

Environmental, Health, and Safety Guidelines for Plantation Crop Production

Introduction

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/ifcext/enviro.nsf/Content/EnvironmentalGuidelines

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

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

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.

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.

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

This document includes information relevant to large-scale commercial plantation crops and focuses on the main plantation crops, including banana, citrus, sugarcane, olives, palm oil, coffee, and cacao, located in both temperate and tropical regions. It does not include the processing of raw materials into semifinished and finished products. Annual crop production is addressed in the EHS Guidelines for Annual Crop Production.

Annex A contains a full description of industry activities for this sector. This document is organized according to the following sections:

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

1.0 Industry-Specific Impacts and Management

The following section provides a summary of EHS issues associated with plantation 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**.

1.1 Environment

Environmental issues in plantation crop production primarily include the following:

- Stress on water resources
- Soil erosion and loss of productive capacity
- Pesticide use
- Eutrophication of aquatic environments
- Biodiversity impacts
- Crop residues and other solid waste
- Atmospheric emissions

Stress on Water Resources

Water management for plantation 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:²

- 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:
 - 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 irrigation applied, in order to develop an understanding of long-term trends in water use.

Soil Erosion and Loss of Productive Capacity

Soil degradation may result from poor management especially due to excessive use of machinery and over-intensive farming

² FAO (2002a).

practices. Soil erosion may be exacerbated by heavy rainfalls, storms, and steep or long slopes, and may contribute to subsequent sedimentation of surface water bodies. Soils should be managed to prevent sediment generation. Sediment is a significant pollutant due to its physical properties, potential chemical interactions and total loads. Suspended sediment carries pollutants such as pesticides, nutrients and trace metals, causing water quality problems. Suspended sediment chemically and physically deteriorates causing water quality problems, resulting in reduced use. The settling of suspended sediment reduces storage and flow capacities of streams, lakes and reservoirs, adversely affecting water supplies and increasing flood potential. Soil loss prevention practices include:³

- Practice Integrated Nutrient Management (INM) (see below) to avoid nutrient depletion or accumulation;
- Use crops suited or adapted to the local climate and soil conditions;
- 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
- Use plant cover or intercrops and shelterbelts to reduce erosion from wind and heavy rain;

³ FAO (2002)

⁴ 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.

- 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 sludge quality for contaminants (for example, heavy metals) 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 plantation 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 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.

Alternatives to Pesticide Application

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.
- 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;

Pesticide Application

If pesticide application is warranted according to the PMP, users should take the following precautions to reduce the likelihood environmental impacts:

- Train personnel to apply pesticides and ensure that personnel have received applicable certifications or equivalent training where such certifications are not required;⁵
- 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 listed in Annexes A and B of the Stockholm Convention, except under the conditions noted in the convention;⁶
- 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 Pesticides⁷;
- 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 Pesticides⁸;
- 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;
- 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.

⁵ 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.

⁶ The Stockholm Convention on Persistent Organic Pollutants (2001).

⁷ FAO (2002c)

⁸ FAO (2002c)

Pesticide Handling and Storage

To prevent, reduce, or control the potential contamination of soils, groundwater, or surface water resources, which may result from accidental spills during transfer, mixing, and storage, pesticides should be stored and handled in accordance with the recommendations for hazardous materials management 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 people⁹. 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;¹⁰
- 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.¹¹ Additionally, the use of obsolete pesticides should be avoided under all circumstances;¹² 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

Nutrient management strategies¹³ should aim to optimize crop yield while maintaining and improving the soil nutrient status without causing off-site environmental problems. These strategies should be implemented as part of an INM approach that aims to prevent, reduce, or control contamination of groundwater resources and eutrophication of surface water resources from runoff and leaching of excess crop nutrients. The periods of greatest risk for runoff and leaching may be during and immediately after spreading if the nutrients are not incorporated into the soil, and during heavy rains that cause rapid runoff.

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.

⁹ FAO (2002c)

¹⁰ See FAO Guidelines for the Disposal of Waste Pesticides and Pesticide Containers.

¹¹ See FAO (1996).

¹² See the FAO publication on pesticide storage and stock control manual. FAO Pesticide Disposal Series No. 3 (1996).

¹³ Roy et al. (2006)

Evaluating the Need for Crop Nutrient Application

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 techniques, nutrient recycling, one-pass 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 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.¹⁴

Crop Nutrient Application

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

- Apply organic matter, such as manure, to replace chemical fertilizers to the extent practical;
- Incorporate manure into the soil 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 manure with the risk of over-fertilization

- Apply “fertigation” in horticulture, in which small amounts of fertilizer added to irrigation water may be applied. This requires detailed management and should be limited to plantations that have water management devices that can control the timing and volume of irrigation return flow
- Time the application of crop nutrients using meteorological information to avoid, where feasible, application during or close to precipitation events
- Use 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 runoff from the land
- Implement INM planning 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 used per field / hectare, purpose of use, and weather conditions during application
 - Rates of nutrient application for the crop growth stage
 - Maintenance schedule of application equipment to ensure efficient dosage

Handling and Storage of Crop Nutrients

To prevent, reduce, or control the potential contamination of soils, groundwater, or surface water resources caused by accidental spills during transfer, mixing, and storage, crop nutrients should be stored and handled in accordance with the recommendations for hazardous materials management presented in the **General EHS Guidelines**. In addition,

¹⁴ See FAO (2000).

fertilizers should be stored in their original packaging and in a dedicated location that can be locked and properly identified with signs, and with access limited to authorized people.

Biodiversity Impacts

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

Personnel in charge of plantation 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, consider 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 plantation 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;
- Use certified crop seeds that do 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.¹⁵

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

- Before converting land to plantation 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 plantation 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 plantation crop production and consider them during management processes;
- Provide for minimum disturbance to surrounding areas when harvesting or gathering crops.

Genetically Modified Organisms (GMOs)

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. The introduction of GMO crops should be assessed for compliance with the existing host country regulatory framework for such introductions. If such a regulatory framework does not exist in the host country, the potential impacts and risks of the introduction should be

¹⁵ For further guidance on organic agriculture, see IFOAM (2005).

assessed, paying specific attention to the potential for invasive behavior, and identifying any appropriate mitigation measures¹⁶.

Crop Residues and Other Solid Waste

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 include the following:

- Recycle crop residues and other organic materials by leaving the materials in the fields, plowing, or composting. The potential for spreading of pests should be considered before implementing this practice;
- 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 water¹⁷; 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.^{18, 19}

¹⁶ Introduction of GMOs should be considered using the principles outlined under the Convention on Biological Diversity available at <http://www.biodiv.org/default.shtml>.

¹⁷ See Footnote 8.

¹⁸ FAO (1999).

¹⁹ In case that disposal of pesticides involves overseas shipments, project must ensure compliance with country's commitments under Stockholm, Rotterdam and Basel Conventions.

Atmospheric Emissions

Atmospheric emissions are primarily associated with emissions of fuel 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. 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.

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;
- Adopt reduced tillage options to increase the carbon storage capacity of soils;
- Where feasible, use biofuels instead of fossil energy to reduce net GHG emissions;
- Where feasible, 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 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 by²⁰:
 - Reducing ammonia and nitrate concentration in soil;

²⁰ Roy et al. (2006)

- 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 etc.

1.2 Occupational Health and Safety

Occupational health and safety issues associated with plantation crop production include the following:

- Physical hazards;
- Confined space entry;
- Chemical hazards;

Physical Hazards

Machinery and Vehicles

Accidents occur in connection with the use of machines and vehicles, including tractors, harvesting machinery, and a variety of other machines on the farm. In addition, operators may be at risk of impacts associated with the noise of operating 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

Occupational health and safety hazards associated with confined spaces on farms (e.g. manure pits, silos, grain bins, water tanks, or inadequately ventilated buildings) include the risk of asphyxiation, primarily due to the accumulation of methane. Entry to 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

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) and inhalation during their preparation 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 plantation crop production include the following:

- Train personnel to apply pesticides and ensure that personnel have received the necessary certifications,²¹ or equivalent training where such certifications are not required;
- 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.

²¹ 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>

1.3 Community Health and Safety

Community health and safety issues during the production of plantation crops may include the following:

- Potential exposure to pesticides caused by spray drift, improper disposal and use of packaging and containers, and the presence of pesticides in potentially harmful concentrations in postharvest products;
- Potential exposure to pathogens and obnoxious odors associated with the use of manure;
- Potential exposure to air emissions from open burning of crop waste.

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. 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 post-harvest products may depend on adherence to pesticide use instructions. There may also be a risk to 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 create harmful air emissions for surrounding communities.

Specific recommendations include the following:

- Avoid the aerial application of pesticides whenever feasible;
- Use biological or safe products, whenever feasible;
- Respect pre-harvest intervals for pesticides to avoid unacceptable levels of pesticide residues in products,

further complying with any applicable pesticide tolerance requirements;²²

- Do not store or transport pesticides and fertilizers with food or beverages (including drinking water);
- Ensure that animals and unauthorized people are not present in the areas where pesticides are handled or applied;
- Store manure as far away from dwellings as possible, and use measures, such as covering the manure, to reduce odors and atmospheric emissions;
- 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 create biogas.

²² 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.

2.0 Performance Indicators and Monitoring

2.1 Environment

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. Guidance on quantitative parameters that can be used to establish a project's water consumption can be found in **Annex B**.

Environmental Monitoring

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 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.

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 using properly calibrated and maintained equipment. 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. Water, soil, and produce quality guidelines

Parameter	Media	Guideline Value
Pesticides, nitrates, coliform or other potential agricultural contaminants	Irrigation water	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) ^a
Pesticides, nitrates, coliform or other potential agricultural contaminants	On-site water supplies	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) ^b
Nutrient balance	On-site soil	Nutrient surpluses should remain stable; nitrogen surplus should be preferably below 25kg/ha/yr ^c
Pesticides	On-site soil and produce	Below applicable tolerance levels ^d

NOTES:

^aWHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater. Volume 2: Wastewater Use in Agriculture
http://www.who.int/water_sanitation_health/wastewater/gsuweg2/en/index.html

^bWHO Guidelines for Drinking Water Quality
http://www.who.int/water_sanitation_health/dwg/en/

^c Agriculture Indicator Fact Sheet, European Environment Agency, Nitrogen surplus from agricultural land, 2001.
http://themes.eea.europa.eu/Sectors_and_activities/agriculture/indicators/nutrients/nutrients.pdf

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

^d 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.

2.2 Occupational Health and Safety

Occupational Health and Safety Guidelines

Occupational health and safety performance should be evaluated against internationally published exposure guidelines, of which examples include the Threshold Limit Value (TLV[®]) occupational exposure guidelines and Biological Exposure Indices (BEIs[®]) published by American Conference of Governmental Industrial Hygienists (ACGIH),²³ the Pocket Guide to Chemical Hazards published by the United States National Institute for Occupational Health and Safety (NIOSH),²⁴ Permissible Exposure Limits (PELs) published by the Occupational Safety and Health Administration of the United States (OSHA),²⁵ Indicative Occupational Exposure Limit Values published by European Union member states,²⁶ 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. US Bureau of Labor Statistics and UK Health and Safety Executive)²⁷.

Occupational Health and Safety Monitoring

The working environment should be monitored for occupational hazards relevant to the specific project. Monitoring should be

designed and implemented by accredited professionals²⁸ as part of an occupational health and safety monitoring program. Facilities should also maintain a record of occupational accidents and diseases and dangerous occurrences and accidents. Additional guidance on occupational health and safety monitoring programs is provided in the **General EHS Guidelines**.

²³ Available at: <http://www.acgih.org/TLV/> and <http://www.acgih.org/store/>

²⁴ Available at: <http://www.cdc.gov/niosh/hpg/>

²⁵ Available at:
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDAR DS&p_id=9992

²⁶ Available at: http://europe.osha.eu.int/good_practice/risks/ds/oel/

²⁷ Available at: <http://www.bls.gov/iif/> and
<http://www.hse.gov.uk/statistics/index.htm>

²⁸ Accredited professionals may include Certified Industrial Hygienists, Registered Occupational Hygienists, or Certified Safety Professionals or their equivalent.

3.0 References and Additional Sources

- BAAP (Baltic Agricultural run-off Action Programme). 2001. Polish Code of Good Agricultural Practice (GAP). [City]: Available at <http://www.baap.lt/index.html> and http://www.baap.lt/codes_gap/code_pl.htm
- BLS (US Bureau of Labor Statistics). 2004a. Census of Fatal Occupational Injuries Charts, 1992–2004. Washington, DC: BLS. Available at <http://www.bls.gov/iif/oshwc/cfoi/cfch0003.pdf>
- BLS (US Bureau of Labor Statistics). 2004b. Industry Injury and Illness Data — 2004. Washington, DC: BLS. Available at <http://www.bls.gov/iif/home.htm> and <http://www.bls.gov/iif/oshwc/osh/os/ostb1479.pdf>
- Coffee Research. Available at <http://www.coffeeresearch.org>
- DAAS (Danish Agricultural Advisory Service). 2000. Manuals of Good Agricultural Practice from Denmark, Estonia, Latvia, and Lithuania. DAAS. Available at <http://www.lr.dk/international/informationsserier/intfbdiv/cgaps.htm>
- Danida (Ministry of Foreign Affairs). 2002. Assessment of Potentials and Constrains for Development and use of Plant Biotechnology in Relation to Plant Breeding and Crop Production in Developing Countries. Working Paper. Copenhagen: Danida.
- DEFRA (Department for Environment, Food and Rural Affairs). 2004. Pesticides and Integrated Farm Management. London: Department for Environment, Food and Rural Affairs. Available at http://www.pesticides.gov.uk/uploadedfiles/Web_Assets/Pesticides_Forum/PesticidesandIFM.pdf
- EC (European Commission). 2006. Biotechnology. Brussels: European Commission, Health and Consumer Protection DG. Available at http://europa.eu.int/comm/food/food/biotechnology/index_en.htm
- EEC (European Economic Communities). 1990. Council Directive 90/642/EEC. EEC Available at http://europa.eu.int/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=EN&numdoc=31990L0642&model=quichelt
- EEC (European Economic Communities). 1991. Council Directive of 12th December 1991 Concerning the Protection of Waters against Pollution Caused by Nitrates from Agricultural Sources 91/676/EEC. L0676 – 20/11 2003. EEC. Available at http://europa.eu.int/eur-lex/en/consleg/pdf/1991/en_1991L0676_do_001.pdf
- EEC (European Economic Communities). 1999. Council Directive 91/414/EEC of 15 July 1991 Concerning the Placing of Plant Protection Products on the Market, CONSLEG 1991 L0414 – 01/01 2004. EEC. Available at http://europa.eu.int/eur-lex/en/consleg/pdf/1991/en_1991L0414_do_001.pdf
- EFSA (The European Food Safety Authority). Available at http://europa.eu.int/comm/food/index_en.htm
- EurepGAP. 2004. Control Points and Compliance Criteria Fruit and Vegetables. Version 2.1. October 2004. Cologne: EurepGap. Available at <http://www.eurep.org/> http://www.eurepgap.org/documents/webdocs/EUREPGAP_CPCC_FP_V2_1_Oct04_update_01July05.pdf
- European Agency for Safety and Health at Work. 2006. Available at <http://europa.osha.eu.int/OSHA>
- European Environment Agency. 2001. Nitrogen surplus from agricultural land, 2001. Agriculture Indicator Factsheet. Available at http://themes.eea.europa.eu/Sectors_and_activities/agriculture/indicators/nutrients/nutrients.pdf
- FAO (Food and Agriculture Organization). 1990. Guidelines on Personal Protection When Using Pesticides in Hot Climates. Rome: FAO. Available at <http://www.fao.org/AG/AGP/AGPP/Pesticid/> and <http://www.fao.org/AG/AGP/AGPP/Pesticid/r.htm>
- FAO (Food and Agriculture Organization). 1992. The Use of Saline Waters for Crop Production. Irrigation and Drainage Paper 48. Rome: FAO.
- FAO (Food and Agriculture Organization). 1995. Revised Guidelines on Good Labeling Practice for Pesticides. Rome: FAO. Available at <http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPP/Pesticid/r.htm>
- FAO (Food and Agriculture Organization). 1996. Pesticide Storage and Stock Control Manual. FAO Pesticide Disposal Series No. 3. Rome: FAO. Available at http://www.fao.org/AG/AGP/AGPP/Pesticid/Disposal/index_en.htm http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/V8966E/V8966E00.htm
- FAO (Food and Agriculture Organization). 1999. Guidelines for the Management of Small Quantities of Unwanted and Obsolete Pesticides. FAO Pesticide Disposal Series No. 7. Rome: UNEP, WHO, and FAO. Available at http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/X1531E/X1531E00.htm
- FAO (Food and Agriculture Organization). 2000. [Guideline And Reference Material on Integrated Soil and Nutrient Management and Conservation for Farmer Field Schools](http://www.fao.org/organicag/frame2-e.htm). AGL/MISC/27/2000. Rome: FAO, Land and Plant Nutrition Management Division. Available at <http://www.fao.org/organicag/frame2-e.htm> [ftp://ftp.fao.org/agl/agll/docs/misc27.pdf](http://ftp.fao.org/agl/agll/docs/misc27.pdf)
- FAO (Food and Agriculture Organization). 2001. Biosecurity in Food and Agriculture, Sixteenth Session, Rome, 26–30 March 2001, Item 8 of the Provisional Agenda. Available at <http://www.fao.org/DOCREP/MEETING/003/X9181E.HTM>
- FAO (Food and Agriculture Organization). 2002a. International Code of Conduct on the Distribution and Use of Pesticides (revised November 2002). Rome: FAO. Available at <http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPP/Pesticid/Code/Download/Code.doc>
- FAO (Food and Agriculture Organization). 2002b. Fertilizer Use by Crop, 5th ed. Rome: FAO. Available at <http://www.fertilizer.org/fa/statistics/crops/fubc5ed.pdf>
- FAO (Food and Agriculture Organization). 2002c. Biological Management of Soil Ecosystems for Sustainable Agriculture. World Soil Resources Report 101. Rome: FAO. Available at http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/006/y4810e/y4810e00.htm

FAO (Food and Agriculture Organization). 2003. Technical Report No. 2: Environmental and Social Standards, Certification and Labeling for Cash Crops. Rome: FAO. Available at <http://www.fao.org/organicag/>
http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/006/y5136e/y5136e00.htm

FAO (Food and Agriculture Organization). 2005. Organic Agriculture at FAO. Rome: FAO. Available at <http://www.fao.org/organicag/>

FAO (Food and Agriculture Organization). 2006. Best Practices. Rome: FAO. Available at
http://www.fao.org/bestpractices/index_en.htm?sessionId=9CC6A87219AC13C83A7DA1479E055C66

FAO AGL (Food and Agriculture Organization, Land and Water Division). 1991. Water Harvesting — A Manual for the Design and Construction of Water Harvesting. Training Manual No. 3. In Water harvesting. AGL/MISC/17/91. Rome: FAO. Available at www.fao.org/docrep/u3160e/u3160e00.htm

FAO AGL (Food and Agriculture Organization, Land and Water Division). 2002a. Crop Water Information. Rome: FAO. Available at
<http://www.fao.org/ag/AGL/AGLW/cropwater/cwinform.stm>

FAO AGL (Food and Agriculture Organization, Land and Water Division). 2002b. CROPWAT: A Computer Program for Irrigation Planning and Management. Sustainable Development Networking Programme (SDNP), Bangladesh. Rome: FAO. Available at
<http://www.sdnbd.org/sdi/issues/agriculture/database/CROPWAT.htm>

FAO AGL (Food and Agriculture Organization, Land and Water Division). 2003. CLIMWAT: A Climatic Database for CROPWAT. Rome: FAO. Available at
<http://www.sdnbd.org/sdi/issues/agriculture/database/CROPWAT.htm>. Rome: Water Resources, Development and Management Service of FAO

FAO and WHO (Food and Agriculture Organization and World Health Organisation). 1962–2005. Codex Alimentarius. Geneva: FAO and WHO. Available at http://www.codexalimentarius.net/web/index_en.jsp

Helcom (Helsinki Commission). 2004. The Convention on the Protection of the Marine Environment of the Baltic Sea Area, 1992. Helsinki: Helcom. Available at <http://www.helcom.fi/stc/files/Convention/Conv0704.pdf>

HSE (Health and Safety Executive, UK). 2005a. Fatal Injuries Report 2004/05. United Kingdom: HSE. Available at
<http://www.hse.gov.uk/agriculture/pdf/fatal0405.pdf>

HSE (Health and Safety Executive, UK). 2005b. Fatal Injuries Report 2004/05. United Kingdom: HSE. Available at
<http://www.hse.gov.uk/agriculture/pdf/fatal0405.pdf>

IFC (International Finance Corporation). 1998. Environmental Health and Safety Guidelines for Wildland Management. Washington, DC: IFC. Available at
<http://www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines>

IFC (International Finance Corporation). Performance Standard 3. Available at
www.ifc.org/envsocstandards

IFOAM (International Federation of Organic Agriculture Movements). 2005. IFOAM Basic Standards for Organic Production and Processing (20 May 2005). Bonn: IFOAM. Available at www.ifoam.org and
http://www.ifoam.org/about_ifoam/standards/norms.html

ILO (International Labor Organization). 2000a. International Labor Conference Report VI, Safety and Health in Agriculture. Geneva: ILO. Available at
<http://www.ilo.org/public/english/standards/reim/ilc/ilc88/rep-vi-1.htm#CHAPTER%20IV>

ILO (International Labor Organization). 2000b. ILC88 — Report of the Director-General: Activities of the ILO, 1998–99. Available at
<http://www.ilo.org/public/english/standards/reim/ilc/ilc88/rep-1a-3.htm>

Institute of Soil Science and Plant Cultivation. 1999. Polish Code of Good Agricultural Practice. Pulawy: Institute of Soil Science and Plant Cultivation.

IOMC (Inter-Organization Programme for the sound Management of Chemicals). 2002. Reducing and Elimination the Use of Persistent Organic Pesticide. Geneva: IOMC and UNEP. Available at
<http://www.chem.unep.ch/pops/pdf/redelipops/redelipops.pdf>

Louisiana Department of Environmental Quality. Nonpoint Source Pollution Program, Agricultural Best Management Practices. Louisiana: Department of Environmental Quality. Available at <http://nonpoint.deq.state.la.us/agbmp.html>

Rainforest Alliance. 2005a. Sustainable Agriculture Standard. Costa Rica: Sustainable Agriculture Network. November 2005. Available at
<http://www.rainforest-alliance.org/programs/agriculture/certified-crops/standards.html>

Rainforest Alliance. 2005b. Sustainable Agriculture Standard with Indicators. Costa Rica: Sustainable Agriculture Network. November 2005. Available at
<http://www.rainforest-alliance.org/programs/agriculture/certified-crops/standards.html>

Rainforest Alliance. 2005c. Additional Criteria and Indicators for Coffee Production. Costa Rica: Sustainable Agriculture Network. November 2005. Available at <http://www.rainforest-alliance.org/programs/agriculture/certified-crops/standards.html>

Rainforest Alliance. 2005d. Additional Criteria and Indicators for Citrus Production. Costa Rica: Sustainable Agriculture Network. November 2005. Available at <http://www.rainforest-alliance.org/programs/agriculture/certified-crops/standards.html>

Rainforest Alliance. 2005e. Additional Criteria and Indicators for Banana Production. Costa Rica: Sustainable Agriculture Network. November 2005. Available at <http://www.rainforest-alliance.org/programs/agriculture/certified-crops/standards.html>

The Stockholm Convention on Persistent Organic Pollutants. 2001. Stockholm. Available at <http://www.pops.int/>

UNDP and GEF (United Nations Development Programme) and Global Environment Facility). 2006. Danube River Basin Project. Reduction of Pollution Releases Through Agricultural Policy Change and Demonstrations by Pilot Projects. UNDP and GEF. Available at <http://www.carbrodrp.org.yu/>

UNEP (United Nations Environmental Programme). 1992. Convention on Biological Diversity. Montreal: Secretariat of the Convention on Biological Diversity UNEP. Available at <http://www.biodiv.org/convention/default.shtml> and
<http://www.biodiv.org/doc/legal/cbd-un-en.pdf>

US EPA (Environmental Protection Agency). 2000. Summary of Operations, Impacts, and Pollution Prevention Opportunities for the Agricultural Production Industries: Crops, Greenhouses/Nurseries, and Forestry. Washington, DC: US EPA. Available at <http://www.epa.gov/compliance/resources/publications/assistance/sectors/notes/crop2.pdf>

US EPA (Environmental Protection Agency). 2006. Pesticides: Health and Safety, Worker Safety and Training. Washington, DC: US EPA. Available at <http://www.epa.gov/pesticides/health/worker.htm>

WHO (World Health Organization). 2005. The WHO recommended classification of pesticides by hazard and guidelines to classification: 2004. Geneva: WHO. Available at http://www.who.int/ipcs/publications/pesticides_hazard/en/index.html, http://www.who.int/ipcs/publications/pesticides_hazard_rev_3.pdf

WHO (World Health Organization). Available at http://www.who.int/water_sanitation_health/wastewater/gsuww/en/index.html

WHO (World Health Organization). Available at http://www.who.int/water_sanitation_health/dwq/en/

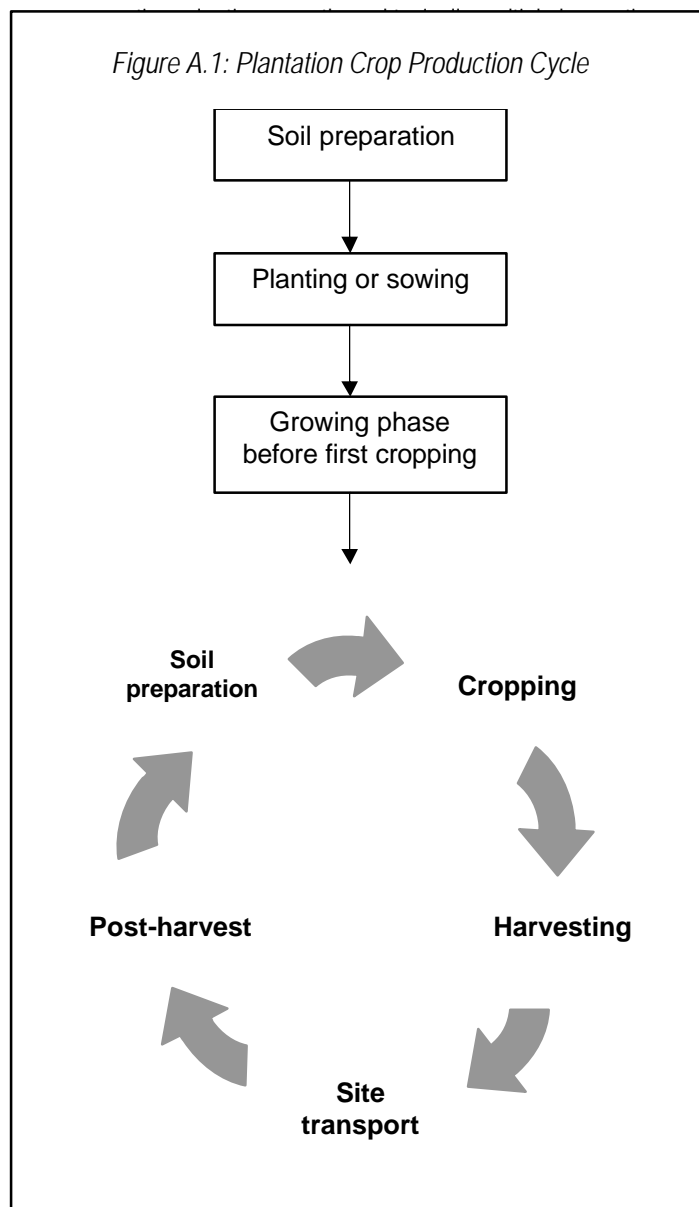
Annex A: General Description of Industry Activities

The production of plantation crops consists of planting useful crops and modifying the environment to provide them with optimum conditions for growth. The life cycle of a plantation is normally longer than one growing season, for example olive trees may be productive for several hundred years, although some plantation crops such as sugar cane are only grown for one season. Most plantations are artificially created, although some may be based on natural growth, for example, mango production.

Plantation crops belong to many different plant classifications and families. Products from trees include palm oil, citrus fruits, and cocoa; products from bushes include coffee and tea; products from herbs include bananas; and sugar cane is derived from a member of the grass family. The optimal growing conditions, including nutrient and water needs, and threats, including diseases and insects, differ for each crop. This is also the case for the utilization of the crop, which varies from human consumption to industrial uses.

Cultivation of different plantation crops is characterized by a wide range of crops, soil types, and climatic conditions. Modification of the environment ranges from minimal to intensive depending on the particular crop, growing conditions (soil, climate, diseases, weeds, and insects), and management techniques. The land area used for plantation crops and the scale of the production output are a factor of the above considerations, in addition to the use of fertilizer, water, and pesticides. It is the management of these latter factors that is of particular concern for environmental protection and occupational and community health and safety.

As illustrated in the schematic diagram in Figure A-1, the agricultural operations for plantation crops are divided into soil



of undesired vegetation, although some ground cover is desirable to prevent erosion. Other activities in this phase include shaping the plantation crop (for example, cutting branches to form the trees or bushes), irrigation, and the application of pesticides and nutrients, as necessary. Some plantations apply intercropping techniques to maximize harvest output. For example, olive tree plantations may also cultivate

plantation crops, such as tomatoes and potatoes, between the rows of olive trees.

its crown may be sufficient to limit weed growth, and weed control activities may not be necessary.

Harvesting, Transport, and Postharvest

Once the crop reaches the desired stage of growth, it is carefully harvested. Harvesting of plantation crops involves digging, cutting, picking, or other methods to remove the crops from the ground, stalks, vines, bushes, or trees. Small fruits and other food crops (for example, strawberries) are typically harvested by hand, although they may be harvested by machine. For some crops, such as sugar cane, preharvest burning may be conducted to improve access to the crop.

After the harvest, the plantation crop is stored on site in a controlled environment and may undergo certain preprocessing activities, such as washing to remove pesticide residues and drying. Agricultural crops destined for use as processed foods (such as olives) are likely to undergo extensive washing and processing at the processing plant. Crops such as coffee and cocoa require drying on site before transport to the processing plant. The plantation crop is then packed using various materials, including corrugated cardboard, paper, and plastic / fabric packaging materials, before being loaded for transport to the processing plants. The potential pollution outputs of harvesting and postharvesting activities include air emissions from harvesting equipment and crop residue burning, wastewater potentially contaminated with organic wastes and pesticides from crop washing, wastewater and waste product from processing, and damaged packaging materials.

Soil Preparation

The plantation is then prepared for the next cropping phase. Activities include cutting branches of existing plants; applying nutrients; controlling harmful vegetation and insects, if needed; replanting or propagating from rootstock; and restoring irrigation systems. When the plantation crop becomes the primary plant,

Annex B: Water Consumption

Water consumption for plantation crops can be calculated and compared with a theoretical standard value (water/yield). In practice, the requirements for irrigation water depend on crop species, soil type, and evaporation and water conservation practices. The irrigation requirements are also based on available nutrients and the presence of harmful diseases, weeds, and insects. The Food and Agriculture Organization has guidance materials on water management that explain how to calculate appropriate irrigation. Examples of water requirements of individual crops and typical yields and efficiencies are presented in table B-1.

Table B-1. Water Consumption by Selected Plantation Crops

Crop	Crop Water Need ⁽¹⁾	Typical Yields and Water Utilization Efficiencies
Banana <i>Herb</i>	Water requirements vary between 200–220 mm	Good commercial yields of banana are in the range of 40 to 60 ton/ha.(2)
Citrus <i>Tree</i>	Water requirements vary between 900 and 1200 mm per yr	Good yields of citrus are: Orange 25 to 40 tons per ha per year; grapefruit 40 to 60 tons per ha; lemons 30 to 45 tons per ha per year; mandarin - 20 to 30 tons per ha per year(2)
Sugar cane <i>Grass</i>	Water requirements vary between 1500 to 2500 mm per yr	Good yields in the humid tropics of a totally rain fed crop can be in the range of 70 to 100 ton/ha cane, and in the dry tropics and subtropics with irrigation, 110 to 150 ton/ha cane. Sugar content at harvest is usually between 10 and 12 percent of the cane fresh weight(2)
Olives <i>Tree</i>	Water requirements vary between 600 to 800 mm per yr	Good commercial yields under irrigation are 50 to 65 kg/tree of fruit with a possible maximum of 100 kg/tree of fruit. Oil content of the fresh fruit ranges from 20 to 25 percent(2)
Palm Oil <i>Palm Tree</i>	Water requirements vary between 1600–5 000 mm/yr	Modern high-yielding varieties are capable of producing in excess of 20 tones of bunches/ha/yr, with palm oil in bunch content of 25 percent(3)
Coffee <i>Bush</i>	Water requirements 1500–2500 mm per yr	Average of 1 100 kg/ha with varieties producing 2 400 kg/ha under good growing conditions(2)
Cocoa <i>Tree</i>	Water requirement 1500mm and 2000mm	Average of 346 kg/ha, cacao with varieties producing over 2,000 kg/ha under good growing conditions(4)

(1) FAO AGL (Food and Agricultural Organization of the United Nations, Land and Water Division). 1991. Water Harvesting – A Manual for the Design and Construction of Water Harvesting. Training Manual No. 3 in "Water Harvesting" (AGL/MISC/17/91). Rome. FAO. <http://www.fao.org/docrep/u3160e/u3160e00.htm>

(2) FAO AGL (Food and Agricultural Organization of the United Nations, Land and Water Division). 2002a. Crop Water Information. Crop Water Information. Rome. FAO. Website with databases:

<http://www.fao.org/aq/AGL/AGLW/cropwater/cwinform.stm> Crop Water Information.

(3)FAO. 2002. Small-Scale Palm Oil Processing In Africa. FAO Agricultural Services Bulletin 148. http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/005/Y4355E/y4355e03.htm

(4) Purdue University. 1983. Centre for New Crops and Plant Products. Handbook of Energy Crops. Theobroma cacao L. cf. "Yields and Economics". http://www.hort.purdue.edu/newcrop/duke_energy/Theobroma_cacao.html#Ecology