

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).¹ 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/ehsguidelines.
2. The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in crop production areas by existing technology at reasonable costs. Application of the EHS Guidelines to existing 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 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. This document includes information relevant to large-scale production, harvesting, post harvesting processing and storage of major annual crops, including cereals, pulses, roots and tubers, oil-bearing crops, fiber crops, vegetables, and fodder crops, located in both temperate and tropical regions. It does not include the processing of raw materials into semi-finished and finished products. Perennial crop production is

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.

addressed in the EHS Guidelines for Perennial Crop Production. Annex A contains a description of industry activities for this sector.

This document is organized in the following manner:

1. Industry-Specific Impacts and Management	2
1.1 Environment.....	2
1.2 Occupational Health and Safety	16
1.3 Community Health and Safety	21
2. Performance Indicators Monitoring	22
2.1 Environment.....	22
2.2 Occupational Health and Safety	25
3. References	26
Annex A. General Description of Industry Activities	31
Annex B. Water Management.....	35

1. 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

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 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.

10. Soil erosion may result from poor crop cover after land preparation and lack of soil conservation structures on sloping land planted with annual crops.² 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 suited or adapted to the local climate and soil conditions and adopt good agronomic practices³ to optimize crop productivity.

² Fred R. Weber and Marilyn W. Hoskins, “Soil Conservation Technical Sheets,” Forest, Wildlife and Range Experiment Station (University of Idaho, 1983).

³ 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

- 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

12. Nutrient management strategies⁴ should aim to maintain and/or improve soil fertility and optimize crop yield while minimizing off-site environmental impact (e.g., contamination of groundwater resources and eutrophication of surface water resources from surface runoff and leaching of nutrients). Consider the following practices:

- Consider the use of green manures, cover crops, or mulching techniques to maintain soil cover, reduce the loss of nutrients, replenish soil organic matter, and capture and/or conserve moisture.
- 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 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.

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.

⁴ Roy et al., "Plant Nutrition for Food Security, A Guide for Integrated Nutrient Management," (FAO, 2006) www.nutrientstewardship.com.

- Conduct periodic soil analysis to detect changes in soil fertility, inform decisions on fertilizer application rates, and avoid unsustainable nutrient depletion and over-fertilization.
- Establish and respect setbacks from watercourses—including appropriate buffer zones, strips, or other “no-treatment” areas along water sources, rivers, streams, ponds, lakes, and ditches—to act as a filter for 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 nutrient planning, monitoring, and documentation, which includes the use of a fertilizer logbook to record the following information:
 - Dates of purchase, dates of use, amount of fertilizer and nutrient used (kg/ha), purpose of use, and crop growth stage.
 - 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.⁵
- 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

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) 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

⁵ FAO, *Guidelines and Reference Material on Integrated Soil and Nutrient Management and Conservation for Farmer Field Schools*, (Rome: FAO, 2000) <http://www.fao.org/docs/eims/upload/230157/misc27.pdf>.

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.^{6,7}

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,⁸ 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,

⁶ FAO, *Guidelines for the Management of Small Quantities of Unwanted and Obsolete Pesticides*, (Rome: UNEP, WHO, and FAO, 1999) http://www.fao.org/fileadmin/user_upload/obsolete_pesticides/docs/small_qties.pdf.

⁷ 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.

⁸ Global Water Partnership.

develop an appropriate irrigation plan and schedule, and monitor consumption and compare regularly with these targets which should be based on available supplies of water

- 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.
 - 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-spraying, 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

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)⁹ 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.
 - Consider using mechanical controls—such as traps, barriers, light, and sound—to kill, relocate, or repel pests.
 - Use pesticides to complement these approaches, not replace them.
 - 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

⁹ 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.

of soils, wildlife, groundwater, or surface water resources caused by accidental spills during the transfer, mixing, storage, and application of pesticides, they should be stored, 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,¹⁰ Rotterdam,¹¹ and Basel¹² 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.¹³
- Do not purchase, store, use, or trade pesticides that fall under the World Health Organization's (WHO) Recommended Classification of Pesticides¹⁴ by Hazard Classes 1a (extremely hazardous) and 1b (highly hazardous), or Annexes A and B of the Stockholm Convention.¹⁵
- 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, 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

Recommended pesticide storage practices include:

- 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.

¹⁰ <http://chm.pops.int/>.

¹¹ <http://www.pic.int/>.

¹² <http://www.basel.int/>.

¹³ FAO, *International Code of Conduct on Pesticides Management* (revised 2014), (Rome: FAO, 2014) http://www.fao.org/fileadmin/templates/agphome/documents/Pests_Pesticides/Code/CODE_2014Sep_ENG.pdf.

¹⁴ World Health Organization (WHO), *Recommended Classification of Pesticides by Hazard and Guidelines to Classification*, (Geneva, 2009) http://www.who.int/ipcs/publications/pesticides_hazard/en/.

¹⁵ The Stockholm Convention on Persistent Organic Pollutants 2011.

- 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 route¹⁶ 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 and ensure non target organisms are not affected.
- 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.

¹⁶ Possible routes of exposure are skin contact, eye contact, inhalation (respiratory system), and ingestion (swallowing).

Disposal

- 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, 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 and Ecosystems

20. 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,¹⁷ 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

¹⁷ UNDP, *Protecting Biodiversity in Production Landscapes*, (UNDP: South Africa, 2012).

to identify species and sites of importance within the broader region or landscape. Tools, such as the Integrated Biodiversity Assessment Tool (IBAT),¹⁸ can facilitate access to key international data sets. Sites of local, regional, and international importance¹⁹ 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),²⁰ 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.²¹ 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 allow 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.,

¹⁸ <http://www.ibatforbusiness.org>.

¹⁹ EC Guidance Document, *Wind Energy Developments and Natura 2000*, (European Commission, 2011).

²⁰ Convention on Biological Diversity National Biodiversity Strategies and Action Plans (NBSAPs) Search <http://www.cbd.int/nbsap/search/default.shtml>.

²¹ E. Brown et al., "Common Guidance for the Identification of High Conservation Values," (2013).

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.

27. Developers should use planting material that does not contain seeds from invasive alien species and that 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.

Genetically-Modified Crops (GM Crops)

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 modern biotechnology.²² Environmental concerns related to the introduction of GM crops should be addressed and appropriate assessment conducted to demonstrate that human and environmental risks (if any) are acceptable.

29. The introduction of GM annual crops should be conducted in compliance with the host country's regulatory framework. If such a regulatory framework does not exist in the host country, the applicability of the Cartagena Protocol on Biosafety²³ should be verified and used to scientifically evaluate the potential impacts and risks related to a specific crop's introduction, including its invasive potential, and identify appropriate mitigation measures. The next steps in the risk assessment are to evaluate the likelihood of such events occurring, the consequences if they should occur, and whether the overall risks (i.e., likelihood and consequence) are acceptable or manageable.

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

²² Cartagena Protocol on Biosafety to the Convention on Biological Diversity (<http://bch.cbd.int/protocol>).

²³ Ibid.

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.
- 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

32. Atmospheric emissions are primarily associated with emissions of combustion by-products—including carbon dioxide (CO₂), sulfur dioxide (SO₂), nitrogen oxide (NO_x), and particulate matter (PM)—resulting from the operation of mechanized equipment or from combustion by-products from the disposal or destruction of crop residues 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:

- 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).
- 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 NO_x from fertilizer use, methane from paddy fields,²⁴ 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 NO_x 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.²⁵

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 NO_x will be emitted during the combustion process, in

²⁴ 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)).

²⁵ Various opportunities for mitigating GHG emissions through water management are discussed in T. K. Adhya et al., "Wetting and Drying: Reducing Greenhouse Gas Emissions and Saving Water from Rice Production," Working Paper, Installment 8 of Creating a Sustainable Food Future, (Washington, DC: World Resources Institute, 2014) <http://www.wri.org/sites/default/files/wetting-drying-reducing-greenhouse-gas-emissions-saving-water-rice-production.pdf>.

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.
- Avoid open burning of biomass during site preparation, field operations, and post-harvest.
- 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

38. In developing suitable plans for mitigating environmental, health, and safety risks associated with all annual crops, the hierarchy of controls²⁶ 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
 - 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

39. 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; and
- Over-exposure to noise, vibration, and extreme or adverse weather conditions.

²⁶ <http://www.cdc.gov/niosh/topics/ctrlbanding/>.

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.²⁷ 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 trimmers) can cause hand/arm problems or hearing loss.

Machinery and Vehicles

41. Accidents may occur in the use of machines and vehicles, including worker transportation, farm tractors, harvesting machinery, and a variety of other machines 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 asset; 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 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 working the land. Occupational safety and health impacts and controls relating to equipment and vehicle operation and repair are discussed in the **General EHS Guidelines**.

Confined and Restricted Space Entry

43. Occupational health and safety hazards associated with confined and restricted spaces on farms (e.g., processing bins and silos, product storage bins, water tanks, inadequately ventilated buildings, areas treated with pesticides, etc.) include risk of asphyxiation; explosions due to 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 subject to permitted supervision by properly trained persons, as described in the **General EHS Guidelines**. Restricted areas should be clearly marked and clearly conveyed to personnel and contractors.

Exposure to Organic Dust

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 grain. Acute toxic alveolitis, otherwise known as organic dust toxic syndrome, can

²⁷ ILO 2011.

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.

45. 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)).²⁸
- 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 suitable filtration/ventilation.
- Store only dry grain (and dry, well-cured forages and hay) to reduce microorganism growth.

46. 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 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.²⁹

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.

²⁸ Threshold Limit Value (TLV®) occupational exposure guidelines published by the American Conference of Governmental Industrial Hygienists (ACGIH).

²⁹ For example, EN 1127-1 Explosive Atmospheres - Explosion Prevention and Protection; EN 13463-1 Non-Electrical Equipment for Potentially Explosive Atmospheres; NFPA 61 Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities, 2013 Edition, OSHA Grain Handling Facilities Standard 29 CFR 1910.272.

Combustible Dust and Silo Safety

48. The following measures are recommended as a means of preventing and controlling fires and explosions from combustible dust:³⁰

- Use recognized international standards in design and operation.³¹
- Classify areas according to respective hazard classes following practices and requirements found in recognized international standards³² 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.

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:

- 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).

³⁰ Persson (2013); Krause (2009); France, MEDDAT (2008).

³¹ E.g., EN 1127-1 Explosive Atmospheres - Explosion Prevention and Protection; EN 13463-1 Non-Electrical Equipment for Potentially Explosive Atmospheres; NFPA 61: Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities, 2013 Edition; NFPA 654 Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids; OSHA 29 CFR 1910.272 Grain Handling Facilities Standard.

https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9874; Directive 94/9/EC on Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres (ATEX) <http://ec.europa.eu/growth/sectors/mechanical-engineering/atex/>; Arrêté du 29/03/04 relatif à la prévention des risques présentés par les silos de céréales, de grains, de produits alimentaires ou de tout autre produit organique dégageant des poussières inflammables http://www.ineris.fr/aida/consultation_document/5163.

³² U.S. National Electrical Code.

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 certifications³³—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.

³³ 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>.

- Ensure that hygiene practices are followed (in accordance with FAO³⁴ 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

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:

- Potential exposure to pesticides (e.g., spray drift, improper disposal and use of packaging and containers) and presence of pesticides or by-products in potentially harmful concentrations in foodstuffs and postharvest products.
- Potential exposure to pathogens and noxious odors associated with the use of manure.
- Potential exposure to air emissions from fires, burning of crop waste, residues, or solid waste (e.g., packaging).
- Increased risk of vehicle or machinery injuries on roads and access routes around the community.

54. While odors from manure—especially during application—are not generally hazardous, they can be a serious source of discomfort to the community. Avoid burning of residual crop and other wastes, which creates harmful air emissions that may adversely impact surrounding communities.

55. Specific recommendations to minimize risks to communities include:

- Monitor and record all potentially harmful products and activities and manage them to minimize the 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 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.

³⁴ FAO 2014.

- Use biological or lower-risk-profile products, if available.
- Respect pre-harvest intervals and post-harvest withholding periods for products that have been treated with pesticides to avoid unacceptable levels of residues.³⁵
- 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.

2. PERFORMANCE INDICATORS MONITORING

2.1 Environment

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. 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. 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**.

³⁵ Examples of potentially applicable pesticide tolerance requirements include the FAO/WHO (1962–2005) Codex Alimentarius' Maximum Residue Limits in Foods and 40 CFR Part 180, Tolerances and Exemptions from Tolerances for Pesticide Chemicals in Food, the latter of which applies to crops sold in the United States.

TABLE 1: CORE PERFORMANCE INDICATORS FOR ANNUAL CROP PRODUCTION SYSTEMS

PERFORMANCE INDICATOR	EXAMPLES OF MEASUREMENT	MONITORING CRITERIA
Annual crop management plan	Yes/ No	A site-specific farm management plan is available for review and updated annually.
WATER		
Water quality (on-site and off-site water supplies)	Biochemical oxygen demand (BOD) (mg/L), pH, total suspended solids (TSS) (mg/L), turbidity (nephelometric turbidity unit), nutrients (mg/L), or other potential pollutants	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).
Irrigation water – pesticides, nitrates, coliform, or other potential agricultural contaminants	See above	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), ^a whichever are the more stringent.
On-site water supplies – pesticides, nitrates, coliform, or other potential agricultural contaminants	See above	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), ^b whichever are the more stringent.
Water resource efficiency	Liters per hectare and liters per ton of product	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. ^c
SOIL AND SOIL MANAGEMENT		
Soil erosion and soil erosion risk	Tons per hectare per year	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.
Nutrient application and management	Kg nutrient per ha	<ul style="list-style-type: none"> ✓ 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.)		
PERFORMANCE INDICATOR	EXAMPLES OF MEASUREMENT	MONITORING CRITERIA
PESTICIDE		
Use and effectiveness of pesticides	Active ingredient usage per ton of market product and/or per hectare treated	System in place that allows effective identification of phytosanitary problems and effective treatment.
Pesticide residues on site soil	Active ingredient in g/ha	These parameters should fall below applicable tolerance levels. ^d
Pesticide residues on produce	Active ingredient in µg/kg of product	These parameters should fall below maximum residue levels.
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/m ² /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).
<p>Notes:</p> <p>^a WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater. Volume 2: Wastewater Use in Agriculture http://www.who.int/water_sanitation_health/wastewater/gsuww/en/</p> <p>^b WHO Guidelines for Drinking Water Quality http://www.who.int/water_sanitation_health/dwg/en/</p> <p>^c See FAO (1998) Crop evapotranspiration – Guidelines for computing crop water requirements and Cropwat 8.0 tool - www.fao.org/nr/water/infores_databases_cropwat.html</p> <p>^d Examples of potentially applicable pesticide tolerance requirements and maximum residue levels include: Food and Agriculture Organization Codex Alimentarius' Maximum Residue Limits in Foods http://www.fao.org/fao-who-codexalimentarius/standards/en/; US Code of Federal Regulations Title 40, Part 180 — Tolerances and Exemptions from Tolerances for Pesticide Chemicals in Food https://www.gloablmrl.com/db#query; European Community MRLs http://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=homepage&language=EN and MRL database of the Japan Chemical Research Foundation http://www.m5.ws001.squarestart.ne.jp/foundation/search.html</p>		

2.2 Occupational Health and Safety

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);³⁶ the Pocket Guide to Chemical Hazards, published by the United States National Institute for Occupational Health and Safety (NIOSH);³⁷ Permissible Exposure Limits (PELs), published by the Occupational Safety and Health Administration of the United States (OSHA);³⁸ Indicative Occupational Exposure Limit Values, published by European Union member states,³⁹ or other similar sources.

Accident and Fatality Rates

61. 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. Fatality rates may be benchmarked against the performance of facilities in this sector in developed countries through consultation with published sources (e.g., U.S. Bureau of Labor Statistics and U.K. Health and Safety Executive).⁴⁰

Occupational Health and Safety (OHS) Monitoring

62. The working environment should be monitored for occupational hazards relevant to the specific project. Monitoring should be designed and implemented by accredited professionals⁴¹ as part of an OHS monitoring program. Facilities should also maintain a record of occupational accidents, diseases, dangerous occurrences, and accidents. Additional guidance on OHS monitoring programs is provided in the **General EHS Guidelines**.

63. 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).

³⁶ <http://www.acgih.org/tlv-bei-guidelines/policies-procedures-presentations/overview> and <http://www.acgih.org/store/>.

³⁷ <http://www.cdc.gov/niosh/npg/>.

³⁸ http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992.

³⁹ <https://osha.europa.eu/en/legislation/directives/exposure-to-chemical-agents-and-chemical-safety/osh-directives>.

⁴⁰ <http://www.bls.gov/iif/> and <http://www.hse.gov.uk/statistics/index.htm>.

⁴¹ Accredited professionals may include Certified Industrial Hygienists, Registered Occupational Hygienists, or Certified Safety Professionals or their equivalent.

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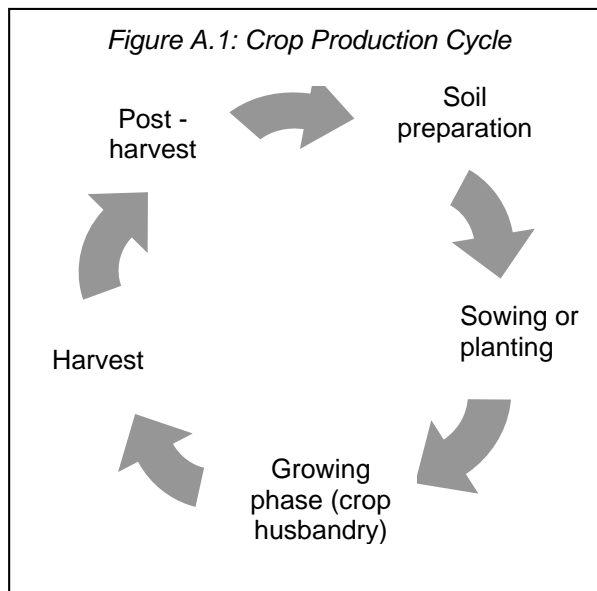
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ANNEX A. GENERAL DESCRIPTION OF INDUSTRY ACTIVITIES

64. Cultivation of annual crops 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 thousands of hectares.

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.⁴²

66. The lifetime of an annual crop is one growing season that falls within one year. More than one crop may be produced on the area during one year. Annual crops are often grown in rotation across years, alternating with other crops and fallow periods. 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.



⁴² Additional information and examples of temperate climate farming systems are provided on the U.S. 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 <http://www.epa.gov/agriculture/ag101/index.html>.

Soil Preparation

67. Before planting, the soil needs to be prepared to establish a seed bed and to manage the weed plants in the seedbed. 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.

68. Farmers rely on chemical and non-chemical methods for weed control under all tillage systems, and the amount of 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 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 A.1: Tillage Methods		
Tillage method	Description	Residue coverage
Conventional (inversion) tillage	Primary tillage with moldboard plow before planting, followed by secondary tillage and mechanical cultivation after the crop is up.	< 15%
Reduced (non-inversion) tillage	Tillage without inverting the soil layer, typically using chisel plow	15%–30%
Conservation tillage	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).	> 30%

Sowing and Planting

69. 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

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

Nutrient Management

71. When applied in proper quantities and at appropriate times, nutrients—especially nitrogen (N), phosphorus (P), and potassium (K)—help achieve optimum crop yields.⁴³ 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.

72. 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 manure, compost, and sludge, which is why organic farms often integrate crop and livestock production.

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

73. 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 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.

Water Management

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 that are either stationary or move through the crops, as well as other variations.

Harvest

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

⁴³ R. N. Roy *et al.*, “Plant Nutrition for Food Security, A Guide for Integrated Nutrient Management,” *FAO Fertilizer and Plant Nutrition Bulletin 16*, 2006, <ftp://ftp.fao.org/agl/agll/docs/fpnb16.pdf>.

harvester include cutting and gathering, feeding, threshing, separating, cleaning, and grain-handling operations in the field.

Post-Harvest Storage and Processing

76. Post-harvest 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. Post-harvest 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. WATER CONSUMPTION

77. Water consumption per crop can be calculated and compared with a theoretical standard value. In practice, the requirements for 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.⁴⁴ CropWat is a computer program for the calculation of crop water requirements and irrigation requirements based on soil, climate, and crop data that can help design and manage irrigation schemes.

78. Crop-specific evapotranspiration factors (crop coefficients—K_c) form the basis of crop water calculations. Table B-1 shows the single-crop coefficients for selected crops.⁴⁵ 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 B.1: Indicative Single-Crop Coefficients (K_c) for Selected Crops

	Single Crop Coefficients (K _c)				Single Crop Coefficients (K _c)		
	Initial ¹	Mid ²	End ³		Initial ¹	Mid ²	End ³
Maize	0.7	1.20	0.35-0.60	Sugar beet	0.35	1.20	0.70
Rapeseed	0.35- ^{**}	1.00	0.35				
Soy Beans	0.50	1.15	0.50	Broccoli/carrots/cauliflower	0.7	1.05	0.95
Sunflower	0.35	1.0-1.15	0.35	Broadbean	0.5	1.15	0.3-1.10
Barley/oats	0.3	1.15	0.25	Cotton	0.35	1.15-1.20	0.7-0.5
Wheat	0.3-0.7	1.15	0.25-0.4	Sisal	0.35	0.4-0.7	0.4-0.7
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 K _c _{ini} 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.							
Source: Allen, R, Pereira, L.S, Raes, D and Smith, M (1998) Crop Evapotranspiration – Guidelines for Computing Crop Water Requirements – FAO Irrigation and Drainage paper 56. Food and Agriculture Organization of the United Nations. Rome. http://www.fao.org/docrep/X0490E/x0490e00.HTM .							

⁴⁴ R. Allen *et al.*, “Crop Evapotranspiration – Guidelines for Computing Crop Water Requirements,” *FAO Irrigation and Drainage Paper 56* (Rome: FAO, 1998).

⁴⁵ The effects of the integration over time represent an average wetting frequency for a “standard” crop under typical growing conditions in an irrigated setting.