risk of exposure). Recommendations to minimize risks associated with pesticides and chemicals include (in addition to those listed in Section 1.1):

- Use alternative products or methods with a lower OHS risk profile (such as using lower toxicity-rated products, or using safer application methods, such as shielded sprayers, incorporation, or low-volume equipment).
- Adopt means of collective protection, such as ventilation systems in warehouses, tractors and self-propelled sprayers with closed cabinets and air filters, and chemical/water mixers, etc.
- Adopt means of personal protection, such as boots, water-repellent clothes, gloves, and respiratory masks with proper chemical protection.
- Train personnel on hazardous product management and storage. Include training on how to read labels and the SDS and to understand the risks associated with all hazardous products, including pesticides, fertilizers, and crop-processing products.
• Train operators and support personnel to apply pesticides and ensure that these personnel have received the necessary certifications\(^{58}\)—or equivalent training where such certifications are not required—so that they are competent.
• Monitor and proactively manage all stages of pesticide and chemical purchase, storage, mixing, usage, and disposal. Maintain accurate records and analyze these records for any evidence of undue exposure or misuse of hazardous products.
• Respect pre- and post-treatment (re-entry) intervals to avoid operator exposure to pesticide residues in production areas.
• Ensure that product withholding periods are observed to minimize the risk of chemicals or their by-products entering the value chain.
• Ensure that hygiene practices are followed (in accordance with FAO\(^{59}\) regulations and the project pesticide management plan) to avoid exposure of personnel or family members to pesticide or chemical residues. PPEs should never be taken home and should be cleaned in a segregated facility provided by the employer.

52. Re-entry into areas that have been treated with pesticides and fungicides should be guided by information provided by the chemical manufacturer, normally included in the SDS.

1.3 Community Health and Safety

47. Community health and safety issues during the production of annual crops may include the following:

53. Community health and safety issues during the production of annual crops may arise due to land use changes or to the loss of natural buffer areas (such as wetlands, mangroves, and upland forests that mitigate the effects of natural hazards, such as flooding, landslides, and fire) that may result in increased vulnerability and community safety-related risks and impacts. The diminution or degradation of natural resources may result in health-related risks and impacts. Hazardous products, including pesticides, may affect community health in the same ways that they affect individual operators: through dermal contact, ingestion, or inhalation of harmful products or chemicals. Risk of exposure to hazardous products can be minimized by ensuring that the plantation group is following guidelines for the transportation, storage, handling, usage, and disposal of those products. Risks also arise from:

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\(^{58}\) The U.S. Environmental Protection Agency (EPA) classifies pesticides as either “unclassified” or “restricted.” All workers that apply unclassified pesticides must be trained according to the Worker Protection Standard (40 CFR Part 170) for Agricultural Pesticides. Restricted pesticides must be applied by or in the presence of a certified pesticide applicator. For more information, see [http://www.epa.gov/pesticides/health/worker.htm](http://www.epa.gov/pesticides/health/worker.htm).

\(^{59}\) FAO 2014.
Potential exposure to pesticides caused by (e.g., spray drift, improper disposal and use of packaging and containers) and the presence of pesticides or by-products in potentially harmful concentrations in foodstuffs and postharvest products.

Potential exposure to pathogens and obnoxious odors associated with the use of manure.

Potential exposure to air emissions from open fires, burning of crop waste, residues, or solid waste (e.g., packaging).

Pesticides may affect community health in the same ways that they affect individual operators, through dermal contact or through inhalation of such chemicals as a result of application as well as through potential contamination of potable water sources. The potential for community exposure to pesticides in the environment may be considerably influenced by climatic conditions, such as wind velocity, while the potential for exposure to residual levels in postharvest products may depend on adherence to pesticide use instructions. There may also be an increased risk of vehicle or machinery injuries on roads and access routes around the community caused by dermal contact with residues in containers, packaging, etc.

While odors from manure, especially during application, are not generally hazardous, they can be a serious source of discomfort to the community. Open burning of residual organic crop waste can result in degradation of air quality for and other wastes, which creates harmful air emissions that may adversely impact surrounding communities.

Specific recommendations to minimize risks to communities include:

- Monitor and record all potentially harmful products and activities and manage them to minimize the following risk to communities. Regularly audit and update operating procedures and ensure that personnel are suitably trained.
- Implement best practice guidelines for management of potentially harmful products, and follow the General EHS Guidelines.
- Avoid the aerial application of pesticides whenever feasible, and give priority to other management strategies, if possible.
- Do not apply pesticides, chemicals, or manure if meteorological conditions are likely to result in adverse impacts in surrounding communities.
- Use biological or safer lower-risk-profile products, whenever feasible, if available.
Respect pre-harvest intervals and post-harvest withholding periods for products that have been treated with pesticides to avoid unacceptable levels of pesticide residues in products, further complying with any applicable pesticide tolerance requirements.

Do not store or transport pesticides and fertilizers with food (human or livestock foodstuffs) or beverages (including drinking water).

Ensure that animals and unauthorized people are not present in the areas where pesticides or other potentially harmful products are handled, stored, or applied.

Store manure and crop protection products as far away from dwellings as possible, and use measures, such as covering the manure, to reduce odors and atmospheric emissions.

Examples of potentially applicable pesticide tolerance requirements include the FAO/WHO (1962–2005) Codex Alimentarius’ Maximum Residue Limits in Foods and 40 CRF Part 180, Tolerances and Exemptions from Tolerances for Pesticide Chemicals in Food, the latter of which applies to crops sold in the United States.
Do not apply manure to the fields if the wind direction is toward nearby dwellings.

Clean (e.g., a triple rinse or pressure technique) and dispose of (e.g., through crushing, shredding, or return to suppliers) pesticide packaging and containers to ensure that they are not subsequently used as containers for food or drinking water.

Open burning of residual, organic crop waste should be avoided. Crop waste should be returned to the fields to enhance the nutrient content of the soil. Opportunities for use of crop waste as a fuel for energy generation should be considered, where feasible, including composting to generate biogas.

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### Table 1. Water / soil / produce quality guidelines

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Media</th>
<th>Guideline Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pesticides, nitrates, coliform or other potential agricultural contaminants</td>
<td>Irrigation water</td>
<td>Concentrations should not exceed national irrigation water quality standards or, in their absence, internationally recognized guidelines (e.g. WHO Water Guidelines applicable to irrigation water quality).³</td>
</tr>
<tr>
<td>Pesticides, nitrates, coliform or other potential agricultural contaminants</td>
<td>On-site water supplies</td>
<td>Concentrations should not exceed national drinking water quality standards or, in their absence, internationally recognized guidelines (e.g. WHO Irrigation or Drinking Water Guidelines for compounds potentially present in on-site groundwater wells or surface waters).⁴</td>
</tr>
<tr>
<td>Nutrient balance</td>
<td>On-site soil</td>
<td>Nutrient surpluses should remain stable; nitrogen surplus should be preferably below 25kg/ha/yr.⁵</td>
</tr>
<tr>
<td>Pesticides</td>
<td>On-site soil and produce</td>
<td>Below applicable tolerance levels.⁶</td>
</tr>
</tbody>
</table>

**NOTES:**


⁶ See also Roy et al. (2006) Plant nutrition for food security, a guide for integrated nutrient management.

⁷ Examples of potentially applicable pesticide tolerance requirements include the Food and Agriculture Organization Codex Alimentarius’ Maximum Residue Limits in Foods and the US Code of Federal Regulations Title 40, Part 180 — Tolerances and Exemptions from Tolerances for Pesticide Chemicals in Food, the latter of which applies to crops sold in the United States.
2.0 Performance Indicators and Monitoring

2.1 Environment

18. The following environmental guidelines in Table 1 should be used in applying pesticides and nutrients in order to avoid or reduce leaching into groundwater or surface water, runoff into surface water, atmospheric emissions, and other losses outside of the crop production system. Additional guidance on quantitative parameters that can be used to help establish a project’s nutrient balance is presented in Annex B. Guidance on quantitative parameters that can be used to establish a project’s water consumption can be found in Annex C.

Environmental Monitoring

56. The indicators in Table 1 can be used to monitor the effectiveness of EHS measures applied to the unit of production. This list of indicators is not crop-specific and can be generally applied to most crop production systems.

57. The performance indicators in Table 1 do not have minimum threshold requirements, as these are difficult to establish at the global level. When consistently measured and monitored as part of the farm management plan implementation, they can be used to determine the effectiveness of risk mitigation actions and to enable adaptive management, where necessary. In addition, some indicators of resource efficiency can be used to demonstrate gradual improvements in resource efficiency against a baseline. Baselines should be measured for individual projects.

58. Environmental monitoring programs for this sector should be implemented to address all activities that have been identified to have potentially significant impacts on the environment, during both normal operations and upset conditions. This may include parameters such as water quality, including water used for irrigation; soil quality; and pesticide and crop nutrient use among others. Environmental monitoring activities should be based on direct or indirect indicators of emissions, effluents, and resource use applicable to the particular project. They should include monitoring of community impacts—such as those from waste, discharges, and emissions from any processing activities—through a well-designed monitoring program.

59. Monitoring frequency should be sufficient to provide representative data for the parameter being monitored. Monitoring should be conducted by trained individuals following monitoring and record-keeping procedures and equipment should be properly calibrated and maintained. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards, so that any
necessary corrective actions can be taken. Additional guidance on applicable sampling and analytical methods for emissions and effluents is provided in the General EHS Guidelines.
### TABLE 1: CORE PERFORMANCE INDICATORS FOR ANNUAL CROP PRODUCTION SYSTEMS

<table>
<thead>
<tr>
<th>PERFORMANCE INDICATOR</th>
<th>EXAMPLES OF MEASUREMENT</th>
<th>MONITORING CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual crop management plan</td>
<td>Yes/ No</td>
<td>A site-specific farm management plan is available for review and updated annually.</td>
</tr>
<tr>
<td>WATER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water quality (on-site and off-site water supplies)</td>
<td>Biochemical oxygen demand (BOD) (mg/L), pH, total suspended solids (TSS) (mg/L), turbidity (nephelometric turbidity unit), nutrients (mg/L), or other potential pollutants</td>
<td>Water quality parameters should not deteriorate from baseline measurement levels. For off-site water supplies, measurement and monitoring according to vulnerable areas and key risks (such as earthworks) should take place and plans may include measurement of TSS at discharge, but also in the upstream and downstream river/stream (mg/L).</td>
</tr>
<tr>
<td>Irrigation water – pesticides, nitrates, coliform, or other potential agricultural contaminants</td>
<td>See above</td>
<td>Concentrations should not exceed those described in national irrigation water quality standards or internationally recognized guidelines (e.g., WHO Water Guidelines applicable to irrigation water quality), whichever are the more stringent.</td>
</tr>
<tr>
<td>On-site water supplies – pesticides, nitrates, coliform, or other potential agricultural contaminants</td>
<td>See above</td>
<td>Concentrations should not exceed those described in national drinking water quality standards or internationally recognized guidelines (e.g., WHO Irrigation or Drinking Water Guidelines for compounds potentially present in on-site groundwater wells or surface waters), whichever are the more stringent.</td>
</tr>
<tr>
<td>Water resource efficiency</td>
<td>Liters per hectare and liters per ton of product</td>
<td>Projects should aim to measure and improve water resource efficiency (e.g., liters/ha and liters/t of product) and assess on a seasonal basis whether water use is in line with water availability within the watershed.</td>
</tr>
<tr>
<td>SOIL AND SOIL MANAGEMENT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil erosion and soil erosion risk</td>
<td>Tons per hectare per year</td>
<td>Projects should aim to reduce erosion hazard rating levels, which should be assessed annually based on topography and slope, ground cover, exposed and bare soil, evidence of sheet, gully, and/or rill erosion; recent sedimentation; silt deposition in streams; and exposed plant roots.</td>
</tr>
</tbody>
</table>
| Nutrient application and management | Kg nutrient per ha | ✓ Soil maps appropriate to culture are available  
✓ Soil analysis indicating nutrient deficiencies is available  
✓ Fertility prescriptions are in place and supported |
### TABLE 1: Core Performance Indicators for Annual Crop Production Systems (Cont.)

<table>
<thead>
<tr>
<th>Performance Indicator</th>
<th>Examples of Measurement</th>
<th>Monitoring Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PESTICIDE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use and effectiveness of pesticides</td>
<td>Active ingredient usage per ton of market product and/or per hectare treated</td>
<td>System in place that allows effective identification of phytosanitary problems and effective treatment.</td>
</tr>
<tr>
<td>Pesticide residues on site soil</td>
<td>Active ingredient in g/ha</td>
<td>These parameters should fall below applicable tolerance levels.¹</td>
</tr>
<tr>
<td>Pesticide residues on produce</td>
<td>Active ingredient in µg/kg of product</td>
<td>These parameters should fall below maximum residue levels.</td>
</tr>
</tbody>
</table>

| **AIR QUALITY, AIR EMISSIONS, AND ENERGY USE** |                     |
| Energy use | MJ/t product, kWh consumed, kWh/ha crop, kWh/t crop product | Projects should aim to show improvements in energy efficiency. Systems to monitor and report energy use and efficiency should be implemented. |

| Particulate matter | Depositional dust (g/m²/month) PM10, PM2.5 | Strategically placed depositional dust gauges or PM2.5/PM10 air quality monitoring equipment, e.g., Tapered Element Oscillating Microbalance (TEOM), especially near sensitive receptors (e.g., clinic near a busy harvest road). |

Notes:


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### 2.2 Occupational Health and Safety

**Occupational Health and Safety Guidelines**

22-60 Occupational health and safety performance should be evaluated against internationally published exposure guidelines, examples of which include the Threshold Limit Value (TLV®) occupational...
exposure guidelines and Biological Exposure Indices (BEIs®), published by the American Conference of Governmental Industrial Hygienists (ACGIH®), the Pocket Guide to Chemical Hazards, published by the United States National Institute for Occupational Health and Safety (NIOSH®), Permissible Exposure Limits (PELs®), published by the Occupational Safety and Health Administration of the United States (OSHA®), Indicative Occupational Exposure Limit Values, published by European Union member states, or other similar sources.

**Accident and Fatality Rates**

Projects should try to reduce the number of accidents among project workers (whether directly employed or subcontracted) to a rate of zero, especially accidents that could result in lost work time, different levels of disability, or even fatalities. Facility rates may be benchmarked against the performance of facilities in this sector in developed countries through consultation with published sources (e.g., U.S., U.K., Health and Safety Executive).

**Occupational Health and Safety (OHS) Monitoring**

Monitoring should be designed and implemented by accredited professionals as part of an occupational health and safety monitoring program. Facilities should also maintain a record of occupational accidents and diseases, dangerous occurrences, and accidents. Additional guidance on occupational health and safety monitoring programs is provided in the General EHS Guidelines.

Where pesticides are used, the health conditions of the workers who handle pesticides should be monitored through periodic health exams that include clinical assessment and blood/urine testing of relevant bio-indicator parameters (e.g., for organo-phosphates, cholinesterase, and alkylphosphates).

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61 Available at: http://www.acgih.org/TLV/ and http://www.acgih.org/store/
62 Available at: http://www.cdc.gov/niosh/npg/
63 Available at: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992
65 Accredited professionals may include Certified Industrial Hygienists, Registered Occupational Hygienists, or Certified Safety Professionals or their equivalent.
3.0 References and Additional Sources


DAAS.


Environmental, Health, and Safety Guidelines

ANNUAL CROP PRODUCTION

2007 version vs 2016 draft revised version


APRIL 30, 2007
Environmental, Health, and Safety Guidelines

ANNUAL CROP PRODUCTION

2007 version vs 2016 draft revised version

European Food Safety Authority (EFSA). Available at http://europa.eu.int/comm/food/index_en.htm
http://www.efsa.europa.eu


European Agency for Safety and Health at Work. 2006. Available at http://europe.osha.eu.int/OSHA


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Danube River Basin Project. Reduction of Pollution Releases through Agricultural Policy Change and Demonstrations by Pilot Projects. UNDP and GEF. http://www.icpdr.org/main/sites/default/files/1.2-3_Agri%20Pilot%20Project_-Ph-II_FINALR_31Jan07-f.pdf


Annex A: General Description of Industry Activities

24-64. Cultivation of annual crops in developing countries is characterized by a wide range of crops, soil types, and climatic conditions. Modification of the environment varies from minimal to intensive. Land use, production levels, and associated costs reflect these and other parameters. The land areas used for production may vary from a few to many hundreds thousands of hectares.

25-65. Modern machinery gives farmers the opportunity to farm greater areas. The tractor, a central tool in crop production, provides power to implement crop production and handling operations. Tractors are most often used to pull equipment through the field and to provide power to rotate equipment components—called power takeoff (PTO). A modern farm tractor is usually equipped with a diesel engine with an output ranging from less than 40 to more than 400 PTO horsepower. 67

26-66. The lifetime of an annual crop is, by definition, one year or at least one growing season; that falls within one year. More than one crop may be produced on the area during one year. However, a single crop is just one cycle of production for a business, which continues for many years, alternating with occasional other crops and fallow periods of fallow or rejuvenation. Rotational practices are determined by nutrient management and economic considerations. In some cases, monoculture, or production of the same annual crop year after year, takes place. Typically, post-harvest operations lead straight to the next field preparation phase. The production cycle is illustrated in Figure A-1, and each step is described below as it applies to grain production.

67 Additional information and examples of temperate climate farming systems are provided on the US EPA’s Agricultural Center website, which provides an overview of the crop production cycle as well as a breakdown of the machinery used at each stage. See http://www.epa.gov/agriculture/ag101/index.html.
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2007 version vs 2016 draft revised version

Figure A.1: Crop Production Cycle

Post-harvest
Soil preparation
Sowing or planting
Growing phase (crop husbandry)

Figure A.1: Crop Production Cycle

Post-harvest
Soil preparation
Sowing or planting
Growing phase (crop husbandry)
Soil Preparation

27.67. Before planting, the soil needs to be prepared to establish a seed bed and to manage the weed plants in the seedbed. In most farming systems, weeds are managed by tillage and herbicide application. Tillage can occur anytime between harvest of the previous year's crop and planting of the new crop. The three main tillage methods vary according to the degree to which the soil is inverted, the resulting amount of crop residue they leave on the surface, and the need to incorporate fertilizers or pH correctives, as summarized in Table A-1. Crop residue is an important factor because it protects soil from erosion due to wind and rain damage and slows runoff from agricultural land.

28.68. Farmers may rely on pesticides, chemical and non-chemical methods for weed control under all tillage systems, and the amount of pesticide chemicals used is more or less independent of the tillage method. Organic farming systems use the same variety of tillage methods for soil preparation but do not use herbicides. Instead, they use only a selection of approved chemical inputs. In organic operations, weeds may be removed manually or mechanically, and a certain amount of weed coverage may be tolerated by the operator.

<table>
<thead>
<tr>
<th>Tillage method</th>
<th>Description</th>
<th>Residue coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional (inversion) tillage</td>
<td>Primary tillage with moldboard plow before planting, followed by secondary tillage and mechanical cultivation after the crop is up.</td>
<td>&lt; 15%</td>
</tr>
<tr>
<td>Reduced (non-inversion) tillage</td>
<td>Tillage without inverting the soil layer, typically using chisel plow</td>
<td>15%–30%</td>
</tr>
<tr>
<td>Conservation tillage</td>
<td>No till (herbicide is applied directly on last season's crop residue), strip till (only the narrow strip used for the crop row is tilled), ridge till (ridges on which the crop is planted are formed during cultivation or after harvest and maintained from year to year in the same location), and mulch till (full-width tillage that disturbs all of the soil surface but retains most of the residue on the land surface).</td>
<td>&gt; 30%</td>
</tr>
</tbody>
</table>
Sowing and Planting

Sowing and planting ideally take place right after tillage to reduce soil erosion. The main equipment used in sowing includes tractor-drawn drills and planters, which open a furrow, meter and deliver the seeds, and cover the seeds with soil. Some planters can cut through residues and till small strips of soil in each row at the time of planting. Planters can also be equipped to apply fertilizer and pesticides during planting.

Crop Husbandry

The main activities in crop husbandry include nutrient management, pest, weed, and disease management, and integrated water management.

Nutrient Management

When applied in proper quantities and at appropriate times, nutrients—especially nitrogen (N), phosphorus (P), and potassium (K)—help achieve optimum crop yields. Nutrient management is the practice of using nutrients wisely for optimum economic benefit, taking into account costs for fertilizers and revenues from crops, while minimizing negative impacts on the environment.

N, P, and K plant nutrients can be applied to the soil in the form of chemical fertilizers, manure, and sewage sludge using spreaders or sprayers. Common nitrogenous chemical fertilizers include anhydrous ammonia, urea, ammonium nitrate and urea solutions, and ammonium nitrate. The use of synthetic nitrogenous fertilizers is prohibited in organic agriculture; alternatives include mineral fertilizers and manure, compost, and sludge, which is why organic farms often integrate crop and livestock production.

Pest, Weed, and Disease Management – Integrated Pest Management (IPM)

Weeds, insects, and disease can all contribute to yield loss in annual crops. Pesticides include herbicides used to manage unwanted weed species, fungicides to manage fungal diseases, insecticides to manage insect pests, and acaricides to manage mites. The application of pesticides, in general, most cases, is not an option for organic agricultural operations. Instead, alternative biological and physical means are used to prevent unacceptable losses from pests, for example, the release of pest predators and parasites.

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Water Management

34.74. Water may be applied during the production cycle depending on crop needs and the climatic conditions during the growth phase. When used for irrigation, water may be applied in many ways, such as drip irrigation (including the application of a water-fertilizer mix known as “fertigation”), open canal irrigation, simple sprinklers, or large-scale irrigation machines, which are either stationary or move through the crops, as well as other variations.

Harvest

35.75. Field crops are often harvested by machine, while other crops may be picked manually. Mechanized equipment is usually used to harvest grain and seed crops. The major functions performed by a combine harvester include cutting and gathering, feeding, threshing, separating, cleaning, and grain-handling operations in the field.

Postharvest Storage and Processing

36.76. Postharvest storage and processing of crops includes removing unwanted fractions of the product, such as cereal glumes and the outer leaves of vegetables; sorting; washing to remove soil or other contaminants that reduce product quality; drying, either in the field or in farm buildings; and storage. Postharvest storage and processing may require the application of pesticides to storage locations or to the product itself to prolong its shelf life. Machinery to transport the crop product into and out of storage includes belts and augers, as well as tractors with various attachments. Storage buildings can vary from simple sheds and silos to large and complex containers with controlled temperature, humidity, and air quality.
Annex B: Nutrient Consumption

19. Using a fertilizer logbook, farmers should document the use of each nutrient. Table B-1 presents examples of the average uptake of nutrients by selected plant species. Nitrogen, phosphorus, and potassium quantities should be expressed as pure substances, because the actual weight of pure substances used in the product varies among different commercial products. It is important to recycle the nutrients present in crop residues. The nutrient content of selected crop residues is presented in table B-2.

### Table B-1: Examples of Nutrient Uptake by Selected Annual Crops

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Nutrient Uptake (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Cereals</td>
<td>2.30-3.15</td>
</tr>
<tr>
<td>Rape</td>
<td>4.61</td>
</tr>
<tr>
<td>Leguminous plants</td>
<td>5.70-7.80</td>
</tr>
<tr>
<td>Potato and fodder beetroot</td>
<td>0.31</td>
</tr>
<tr>
<td>Sugar beetroot</td>
<td>0.54</td>
</tr>
<tr>
<td>Silage maize</td>
<td>0.38</td>
</tr>
<tr>
<td>Lucerne, clover</td>
<td>0.80</td>
</tr>
<tr>
<td>Mixtures for green fodder</td>
<td>0.40</td>
</tr>
</tbody>
</table>

### Table B-2: Nutrient Residues in Selected Annual Crops

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Amount produced (ton/ha)</th>
<th>Nutrient Content (kg/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize stover</td>
<td>3 t/ha</td>
<td>10 2 12</td>
</tr>
<tr>
<td>Rice straw</td>
<td>1.5 t/ha</td>
<td>4.7 0.7 12</td>
</tr>
<tr>
<td>Wheat straw</td>
<td>1 t/ha</td>
<td>3 0.8 14</td>
</tr>
</tbody>
</table>

NOTES:
- With appropriate bulk of by-products
- Nitrogen fixed by Rhizobium from the atmosphere
Annex C: Water Consumption
Water consumption per crop can be calculated and compared with a theoretical standard value. In practice, the requirements for irrigation water depend on crop species, soil type, evaporation, and water conservation practices. The Food and Agriculture Organization (FAO) provides guidance on water management and how to calculate appropriate irrigation.

**CROPWAT**70 is a practical toolcomputer program for the personal computer that can complete standard calculations for evapotranspiration and calculation of crop water requirements and crop irrigation requirements and, more specifically, based on soil, climate, and crop data that can help design and manage irrigation schemes.

It allows the development of recommendations for improved irrigation practices, the planning of irrigation schedules under varying water supply conditions, and the assessment of production under rain-fed conditions or deficit irrigation. Calculations of crop water requirements and irrigation requirements are carried out with inputs of climatic and crop data. Standard crop data are included in the program and

<table>
<thead>
<tr>
<th>Annual Crop</th>
<th>Crop water need (mm in total growing period)</th>
<th>Typical yield and efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beans</td>
<td>300 – 500</td>
<td>Good commercial yield in favorable environments under irrigation is 6 – 8 ton/ha fresh and 1.5 – 2 ton/ha dry seed. The water utilization efficiency for harvested yield (Ey) for fresh beans containing 80 – 80% moisture is 1.5 – 2.0 kg/m³ and for dry beans containing about 10% moisture is 0.3 – 0.6 kg/m³.</td>
</tr>
<tr>
<td>Cotton</td>
<td>700 – 1300</td>
<td>A good yield of a 160 – 180 day cotton crop under irrigation is 4 – 5 ton/ha seed cotton of which 35% is lint. Water utilization efficiency for harvested yield (Ey) for seed cotton containing about 10% moisture is 0.4 – 0.6 kg/m³.</td>
</tr>
<tr>
<td>Maize</td>
<td>500 – 800</td>
<td>Under irrigation a good commercial grain yield is 6 to 9 ton/ha (10 – 13% moisture). The water utilization efficiency for harvested yield (Ey) for grain varies then between 0.6 and 1.4 kg/m³.</td>
</tr>
<tr>
<td>Sorghum/ Millet</td>
<td>450 – 650</td>
<td>A good yield under irrigation is 3.5 – 5 ton/ha (12 – 15% moisture). The water utilization efficiency for harvested yield (Ey) for grain is between 0.6 and 1.0 kg/m³.</td>
</tr>
<tr>
<td>Soybean</td>
<td>450 – 700</td>
<td>The giant varieties, grown for poultry feeding and human consumption because of their low oil content, produce seed yields in the range of 0.8 – 1.5 ton/ha under rain-fed conditions. The seeds of dwarf and semi-dwarf varieties contain 25 – 35% oil and give a total yield similar to the giant varieties. New Russian varieties with seeds of low hull content have an oil content of up to 50%. Under irrigation seed yields of 2.5 – 3.5 ton/ha are commonly obtained. The water utilization efficiency for harvested yield (Ey) for seed containing 6 – 10% moisture is 0.4 – 0.7 kg/m³.</td>
</tr>
<tr>
<td>Sunflower</td>
<td>600 – 1000</td>
<td>The giant varieties, grown for poultry feeding and human consumption because of their low oil content, produce seed yields in the range of 0.8 – 1.5 ton/ha under rain-fed conditions. The seeds of dwarf and semi-dwarf varieties contain 25 – 35% oil and give a total yield similar to the giant varieties. New Russian varieties with seeds of low hull content have an oil content of up to 50%. Under irrigation seed yields of 2.5 – 3.5 ton/ha are commonly obtained. The water utilization efficiency for harvested yield (Ey) for seed containing 6 – 10% moisture is 0.4 – 0.7 kg/m³.</td>
</tr>
<tr>
<td>Potato</td>
<td>500 – 700</td>
<td>Good yields under irrigation of a crop of about 120 days in the temperate and subtropical climates are 25 – 35 ton/ha fresh tubers and in tropical climates yields are 15 – 25 ton/ha. The water utilization efficiency for harvested yield (Ey) for tubers containing 70 – 75% moisture is 0.4 – 0.7 kg/m³.</td>
</tr>
<tr>
<td>Wheat</td>
<td>450-650 (for high yields)</td>
<td>A good yield of wheat under irrigation is 4 – 6 ton/ha (12 – 15% moisture). The water utilization efficiency for harvested yield (Ey) for grain is about 0.8 – 1.0 kg/m³.</td>
</tr>
</tbody>
</table>

**NOTES:**

climatic data can be obtained for 144 countries through the CLIMWAT database. Examples of water requirements of individual crops and typical yields and efficiencies are presented in table C-1. Crop-specific evapotranspiration factors (crop coefficients—Kc) form the basis of crop water calculations. Table B-1 shows the single-crop coefficients for selected crops. It is provided for illustrative purposes only and demonstrates that water requirements vary over the growing season, influencing the risks and impacts of a particular project. The total water requirements are therefore affected by the length and time of the growing season, which must also be considered when estimating whether crop water requirements are in line with water availability.

79. The risks and impacts associated with water use should consider the status of the river basin within which the project is located.

<table>
<thead>
<tr>
<th>Table B.1: Indicative Single-Crop Coefficients (Kc) for Selected Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crop</strong></td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>Maize</td>
</tr>
<tr>
<td>Sugar beet</td>
</tr>
<tr>
<td>Soy Beans</td>
</tr>
<tr>
<td>Broccoli/carrots/cauliflower</td>
</tr>
<tr>
<td>Sunflower</td>
</tr>
<tr>
<td>Broadbean</td>
</tr>
<tr>
<td>Cotton</td>
</tr>
<tr>
<td>Sisal</td>
</tr>
</tbody>
</table>

1 Crop coefficient during the initial crop development stage. These values are subject to the effects of large variations in wetting frequencies. For frequent wettings, such as with high-frequency sprinkler irrigation or rainfall, the values for Kc_initial may increase substantially.
2 Crop coefficient in the mid-season.
3 Crop coefficient at the end of the season.
** The lower value is for rainfed crops with lower plant density.


71 FAO AGL (2003).
72 The effects of the integration over time represent an average wetting frequency for a “standard” crop under typical growing conditions in an irrigated setting.