Caribbean Environment Programme

United Nations Environment Programme

Best Management Practices for Agricultural Non-Point Sources of Pollution

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ACRONYMS

BMP	best management practices
BOD	biological oxygen demand
CAR/RCU	Caribbean Regional Coordinating Unit
CCA	Caribbean Conservation Association
ESC	erosion and sediment controls
FAO	Food and Agriculture Organization
IPM	integrated pest management
IRF	Island Resources Foundation
LACCDE	Latin American and Caribbean Commission on Development and Environment
LBSMP	land-based sources of marine pollution
NGO	nongovernment organization
SAV	submerged aquatic vegetation
UNEP	United Nations Environment Programme
USDOS	United States Department of State
USEPA	United States Environmental Protection Agency
WCR	Wider Caribbean Region

SECTION 1. INTRODUCTION

1.1 Background

During the past two decades, awareness of the impacts of pollution on the coastal and marine environments of the Wider Caribbean Region (WCR) has increased. Tourism, one of the dominant economic bases in the region, depends on a healthy coastal and marine environment. In a concerted effort to prevent the further decline of the coastal and marine environment, countries and territories, through national research institutions and international organizations, have undertaken technical and legal actions to prevent and control marine and coastal pollution within the WCR (UNEP, 1994b).

The Cartagena Convention, signed in 1983 by 29 Caribbean countries and territories (Table 1-1), represents the joint action taken to protect the coastal and marine environment and its resources in the Gulf of Mexico and the Caribbean Sea. Under the Cartagena Convention, the governments of the WCR are developing a Protocol on Marine Pollution from Land-based Sources and Activities (the LBSMP Protocol). Land-based pollutants are the most serious threat to the coastal and marine waters of the WCR. The LBSMP Protocol, when it enters into force, calls for the protection of the fragile coastal and marine environment encompassing the Gulf of Mexico, the Caribbean Sea, and those parts of the western Atlantic within 200 nautical miles of the Bahamas and Florida, down to the northern border of Brazil (Hoagland et al., 1995). The coastal and marine environment includes nearshore and open-water habitats that can be affected by land-based pollution.

As defined in the Cartagena Convention, land-based sources of marine pollution are sources emanating from land by coastal disposal, discharges from rivers, estuaries, coastal establishments, outfall structures, or any other source being on the territory of a contracting party to the Cartagena Convention. Because of the comparatively small land mass in many of the Caribbean countries and territories, much of the coastal and marine environment is generally no farther than 5 to 10 kilometers from agricultural and urban development, as well as construction and other development activities, thus establishing the need for the protection of the coastal and marine environment from impacts associated with land-based pollutants (Archer, 1987). The LBSMP Protocol addresses, among other issues, agricultural nonpoint source pollution as one of the major categories of land-based source pollution in the WCR. Agriculture is the production of crops and livestock, and the pollutants associated with it include sediment, nutrients, pesticides, pathogens, and solid waste.

Table 1-1. The Cartagena Convention signatory countries and territories

Antigua & Barbuda	Grenada	St. Lucia
Barbados	Guatemala	St. Vincent & Grenadines
Colombia	Jamaica	Trinidad & Tobago
Costa Rica	Mexico	United Kingdom
Cuba	Netherlands	United States
Dominica	Panama	Venezuela
France		

Agricultural runoff and ground water discharge, the main sources of agricultural nonpoint source pollution, could potentially lead to the environmental degradation of the coastal waters throughout the WCR. The need to strengthen the institutional capacity to manage problems related to agricultural nonpoint sources of pollution has been recognized as a critical factor in sustaining the use of coastal and marine waters in the region. At the request of the governments of the WCR and the Secretariat to the Cartagena Convention, the United Nations Environment Programme-Caribbean/Regional Co-ordinating Unit (UNEP-CAR/RCU) assists the governments in developing an Annex on appropriate controls for agricultural nonpoint source pollution under the LBSMP Protocol. This document addresses the agricultural nonpoint source aspect of land-based pollution sources and serves as the technical basis for the development and further implementation of an Annex on agricultural nonpoint sources of pollution under the LBSMP Protocol.

1.2 Purpose and Scope

In developing the LBSMP Protocol, the UNEP-CAR/RCU and various governmental and nongovernmental organization representatives recognize the absence of consistent requirements for any best management practices (BMPs) relating to agricultural nonpoint sources of marine pollution in the WCR. Furthermore, in attempting to reduce agricultural nonpoint source pollution through the implementation of the LBSMP Protocol, attention needs to be focused on the economic and technical capabilities of the countries and territories in the region. The agriculture segment of the economy in many countries and territories might be limited in its capacity to implement a BMP program when considering investment, construction, and maintenance costs. An effective BMP program needs to address the capabilities of the countries and territories within the WCR and must be applicable to the largest plantation as well as the smallest subsistence farm.

In developing this report, a site visit to several agricultural operation in Costa Rica helped provide an overview of the issues related to agricultural nonpoint source pollution control in the WCR (Appendix A). In January 1998, a meeting of regional experts on agricultural nonpoint source pollution control was held in Castries, St. Lucia. Section 6 is a summary of the experts meeting.

The purpose of this document is to describe BMPs for the cost-effective control of agricultural nonpoint source pollution from crop and livestock production. Factors considered in selecting BMPs for inclusion in this report include topographic, climatic, socioeconomic, and environmental conditions within the countries of the WCR. The document has three primary goals:

1. Improve communication regarding agricultural nonpoint source pollution among regional technical experts in the WCR, including persons from the private sector and academia.

2. Develop a compilation of current, relevant literature that focuses on the extent of agricultural nonpoint source pollution problems in the WCR and identifies low-tech, low-cost control measures to reduce them (Appendix B).

3. Improve knowledge of different types of structural and nonstructural agricultural nonpoint source pollution controls (BMPs), their benefits and limitations, and how they might be applied in the WCR.

The document contains descriptions of applicable BMPs and nonpoint source pollution information as they apply to the WCR. A discussion of agricultural practices in the WCR is included. Cultivation and livestock production practices are discussed as well. This document focuses on five pollutants (sediments, nutrients, pesticides, pathogens, and solid waste) and their adverse impacts on the coastal and marine environment of the WCR. The BMPs discussed are those which are applicable to the targeted pollutants, are cost-effective, and can be easily implemented.

The discussion of agricultural nonpoint source BMPs includes the following:

A description of practices, including commonly used structural and nonstructural controls and, where applicable, their operation and maintenance.

An identification of the individual pollutants or classes of pollutants that might be controlled by each practice and the resulting effects on water quality.

A description of the factors that should be considered (e.g., topography, climate, acceptability) when implementing the practices within specific sites or locations.

A BMP is included only if the practice is technically and economically achievable in the WCR. A decision matrix is included to compare individual BMPs and the various constraints and incentives applicable to their use (Section 4). Case studies demonstrating how low-cost/low-tech BMPs have been used to reduce agricultural nonpoint source pollution are also included (Section 5).

SECTION 2. REGIONAL OVERVIEW

2.1 Geographic Area

For the purpose of this document, the geographic area of the WCR is based on the definition used in the Cartagena Convention: "the [coastal and] marine environment of the Gulf of Mexico, the Carib-bean Sea and areas of the Atlantic Ocean adjacent thereto, south of 30° north latitude and within 200 nautical miles" of the Atlantic coasts from the Bahamas and Florida down to the northern border of Brazil (Hoagland et al., 1995). (See Figure 2-1.) It should be observed, however, that, although the Convention area encompasses the area closest to the seas, the drainage area from which pollutants are transported to the seas consists of huge land areas on the North American and South American continents.

The WCR encompasses an area of 6.4 million square kilometers, including the U.S. Gulf coast states. The numerous islands of the Greater Antilles and Lesser Antilles account for 4.6 percent of the total area; Mexico and the Central American countries compose 48.3 percent of the area (Gajraj, 1981).

2.2 Land Use and Water Resources

Much of the WCR is mountainous and a significant, but rapidly diminishing, proportion of the land is forested. A prospective analysis by Gallopín (1990) projects severe changes in the land ecosystems of Latin America and the Caribbean to accommodate the growing population over the next three decades (LACCDE, 1990). (See Table 2-1.)

Table 2-1. Projected land use changes in the WCR

	Initial (1980)	2030	% Change
Primary (forested)	40.6	30.0	-26.7
Altered	22.1	21.0	-6.4
Uncultivated	2.0	3.2	69.6
Farming	7.5	11.0	46.5
Livestock	26.8	32.0	20.4
Plantations	0.3	1.5	443.2
Urban	0.7	1.3	92.7
TOTAL	**100.0**	**100.0**	

Source: LACCDE, 1990.

The freshwater drainage basins within the WCR cover approximately 5.6 million square kilometers. The largest portions are in the United States (62 percent), Venezuela (17 percent), Colombia (4 percent), and Mexico (4 percent) (Diamante et al., 1991). The lands draining into the marine area are clearly of importance to the management of this area, particularly when considering nonpoint source pollution. Table 2-2 denotes the major drainage systems in the region, but it does not include such inputs as the freshwater lagoons, mangrove swamps, and bayous that constitute the coastlines of Florida, Colombia, Venezuela, and the Yucutan peninsula.

Additionally, although the freshwater inputs originating from the Amazon River are outside the WCR, they should be accounted for as well.

Table 2-2. Principal rivers draining into the WCR

River	Drainage Area (km^2)	Water Discharge (m^3/sec)	Sediment Discharge (10^6 t/year)	Specific Transport (t/km^2/year)	Mean Suspended Solids (mg/L)
USA					
Mississippi	3,268,000	18,400	222.00	76.00	380
Apalachicola	44,000	620	0.16	6.80	15
Mobile	97,000	1,500	4.50	42.00	95
Brazoa	114,000	160	15.90	0.14	3,200
Colorado	107,000	79	1.90[a]	17.90	
USA-Mexico					
Rio Grande	467,000	23	very low[a]	—	—
Colombia					
Magdelena	235,000	7,500	234.00	1000.00	1,000
Venezuela					
Orinoco	950,000	30,000	85.00	91.00	90

[a] Low values due to dams.
Sources: Hoagland et al., 1995; UNEP, 1994b.

2.3 Socioeconomic Conditions—Agriculture, Industry, and Resources

The Caribbean region has an extraordinary diversity of natural and cultural resources, which are subject to unprecedented development pressures (UNEP, 1994a). Major marine-based industries, such as fisheries, sea transportation (upon which agriculture is dependent), oil and gas extraction, and tourism, have all played an important role in the development of the WCR (UNEP, 1996). Approximately 20 million tourists visit the islands and coastal regions each year to enjoy the coastal and marine environment. Tourists are attracted to the region by the beautiful white beaches, pristine blue waters, bountiful seafood, diving and snorkeling, sportfishing, and mild climates (DeGeorges, 1990).

Agriculture, however, has long been the mainstay of the economies in the WCR countries. The region produces approximately 60 percent of the world's coffee, 40 percent of the world's bananas, 25 percent of the world's beans, 20 percent of the world's cocoa, and significant quantities of sugar, corn, vanilla, cotton, potatoes, rice, and wheat (CCA and IRF, 1991). Along the northern coast of South America, crops such as cotton, corn, sugarcane, and vanilla dominate. Central America and Mexico focus on cocoa, bananas, sugarcane, mahogany, and livestock. In the eastern Caribbean, agriculture has historically been the most productive sector of the economy, dominated by sugarcane and, more recently, bananas (CCA and IRF, 1991). Dependence on monoculture economies dominates. For instance, Barbados, St. Kitts, and the Dominican Republic have traditionally depended on sugarcane, while Grenada, St. Vincents, St.

Lucia, and Dominica depend on banana production (DeGeorges, 1990). Table 2-3 provides the annual banana revenue for the Windward Islands from 1994 to 1997.

Livestock activity traditionally has not been as developed as other areas of agriculture, especially within the island countries and territories. Although livestock was targeted for generous subsidies and government programs among the islands, only the poultry and pork industries have been developed extensively. The island countries' beef and dairy industries, in particular, are lacking. Most beef has been imported from New Zealand and Australia. Dairy production also has been inadequate. In mainland regions of the WCR, livestock production can be found in greater quantities.

Table 2-3. Windward Islands banana revenue

Country	Revenue (EC$M)				
	1994	1995	1996	1997	Total
Dominica	55.37	45.15	44.53	41.31	**186.36**
Grenada	6.52	5.20	1.63	0.00	**13.35**
St. Lucia	115.71	128.10	125.79	76.37	**445.97**
St. Vincent and the Grenadines	39.83	61.27	52.43	37.10	**190.63**
TOTAL	**217.43**	**239.72**	**224.38**	**154.78**	**836.31**

Source: Naula Williams, Documentalist, Documentation Centre, Organization of East Caribbean States, March 1998.

Mining plays a key role as well. Bauxite, copper, nickel, gold, silver, lead, zinc, manganese, iron ore, oil, and natural gas are present in commercially exploitable quantities. Again, however, the majority of the smaller countries of the WCR have no significant mineral resources and their economies are based primarily on agriculture and tourism (Gajraj, 1981).

Three distinct farming systems typify agricultural production in much of the WCR:

1. The export-oriented plantation system, characterized chiefly by monocultures on large estates and generally occupying the most fertile land (Gumbs, 1981). These systems range in size. For example, in Costa Rica, the smallest plantation growing bananas for export has 40 hectares but the majority of the farms range between 100 and 300 hectares (Hernández, 1997).

2. The subsistence-based agricultural system, which is typically smaller than the plantation system and developed on the more marginal agricultural lands (CCA and IRF, 1991). Most farmers have small plots of only a few hectares or less (DeGeorges, 1990).

3. Migratory, shifting agriculture practiced mainly by indigenous groups in Central America, Colombia, Venezuela, and the Guyanas (Gumbs, 1981).

Farming systems are determined by both the natural landscape and the prevailing socioeconomic conditions of the area (Sentis, 1992). Continued economic growth and development in the WCR have required changes in the traditional use of the land, such as increased agricultural development at the expense of forestland (UNEP, 1994a). (See Tables 2-1 and 2-4.) Food-growing potential in the WCR is further constrained by lack of natural soil fertility, high soil erosion potential due to steep slopes and poor soil drainage, salinization, and shallow soils. In addition, variable climatic conditions such as drought and flooding and natural disasters like hurricanes can impose serious limitations on the productivity of the land (Gajraj, 1981).

The focus of this document is the problems resulting from crop and livestock production. Table 2-5 provides a brief summary of the leading agricultural crop producers of the WCR. They are ranked in terms of the percentage of land area devoted to agriculture. Table 2-6 provides information regarding two key crops in the WCR, ranking sugarcane and banana production according to metric tons produced in 1994 (Hoagland et al., 1995).

Table 2-4. Land use percentage changes in croplands, pasturelands, and forest woodlands in 17 countries of the WCR during the 1977-1989 period

Country	Percentage change (1977-1989)		
	Cropland	Pastureland	Forestland
Barbados	0.0	0.0	0.0
Belize	12.8	15.2	(1.1)
Costa Rica	5.5	24.0	(17.9)
Colombia	3.5	6.8	(5.6)
Cuba	5.3	14.3	(11.8)
Dominican Republic	5.5	0.0	(3.1)
Guatemala	8.3	7.8	(17.0)
Haiti	2.7	(3.0)	(30.0)
Honduras	2.3	7.2	(18.8)
Jamaica	1.5	(7.9)	(5.1)
Mexico	1.9	0.0	(12.0)
Nicaragua	2.8	11.5	(23.5)
Panama	4.6	15.9	(19.4)
Trinidad and Tobago	3.7	0.0	(4.3)
Suriname	53.7	11.1	(0.3)
Venezuela	5.9	2.9	(8.6)
Average	4.8	6.7	(9.3)

( ) indicates a decline in land use.
Source: UNEP, 1994b.

Table 2-5. Leading agricultural crop producers in the WCR (% of total land area in agricultural land use)

Producer	%	Producer	%	Producer	%
Martinique	87	Barbados	46	Colombia	27
Guadeloupe	84	St. Kitts	45	Trinidad & Tobago	26
Cuba	78	United States	41	Guyana	26
Mexico	73	Panama	39	Dominica	26
Costa Rica	60	Puerto Rico	39	Honduras	24
Haiti	57	Guatemala	38	U.S. Virgin Islands	21
Jamaica	55	St. Lucia	38	Belize	10
Dominican Republic	50	St. Vincent	35	Antigua & Barbados	9
Nicaragua	48	Venezuela	34	Bahamas	3

Source: Hoagland et al., 1995.

Table 2-6. Leading sugarcane and banana producers in the WCR

Leading Sugarcane Producers (thousands of metric tons in 1994)		**Leading Banana Producers** (thousands of metric tons in 1994)	
Cuba	44,000	Colombia	1,950
Mexico	41,652	Mexico	1,650
United States	29,335	Costa Rica[a]	1,633
Colombia	29,000	Venezuela	1,215
Guatemala[a]	9,788	Panama[a]	1,110
Venezuela	6,700	Honduras[a]	1,086
Honduras	3,004	Guatemala	465
Costa Rica	2,840	Cuba	295
Jamaica	2,661	Martinique	255
Nicaragua	2,400	Haiti	230
Haiti	2,250	Guadeloupe[a]	148
Panama	1,400	Nicaragua	136
Trinidad & Tobago	1,210	St. Lucia[b]	90
Belize	1,159	Jamaica	77
Barbados[a]	533	Suriname	50
Guadeloupe[a]	516	Belize	41
St. Kitts & Nevis[a]	200	Dominica[a,b]	42
Martinique	98	St. Vincent and the Grenadines[b]	31
Suriname	45	Guyana	21
		Grenada[b]	4

[a] Exporting to United States, United Kingdom, Germany, Netherlands.
[b] Data for the Windward Islands were obtained through personal communication with the Organization of East Caribbean States.
Source: Adapted from Hoagland et al., 1995.

Pathogens (bacteria, viruses, or any microorganisms that can transmit disease) can be transmitted to humans through contact with animal feces. Runoff from fields receiving manure as fertilizer will contain extremely high numbers of bacteria if the manure has not been mixed with other substances or the bacteria have not been subject to stress (USEPA, 1993). Although not the only source of pathogens, animal waste has been responsible for shellfish contamination in some coastal waters (USEPA, 1993).

Problems result from stocking too many animals within too small an area. Animals may congregate along streams or watering areas, around feeding areas, and in shady spots. If there are more animals than the vegetation in such areas can maintain, soil erosion and excess manure deposition are likely (Graves, 1992). Animal traffic within a confined area can impact stream integrity and plant biodiversity. Improper livestock grazing affects all four components of the water-riparian system—banks/shores, water column, channel, and aquatic and bordering vegetation. The potential effects of grazing include the following (USEPA, 1993):

Shore/banks

- Shear or sloughing of stream bank soils by hoof or head action.
- Water and wind erosion of exposed stream bank and channel soils because of loss of vegetative cover.
- Elimination or loss of stream bank vegetation.
- Reduction of the quality and quantity of stream bank undercuts.
- Increasing stream bank angle, which increases water width, decreases stream depth, and alters or eliminates fish habitat.

Water column

- Withdrawal from streams to irrigate grazing lands.
- Drainage of wet meadows or lowering of groundwater table to facilitate grazing access.
- Pollutants (e.g., sediments) in return water from grazed lands.
- Changes in magnitude and timing of organic and inorganic energy (i.e., solar radiation, debris, nutrients) inputs to the water body.
- Increase in fecal contamination.
- Changes in stream morphology, such as increases in stream width and decreases in stream depth, including reduction of stream shore water depth.
- Changes in timing and magnitude of stream flow events from changes in watershed vegetative cover.

- Increase in stream temperature.

Channel

- Changes in channel morphology.

- Altered sediment transport processes.

Riparian vegetation

- Changes in plant species composition (e.g., shrubs to grass to forbs).

- Reduction of floodplain and stream bank vegetation, including vegetation hanging over or entering into the water column.

- Decrease in plant vigor.

- Changes in timing and amounts of organic energy leaving the riparian zone.

- Elimination of riparian plant communities (i.e., lowering of the water table, allowing xeric plants to replace riparian plants).

In the WCR, land is often cleared for subsistence farming. However, because the soils are typically shallow and of low fertility, these lands are often abandoned and cattle ranchers replace the subsistence farmers. This process results in large, deforested areas with soils that are heavily compacted, organically weak, and poorly protected from grazing livestock and natural weather events such as rain and sunlight (UNEP, 1991). Soil loss and erosion in the region are largely affected by this process in conjunction with poor soil management.

Soil erosion and general land degradation resulting from overgrazing of livestock have been significant problems in the WCR (CCA and IRF, 1991). A common practice in the WCR is to permit livestock to roam without restriction after harvesting each year. Such grazing practices over time accelerate land deterioration, deforestation, erosion, and general denudation of the natural resources (CCA and IRF, 1991).

3.3 Agricultural Pollutants and Their Sources

The environmental problems linked to agricultural production range from declines in the local and regional productivity of soil and water (through erosion, sedimentation, and chemical pollution) to the destruction of biodiversity and reduction in genetic diversity (through deforestation, habitat alteration, and other changes) (Altieri, 1991). Runoff of agricultural chemicals is estimated at more than 1 billion pounds per year (UNEP, 1990, as cited in Diamante et al., 1991). Agricultural activities also affect marine habitats through physical disturbances caused by equipment or through the management of hydrology (e.g., constructing ditches to drain soil). Table 3-7 highlights the range of impacts on water quality due to agricultural activities.

The primary agricultural nonpoint source pollutants that affect coastal and marine environments are sediment, nutrients, pesticides, pathogens, and solid waste. The following sections address these five categories of pollutants. The pathways for transport of these pollutants from agricultural lands to water resources are shown in Figure 3-2.

Table 3-7. Agricultural activities that potentially affect water quality

Agricultural Activity	Potential Impacts on Surface Waters
Tillage/ploughing	Sediment/turbidity: sediments carry nutrients and pesticides adsorbed to sediment particles; siltation and loss of habitat, spawning ground, etc.
Fertilizing	Nonpoint source pollution, especially nutrients, leads to eutrophication, excess algae growth leading to deoxygenation of water and fish kills.
Manure spreading	Nonpoint source pollution containing pathogens, metals, and nutrients leads to eutrophication and potential contamination.
Pesticides	Nonpoint source pollution leads to contamination of surface water and biota; dysfunction of ecological system in surface waters by loss of top predators due to growth inhibition and reproductive failure; public health impacts from eating contaminated fish.
Irrigation	Runoff of fertilizers and pesticides to surface waters leads to ecological damage, bioaccumulation in edible fish species, etc.
Clear-cutting	Erosion of land leads to high levels of turbidity, siltation of bottom habitat, etc. Hydrologic regime is disrupted and changed.

Source: Adapted from Ongley, 1996.

3.3.1 Sediment

Erosion. In the WCR, the most serious constraint to agricultural production is the inadequacy of the soil resources for agricultural purposes, a problem that can be compounded by mismanagement (Gajraj, 1981). Specific natural soil characteristics, type of vegetation cover, intensity of rainfall, winds, topography, and poor land use management affect the conservation of soil in the region. Approximately 25 percent of Latin America is composed of hillsides and plateaus susceptible to erosion and land degradation (Altieri, 1991). Some estimates of the long-term effects of soil erosion suggest losses of 30 percent of the potentially cultivatable unirrigated land in Central America. The areas most vulnerable to erosion are the Greater and Lesser Antilles, parts of Caribbean South America, and Trinidad and Tobago (Gajraj, 1981).

Soil erosion is a natural process characterized by the transport or displacement of particles (sediment) that are detached by rainfall, flowing water, or wind. Although it is a natural process, adverse impacts on receiving waters increase due to agricultural activities that alter the landscape and increase the rate of erosion. Soil erosion can be caused by the improper use of lands for cultivation or grazing and by deforestation (LACCDE, 1990). The types of soil erosion associated with agricultural activities are as follows (Figure 3-3):

- Splash erosion, which occurs when rain hits exposed soils.
- Sheet and rill erosion, which mainly moves soil particles from the surface or plough layer of the soil. Surface sediments typically contain higher pollution

potential due to richer nutrient content, the presence of chemicals from past fertilizer and pesticide applications, and natural biological activities.

- Rill and gully erosion, severe erosion in which trenches are cut to a depth greater than 1 foot. Generally, trenches too deep to be crossed by farm equipment are considered gullies (USEPA, 1994).

- Stream and channel erosion, which occurs due to increased rates and volumes of runoff from agricultural land uses flowing through a stream or channel.

During the Pollution Control Measures for Agricultural Runoff Experts Meeting in St. Lucia (January 22 and 23, 1998), several causes of erosion and sedimentation were identified. They include the following:

- Planting on steep slopes
- Deforestation
- Clear-cutting
- Improper tillage methods
- Improper timing of site preparation
- Compaction by animals

- Improper irrigation methods and water management practices
- Channelization and artificial drainage

The primary factors affecting soil erosion rates include rainfall intensity and frequency, soil characteristics, vegetative and other surface cover, topography (slope), and climate (e.g., degree of exposure to trade winds) (USVI Conservation District, 1995). Soil characteristics play a key role; even low-intensity rainfall induces erosion in areas where soils are easily saturated (UNEP, 1994a). In addition, the topography, slope length, and slope steepness influence soil erosion. Steeper slopes are susceptible to erosion due to increased runoff velocity, greater downslope transport of rain-splashed soil, and greater susceptibility to landslides (UNEP, 1994a). Disruption of soil through earthmoving (tilling, ploughing, etc.) or livestock activity increases erosion potential regardless of the soil type. Generally, the more vegetative cover, the less potential there is for erosion.

Turbidity, Siltation, and Sedimentation. When soils are eroded from agricultural lands and carried to coastal waters in runoff, the result is usually increased turbidity, siltation, and sedimentation. Throughout the WCR, siltation and turbidity of coastal waters are on the rise due to the transport of eroded soils to the sea. Data on the distribution of sediments and the turbidity of coastal waters of the WCR are insufficient to assess the magnitude of the adverse effects of present-day land use practices (UNEP, 1994a). However, reefs near the Central American coast and areas of the eastern Caribbean are believed to be suffering from sediment stress related to agricultural practices, and some estimates of the long-term effects of soil erosion suggest losses of potentially 30 percent of arable unirrigated land in Central America (Hoagland et al., 1995).

The adverse impacts of accelerated erosion and sedimentation include the following:

- Loss of agricultural productivity. Erosion removes valuable topsoil and thus reduces the productivity and water-holding capacity of agricultural land.

- Lost reservoir capacity. Sedimentation reduces the water storage capacity of reservoirs and shortens their functional life span. In Puerto Rico, for example, some reservoirs have lost virtually all of their storage capacity and others are filling with thousands of cubic meters of sediment annually.

- Other downstream impacts. Sedimentation can fill culverts, ponds, and storm drainage systems. Navigation may be impeded by increased sediment loading to receiving waters, necessitating expensive dredging (UNEP, 1994a).

Erosion and sedimentation affect water quality in many ways:

- Suspended solids reduce the amount of sunlight available to aquatic plants, cover fish spawning areas and food supplies, smother benthic communities, clog the filtering capacity of filter feeders, and clog and harm the gills of fish. Turbidity interferes with the feeding habits of fish. These effects combine to reduce fish, shellfish, coral, and plant populations and decrease the overall productivity of coastal waters.

- Turbid waters reduce the recreational appeal of coastal areas, limiting sportfishing, diving, and swimming opportunities.
- Sediment can cause property damage and cost property owners money for removal (USVI Conservation District, 1995).

- Nutrients and pesticides are transported mixed with sediment, or chemically bound to the sediment, changing the aquatic environment through eutrophication and introduction of toxics.

3.3.2 Nutrients

In the Caribbean, the most common marine pollution problems arise due to nutrient overenrichment resulting from sewage discharge and runoff from agricultural land uses. Sources of nutrient overenrichment include fertilizers, soil mineralization, and manure. During the Pollution Control Measures for Agricultural Runoff Experts Meeting, the causes of nutrient overenrichment in the WCR were identified as the following:

- Artificial drainage
- Overfertilization
- Poor crop siting (land use)
- Lack of natural buffers between agricultural and natural resources
- Timing of fertilization
- Erosion of absorbed nutrients in sediment
- Improper irrigation techniques
- Allowing open grazing of livestock

- Confined livestock facilities
- Volatilization of animal waste

Agricultural crops require nutrients for healthy growth. Some of these nutrients occur naturally, supplied to a plant through the air, water, and soil. To supplement the naturally occurring nutrients, organic and inorganic fertilizers are applied in a commercial dry or liquid form, as manure from animal production facilities, as crop residues, in irrigation water, and through aerial deposition. Table 3-8 presents data on the use of fertilizers in 17 countries of the WCR. When applied correctly, fertilizers promote plant growth; when used excessively or inappropriately, however, fertilizers can lead to nutrient overenrichment within water bodies, one of the most widespread coastal pollution problems today. As a result, surface water runoff from poorly managed agricultural lands may transport the following pollutants (USEPA, 1993):

- Particulate-bound nutrients, chemicals, and metals, such as phosphorus, organic nitrogen, and metals applied with some organic wastes.

- Soluble nutrients and chemicals, such as nitrogen, phosphorus, metals, and many other major and minor nutrients.

- Sediment, particulate organic solids, and oxygen-demanding material.

- Salts.

- Bacteria, viruses, and other microorganisms.

Table 3-8. Average annual fertilizer use in 17 countries of the WCR, including changes during the 1979-1989 period

Country	Fertilizer Use in kg/ha of Cropland		
	1979	1989	% Change
Barbados	162.0	91.0	(43.8)
Belize	36.0	71.0	97.2
Costa Rica	143.0	90.0	(37.1)
Colombia	55.0	191.0	247.3
Cuba	133.0	192.0	44.7
Dominican Republic	41.0	50.0	21.9
Guatemala	53.0	69.0	30.2
Guyana	22.0	29.0	31.8
Haiti	4.0	3.0	(25.0)
Honduras	13.0	20.0	53.8
Jamaica	55.0	105.0	90.9
Nicaragua	31.0	55.0	77.4
Panama	44.0	62.0	40.9

Trinidad and Tobago	61.0	28.0	(54.1)
Suriname	49.0	74.0	51.0
United States (Gulf Coast)	106.0	95.0	(10.4)
Venezuela	51.0	162.0	217.6
Average	**62.3**	**81.6**	**31.0**

Source: World Resources Institute, 1992, cited in UNEP, 1994b.

Excess nutrients also enter coastal waters through improper storage and handling of fertilizers and disposal of fertilizer containers. For example, if bags of fertilizer are stored in such a manner that the bags can break open and inadvertently release fertilizer into the environment, the fertilizer adds to the volume of nutrients that could flow to coastal waters in runoff.

Excess nitrogen and phosphorus, considered the nutrients that have the greatest effect on water quality, enter waters from agricultural fertilizers and manures. Nitrogen dissolves in water and is carried in runoff. Phosphorus is either dissolved or held tightly by soil clays and transported mainly through erosion (Lilly, 1995). Excess fertilizers in the form of liquid leachates, surface runoff, erosion, or gases leave the system and enter surface waters. Nutrients can increase the productivity and yield of a crop on land and may do the same to aquatic plants when they enter a water body. Excess levels of nutrients in runoff to coastal waters can result in an imbalance in the natural nutrient cycle, leading to unwanted and excessive plant growth, a process called eutrophication (USVI Conservation District, 1995). When nutrients are introduced into a stream, lake, or estuary at higher-than-natural rates, aquatic plant productivity can increase dramatically (USEPA, 1993). Increased productivity results in an increase of organic matter in the aquatic system. Organic matter dies and decays after a period of time. Since the decaying process requires oxygen, an excessive increase in plant productivity can ultimately result in a reduction in the oxygen supply. This can lead to anoxic conditions, resulting in an environment where few organisms can live.

Nutrient enrichment of coastal waters can lead to an increase in algal (planktonic) growth, which is harmful to coral reefs and other benthic communities. With increases in algal growth, turbidity increases, further inhibiting the growth of submerged aquatic vegetation (SAV). A loss in SAV equates to a loss of habitat. The accumulation of nutrients in deposited sediments can further compound problems associated with nutrient enrichment. Changes in the aquatic environment (e.g., temperature, salinity) allow the nutrients to be released from the sediment and serve as a long-term contributor to eutrophication.

3.3.3 Pesticides

The term *pesticide* includes any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest or for use as a plant regulator, defoliant, or desiccant (USEPA, 1993). For the purposes of this document, pesticides include insecticides, herbicides, fungicides, miticides, and similar substances. Within the WCR, regional experts have identified the following causes for pesticide contamination:

- Improper application (timing, method, amount, etc.)
- Erosion (absorbed chemicals)

- Cropping systems (e.g. monocultures)
- Improper equipment maintenance
- Mishandling, storage, and disposal
- Inappropriate selection
- Leaching
- Improper water management
- Artificial drainage
- Volatilization

The pesticides most commonly used in agriculture are the organochlorine and organophosphorus types, the more toxic but less persistent being the organophosphates. These pesticides are toxic to crustaceans such as shrimp, lobster, and crab and are similarly toxic to some fish species. They are known to bioaccumulate in some marine fauna (Archer, 1987).

The impacts of pesticides are not necessarily limited to the intended sites of application. There is considerable waste when chemicals are applied heavily and infrequently; the crop cannot benefit from the application before much of it is washed away or dissipated (Hernández and Witter, 1996). Depending on the application method used, dispersion of pesticides off site occurs by wind, runoff, high-flight-altitude drift of spray outside crop areas, accidental spills, improper storage and handling, and improper disposal of pesticide containers. Heavy use of pesticides for agriculture in watersheds some distance from the coast can be as destructive as direct industrial discharges of toxics, depending on such factors as persistence of the pesticide, quantities reaching the aquatic environment, potential for bioaccumulation, and toxicity (Coté, 1988). The dispersal of a pesticide from sites of intentional or accidental application is strongly affected by its persistence in the environment, its solubility in water, and its tendency to bind to organic matter or clays in soil (Rainey et al., 1987).

Unintended effects of pesticide use include elimination or reduction of populations of nontarget desirable organisms, including endangered species (USEPA, 1993). The amount of field-applied pesticide that leaves a field in the runoff and enters a stream, as depicted in Figure 3-4, primarily depends on the following factors (USEPA, 1993):

- Intensity and duration of rainfall or irrigation.
- Length of time between pesticide application and rainfall occurrence.
- Amount of pesticide applied and its soil/water partition coefficient.
- Length and degree of slope and soil composition.
- Extent of exposure to bare (vs. residue- or crop-covered) soil.
- Proximity to streams.
- Method of application and formulation.
- Extent to which runoff and erosion are controlled with agronomic and structural practices.

Pesticides that bind to soil particles and show little tendency to leach into ground water may still disperse if the soil particles themselves are eroded downslope and carried into streams, settling for varying times in stream or estuarine sediments or coastal marine habitats (Rainey et al., 1987). Furthermore, many pesticides are soluble in water and may enter surface waters through runoff.

Pesticide losses are generally greatest when rainfall is intense and occurs shortly after pesticide application, a condition for which runoff and erosion losses are also greatest (USEPA, 1993). This loss of pesticide not only harms the environment but also leads to economic losses. The misuse of pesticides, through misapplication or overapplication, increases costs for pesticides.

The pesticides that are particularly harmful are those that are resistant to degradation and, as a consequence, accumulate in the environment. According to their chemical make-up, pesticides can be transported through sediment transport or by dissolution in water. Pesticides may inhibit the development or reproductive process of certain organisms. Herbicides may eliminate food sources of aquatic organisms. Pesticides that bioaccumulate in marine biota can be transmitted through fishery resources to humans, posing serious health and ecological hazards (Diamante et al., 1991). Excessive and careless use of agrochemicals, specifically pesticides, is one of the predominant causes of chemical poisoning in the WCR (Hoagland et al., 1995). Pesticide residues present at dangerous levels in the food chain and water supply pose immediate threats to public health.

The extensive use of pesticides due to intensive agricultural activity within the WCR is well documented, and its impact on land and coastal marine ecosystems is reasonably evident (UNEP, 1994b). In Colombia alone, more than 600 different pesticides are used, which represent approximately 33,000 metric tons per year (Tinoco, 1994). Through runoff, erosion, and misapplication, significant quantities of pesticides are reaching the coastal and marine environment, where they may affect nontarget species and, through the contamination of seafood, may become a public health problem (UNEP, 1994b). Furthermore, many pesticides that are banned in developed countries are widely used in Latin America (Altieri, 1991). Approximately 75 percent of the pesticides used in Central America are either prohibited or restricted in the United States (LACCDE, 1990). The use of pesticides is further influenced by government subsidies in some countries, which lower the financial burden and thereby induce farmers to substitute chemical for nonchemical methods of pest management.

Overall, the use of pesticides within the WCR appears to be on the increase. A 1992 report from the World Resources Institute showed a general increase in the use of pesticide compounds during the 1974-1984 period (Table 3-9). Pesticide use is expected to increase in Latin America by 280 percent during the period from 1980 to 2000 (Altieri, 1991). Those countries showing a reduction in use attributed this to changes in agricultural practices to reduce the use of pesticides and use less persistent pesticides with lower application rates (UNEP, 1994b).

3.3.4 Pathogens

Wastes from livestock production are a significant component of agricultural nonpoint source pollution (Myers, 1985). Animal use of water sources, improper location of animals, and improper application of manure can cause serious water quality problems. As stated in Section 3.3.2, runoff from livestock production areas can lead to water quality problems related to nutrients. This runoff can have serious human health impacts as well. Animal diseases can be transmitted to humans through contact with animal feces (USEPA, 1993) and dead animals. A number of pathogenic bacteria can be found in untreated wastewater, including those which cause typhoid fever, hepatitis,

Table 3-9. Average annual pesticide use in 14 countries of the WCR, including changes during the 1974-1984 period

Country	Pesticide Use in Metric Tons		Change
	1974-1977	1982-1984	(%)
Costa Rica	3,037	3,667	21
Colombia	19,344	16,100	(17)
Dominican Republic	1,961	3,297	68
Guatemala	4,627	5,117	11
Guyana	705	658	(7)
Honduras	940	859	(9)
Jamaica	861	1,420	65
Mexico	19,148	27,630	44
Nicaragua	2,943	2,003	(32)
Panama	1,542	2,393	55
Suriname	974	1,720	77
U.S. Gulf Coast	5,320	4,500	(15)
Venezuela	6,923	8,143	18

( ) = loss in value.

Source: World Resources Institute, 1992, cited in UNEP, 1994b.

and dysentery (Lilly, 1996). Runoff from fields receiving manure will contain extremely high numbers of bacteria if the manure has not been properly treated for bacterial content. In addition, the amount of animal waste or manure in runoff can be quite substantial. For example, a 100-cow dairy herd produces as much fecal matter as a community with a population of 15,000 (Myers, 1985). The bacteria most often mentioned in connection with water quality problems are the coliforms, since they are reliable indicators of fecal contamination (Lilly, 1996). Although not pathogenic themselves, coliform bacteria are easily detectable and usually indicate that animal or human waste is present and, by inference, that pathogens might be present as well (Lilly, 1996).

Shellfish closure and beach closure can result from high fecal coliform counts. Although not the only source of pathogens, animal waste has been known to be responsible for shellfish contamination (USEPA, 1993). Shellfish that ingest pathogenic bacteria can cause disease when eaten by humans (Lilly, 1996).

Another source of pathogens in surface and ground waters is dead livestock. If decaying animals are not properly disposed of, they introduce fecal coliforms and other bacteria. Mammals serve as a host for a variety of microorganisms that may be released once the animal is dead. Depending on the cause of death, lethal substances might also be released. Decaying animals, like decaying plants, are also a source of nutrients.

3.3.5 Solid Waste

The pollution caused by solid waste is largely disregarded (Silva, 1994). All plants produce significant quantities of general waste, including large quantities of peels, cores, seeds, or other unusable parts of the raw product that must be discarded. In addition, many facilities produce office waste, plastics, twine, unusable containers, waste packaging materials, and household waste (if housing is provided for workers). Improper handling and disposal of these items, coupled with a lack of disposal alternatives, can result in a significant source of nonpoint source pollution. Trash and debris from an agricultural facility can be washed off site and into a water body. These artificial materials can litter the ocean floor and can be detrimental to marine organisms. Furthermore, solid wastes cause not only impacts related to infectious diseases and organic matter but also adverse impacts related to high organic concentrations, toxic waste, hazardous waste, infectious waste, and radiological waste (Silva, 1994).

SECTION 4.   BEST MANAGEMENT PRACTICES

4.1   Introduction

Agricultural best management practices (BMPs) are procedures and practices designed to reduce the level of pollutants in runoff from farming activities to an environmentally acceptable level, while simultaneously maintaining an economically viable farming operation for the grower (Bottcher et al., undated). This section discusses BMPs that can be used to control the categories of pollutants described in Section 3.3—sediment, nutrients, pesticides, pathogens, and solid waste.

The concept and use of BMPs are not new to the WCR. Indigenous farmers have traditionally used and still use an array of traditional slope, water, soil, pest, and vegetation management techniques, including composting, crop rotation, polycultures, agroforestry, and watershed management systems (Altieri, 1991). Several indigenous techniques are outlined in Table 4-1. Traditional subsistence and

Table 4-1. Some examples of traditional systems of soil management, vegetation, and water use by farmers

Environmental Limitation	Objective	Management Practices
Limited space	Maximize the use of available environmental resources and land	Multiple crops, agroforestry, family orchards, altitudinal zoning, land, rotation
Steep hillsides	Control erosion, conserve water	Terracing, contour strips, dead and living vegetative barriers, mulching, continuous living cover, fallow land
Marginal soil fertility	Sustain fertility and recycle organic material	Natural and improved fallow land, rotation, composting, green and organic fertilizers, pasturing in fallow fields or after harvest, use of alluvial sediments
Floods or excess water	Integrate irrigation and bodies of water	High-field crops
Scarce or unpredictable rain	Conserve water and optimize the use of available humidity	Use of drought-resistant crops, mulching, multiple crops, use of short cycle, etc.
Extremes of temperature and/or radiation	Improve microclimate	Reduction or increase of shade, pruning, spacing of crops, use of crops that tolerate shade, use of windbreaks, live fences, minimum cultivation, multiple crops, agroforestry, etc.
Incidence of blight	Protect crops, reduce pests	Overseeding, damage tolerance, use of resistant varieties, sewing in periods of low pest risk, management of habitat to increase natural enemies, use of repellant plants, etc.

Source: Altieri, M.A. 1988, cited in LACCDE, 1990.

small farm practices employ (1) the use of technology as well as a special spatial and social organization, (2) exact knowledge of resources, (3) adequate consumption, and (4) a nonantagonistic concept of the environment (LACCDE, 1990).

Source controls are often the most effective BMPs for reducing some types of pollution. Examples of source controls include the following:

- Reducing or eliminating the introduction of pollutants to a land area. An example is minimizing the application rates for chemical pesticides, herbicides, and fertilizers.

- Preventing potential pollutants from leaving a site during land-disturbing activities. Examples include conservation tillage and limited land clearing.

- Preventing interaction between precipitation and a potential pollutant. An example is timing chemical applications according to weather forecasts or seasonal weather patterns.

- Protecting riparian habitat and other sensitive areas. Examples include protection of shorelines and highly erosive slopes.

- Protecting natural hydrology. An example is proper water management (USEPA, 1993).

Effective control of nonpoint source pollution in agriculture should focus on controlling soil detachment and overland flow, with considerations for solutional transport and chemical drift. For pollutants that tend to bind to sediment, control of erosion and sediment transport off site can reduce not only impacts from increased sediment loading, but impacts from other pollutants as well due to the interactions of pesticides and nutrients with sediment (Ongley, 1996). The majority of the BMPs described in this document are related to soil conservation practices.

Erosion is not the only factor contributing to agricultural nonpoint source pollution. When a field is actively farmed with the same crop for a number of years, a depletion of nutrients in the soil occurs, requiring the addition of fertilizers to the soil. Loss of soil fertility can also be mitigated by shifting cultivation or crop practices. Shifting cultivation is often characterized by a season-to-season progression of different crops that vary in soil nutrient requirements and susceptibility to weeds and pests (Reijntjes et al., 1992).

The principles of soil and water conservation include increasing infiltration of water for plant use instead of surface runoff which can contribute to nonpoint source pollution. Farmers can reduce erosion, sedimentation, and nonpoint source pollution by 20 to 90 percent by using BMPs to control the volume and flow rate of runoff water, to keep the soil in place, and to reduce soil transport (USEPA, undated).

Best management practices can also encompass a revised approach to traditional agricultural practices. For instance, an effective pest control program might require the use of pesticides as a small component of a comprehensive pest management program. Practices such as crop rotation, proper site selection, proper fertilization, and good cultivation techniques promote a healthy crop and reduce pest infestation, thereby reducing the need for pesticide use. An integrated pest management program protects the environment, reduces pesticide and fertilizer inputs, and enhances economic gain.

The following sections describe structural and nonstructural BMPs that can be used to control agricultural nonpoint source pollution. They focus on pollution prevention, source reduction, and transport control. Although individual techniques are described, their use should be integrated into an agricultural nonpoint source control plan that is appropriate for local site conditions and cropping practices. Many of the methods described minimize or reduce more than one pollutant. The BMPs discussed in this document is not exhaustive and does not preclude any individual or group from using other practices. The selection of BMPs should be based on local cropping practices and site conditions. Table 4-2 provides *general* guidance on the applicability of the BMPs described based on certain variables. Table 6-1 (Section 6, Meeting Summary) outlines the pollutants, providing sources and various methods for control.

4.2 Nonstructural BMPS

Nonstructural BMPs are modifications in agricultural practices that do not require some type of construction. They focus on source reduction (pollution prevention) and programs and procedures for controlling agricultural nonpoint source pollution.

4.2.1 Education

Education needs to occur on a variety of levels. These include decision makers (elected officials, heads of agencies, and political appointees) who develop policy and regulations and their implementing measures, farm owners and farmworkers, and the general public. The importance of protecting natural resources and the impact of nonpoint source pollution on resource degradation need to be communicated effectively. People need to be educated on the importance of conserving soils and water and protecting sensitive marine ecosystems (coral reefs, sea grasses, bathing beaches, etc.). Linkages between healthy natural resources and a strong economy also need to be communicated. Information on the impacts of nonpoint source pollutants due to some farming practices on these resources needs to be conveyed at all levels. Availability of data, information, resources, technologies, and educational materials must be effectively communicated to the appropriate groups.

Public education and outreach activities and materials can take on a variety of forms, depending on the target audience. Decision makers need *general* information on the impacts of nonpoint source pollution, how nonpoint source pollution affects the environment, ways of controlling nonpoint source pollution, and how the adverse impacts of nonpoint source pollution affect the economy and aesthetics of the region. Farmers need *detailed* information on how to select and implement proper nonstructural and structural BMPs, operate and maintain structural BMPs, recognize the limitations of the land and obtain the maximum sustainable yield within those limitations, correctly apply fertilizers and pesticides, manage land properly, and develop and implement erosion and sediment control plans. The general public needs to understand the linkages between their actions, nonpoint source pollution, and degradation of the natural environment.

Education programs should be tailored to the specific needs of the community, the needs of the farmers, and the education level of the target audiences. An effective strategy for public education and outreach regarding agricultural nonpoint source pollution in the WCR should include the following, at a minimum:

Table 4-2. BMP acceptability

Practice[a]	Relative Cost[b]	Implementation Degree of Difficulty[c]	Acceptability[d]	
			Economic	Societal
Soil and plant analysis (N, S, P)	Moderate[e]	moderate	moderate	high
Use of proper fertilization techniques (N)	low[e]	low	high	high
Planting ground covers (N, S, P)	Moderate	moderate	moderate	high
Buffer zones (N, S, P)	Moderate	moderate/high	moderate	low
Leguminous trees and plants (N)	Moderate	moderate	high	high
Water management (N, S, P)	low[e]	low	low to moderate	low to moderate
Use of organic fertilizers (N)	Moderate	moderate	moderate	moderate
Good housekeeping practices (N, S, P)	low[e]	low	high	high
Crop management (e.g., maintaining ground cover) (N, S, P)	Low	low	moderate to high	moderate to high
Vegetating drainage canal banks (N, S, P)	Moderate	moderate	high	low
Good record keeping (N, P)	low[e]	low	high	moderate to low
Land use planning (N, S, P)	low[e]	low	moderate to low	moderate to low
Animal placement - away from drainage ways (N, Pa)	Moderate	moderate	moderate	low
Proper animal waste handling (N, Pa)	Moderate	moderate	moderate	moderate
Controlled land clearing (S)	Low	low	high	moderate to low
Proper animal grazing practices (S)	Low	low	low	low
Conservation tillage (S)	Moderate	high	moderate	moderate

Table 4-2. (continued)

Practice[a]	Relative Cost[b]	Implementation Degree of Difficulty[c]	Acceptability[d]	
			Economic	**Societal**
Terracing (S)	High	high	moderate to low	moderate
Wind erosion controls (S)	Low	low	moderate	moderate to low
Sediment basins (S)	High	high	high	moderate
Use of organic trash fences (S)	Low	moderate	high	moderate
Diversions (S)	High	high	moderate to low	high
Grassed waterways (S)	Moderate	moderate	moderate	moderate
Contouring (S)	Moderate	high	moderate to high	high
Contour drains (S)	High	high	moderate to high	high
Integrated pest management (P)	Moderate[e]	moderate	moderate	moderate
Use of biodegradable pesticides (P)	Moderate	low	moderate	high
Reuse of rinse water (P)	low[e]	low	moderate	moderate
Crop rotation (P)	Low	low	high	high
Mixed cropping (P)	Low	low	high	high
Use of resistant pesticide varieties (P)	low/moderate	low/moderate	moderate	high
Education of farm workers and farm management (N, S, P, Pa, Sw)	Moderate[e]	low/moderate	high	high
Pesticide rotation (P)	Low	low	high	moderate
Aerial buffer (no spray) zone (P)	Moderate	moderate	low	low

Proper manure application (Pa)	low[e]	low	moderate	moderate

Table 4-2. (continued)

Practice[a]	**Relative Cost**[b]	**Implementation Degree of Difficulty**[c]	**Acceptability**[d]	
			Economic	**Societal**
Provision of alternate shade and water for livestock (Pa)	Low	moderate	high	high
Composting and proper disposal of dead livestock (Pa)	Low	low	moderate	moderate
Integrated waste management (Sw)	low[e]	low	moderate	moderate
Landfilling waste (Sw)	Moderate	low	low	moderate
Trash catchment basins (Sw)	Moderate	low	moderate	moderate
Proper reuse of pesticide containers (Sw)	low[e]	low	high	moderate
Plastics management (Sw)	low[e]	low	high	high
River traps on small flow rivers (Sw)	High	high	low	moderate
Composting facilities (Sw)	moderate[e]	moderate	moderate	high

[a] N: applicable to nutrient control.
S: applicable to sediment control.
P: applicable to pesticide control.
Pa: applicable to pathogen control.
Sw: applicable to solid waste control.

[b] Low cost: no construction involved; can be implemented through minimal education (e.g., pamphlets, manuals, etc.).
Moderate cost: little or no construction involved; can be implemented through education programs such as agricultural extension services (public and private), outreach programs, seminars, on-site training, etc.
High cost: construction involved; requires development of plans and the input of BMP designers.

[c] Low: can be done with little or no change in existing infrastructure; some education may be required.
Moderate: some infrastructure changes may be required; education would be required.
High: infrastructure changes and training and education would be required.

[d] Low: not necessarily acceptable, primarily because of economic cost or lack of understanding of the benefits achieved by the BMP.
Moderate: generally acceptable but requires some education on the benefits.

High: acceptable.

[e] Can result in a cost savings for the farmer.

- Development of a commission or similar mechanism for coordinating educational policy for the region.

- Development of national plans and program strategies for education. Plans can include (but need not be limited to):
  - Community education programs
  - Field demonstrations and follow-up site visits
  - School and community workshops
  - Outreach and extension programs, including courses for farmworkers
  - Use of media (TV, radio, videos, etc.)
  - Required school environmental education curriculum

- Development of outreach materials such as fact sheets, guidance documents, and courses for decision makers, farmers, and the general public.

- Education of political and policy leaders in the WCR.

- Appointment of one responsible or lead coordinating agency (e.g., Ministry of Agriculture).

- Economic incentives for implementing education programs.

- Accessibility of data and information to user groups.

Achieving the successful implementation of BMPs by farmers hinges on demonstrating to them that adopting such practices can save them money, resources, and time (J. Wright, Cooperative Extension Service, University of the Virgin Islands, personal communication, February 12, 1998). Education and outreach programs can focus on working with farmers to implement the BMPs described in this report.

4.2.2 Water Management

Water management practices reduce erosion and nutrient losses in runoff by minimizing or slowing water flow off fields. They also conserve water. Contour tillage, buffer strips, diversions, and terraces (see Section 4.3.1, Erosion and Sediment Controls) are a few methods to slow and trap nonpoint source pollutants. When water is slowed or stilled, sediments (and associated pollutants) can settle out of the water column, thereby inhibiting their entrance into the coastal waters.

Water management on farms involves two aspects. The first is managing the surface and ground water flow (hydrology) so as to maximize resource use and minimize environmental damage. The second is managing irrigation of crops.

Effectively controlling the flow of water over the land and in the ground, either from runoff or irrigation, reduces erosion potential and sediment transport off site. Management of water on the site is dictated by site characteristics such as soil type, crop or ground cover, topography, and climate. Designing the site so that unnecessary water flow is minimized (e.g., planting crops on the contour, locating infrastructure) can result in less erosion and maximum availability of water resources.

4.2.3 Land Use

Proper land use is an important concept when trying to control nonpoint source pollution. It addresses a variety of issues and concepts. Proper land use planning involves setting goals for the community or country, completing an inventory of existing land uses and natural resources (including agricultural soils), and designating areas suitable for various types of development (including agricultural development) or conservation. Once appropriate land use designations are categorized and mapped, regulations and policies regarding how the land uses are implemented can be developed. For example, areas on steep slopes may be appropriate for only minimal agricultural development and agricultural crops that do not require removal of all the natural vegetative cover. Areas with highly erodible soils should be cleared only as development is to occur (no clear-cutting). Crops should be chosen based on the natural resource limitations and assets of the land; for example, minimal soil preparation and chemical addition should have to occur to achieve a sustainable yield. Area that is prime for agriculture should be left for agricultural development, not residential or commercial development. This prevents forcing agriculture to less desirable locations where cultivation may result in environmental degradation (e.g., steep slopes). By systematically assessing resources, planning development and conservation activities, and managing agriculture in a sound manner, environmental degradation can be diminished.

4.2.4 Erosion and Sediment Control

Nonstructural erosion and sediment control (ESC) focuses on minimizing the amount of exposed soil and the time the soil is exposed. If crops or other ground cover is kept in place, the soil is less susceptible to erosion. Many of these practices are beneficial for controlling other pollutants as well. This is noted in the descriptions.

4.2.4.1 Erosion and Sediment Controls for Cultivated Crops

Conservation Cover/Stabilization Practices. Conservation cover/stabilization practices establish and maintain perennial vegetative cover to protect soil and water resources on land not currently in use for agricultural production (Ongley, 1996). This may be accomplished by preserving existing vegetation or revegetating disturbed soil. Vegetative cover reduces erosion potential by (1) shielding the soil surface from the impact of falling rain, (2) slowing runoff velocity and allowing sediment deposition, (3) physically holding soil in place with plant roots, and (4) increasing infiltration rates by improving the soil's structure and porosity through the incorporation of roots and plant residues (USVI Conservation District, 1995). Long-term effects of the practice will reduce agricultural nonpoint sources of pollution to all water resources (USEPA, 1993). Areas where natural vegetation preservation is particularly beneficial are floodplains, wetlands, steep slopes, and other areas where erosion controls would be difficult to establish, install, or maintain. Conservation cover/stabilization practices are also suggested for use in drainage structures on agricultural lands where canals or ditches are used to remove excess water. The slopes and bottoms of the canals should be planted with suitable ground cover vegetation. This practice aids in preventing the erosion of ditches and canals and provides uptake for excess nutrients and pesticides that might otherwise run off.

Ground cover and crop residue can reduce erosion and yields of sediment and sediment-related water pollutants. Surface runoff temperatures to receiving waters may also be reduced. Effects will vary during the establishment period and could include increases in runoff, erosion, and sediment yield (USEPA, 1993).

Conservation Tillage. Conservation tillage, including no-till and reduced tillage, is a planting system that maintains at least 30 percent of the soil surface covered by residue after planting. This practice reduces soil erosion, detachment, and sediment transport by providing soil cover during critical times in the cropping cycle (USEPA, 1993). It increases infiltration into ground water by reducing soil compaction from raindrops.

Reduced tillage consists of either minimizing tillage to a coarse, cloddy finish with machinery or hand tools (to improve infiltration and reduce erosion) or tillage in which only the rows are tilled or holes are dug for crops like banana (Gumbs, 1993). Reduced tillage systems incorporate some pesticides and fertilizers when applied to the soil surface, reducing the effects of runoff.

No-till is a conservation practice common in North America (Ongley, 1996). The no-till method consists of planting crops without prior seedbed preparation, into an existing cover crop, sod, or crop residues, and eliminating subsequent tilling operations (USEPA, 1994). No-till planting is the most effective conservation method to protect against soil erosion (York et al., 1993), but it can result in higher losses of nutrients and pesticides in surface runoff.

Although reduced tillage is practiced on steep slopes in the WCR, no-till is seldom practiced on slopes or flat terrain (Gumbs, 1993).

Cover Crop. A cover crop is a crop of close-growing grasses, legumes, or small grains grown primarily for seasonal protection and soil improvement. Usually, it is grown for one year or less (Ongley, 1996). Maintaining a cover crop prevents or reduces erosion and takes up nitrogen, preventing its undesired movement. In addition, a cover crop traps and recycles nutrients for use by later crops. A cover crop, planted between the rows of a cash crop, can also be used to outcompete weeds. Small-scale farmers can plant a cover crop that can be used for food or feed for animals. Furthermore, the overall volume of fertilizer application may decrease because the vegetation (if nitrogen-fixing) will supply nutrients (USEPA, 1993).

Buffer Zones. Vegetated buffer zones, either planted or natural, can prevent the movement of sediment, nutrients, and pesticides to receiving waters such as bays and streams. The vegetation acts tp slow surface water runoff, allowing sediment to drop out of suspension before entering receiving waters. Pollutants that are transported with sediment are also prevented from entering the receiving waters. Soluble nutrients and pesticides can also be taken up by plants in the buffer zone. Ideally, buffer zones should be areas adjacent to water bodies that are conserved when the land is initially developed for agricultural purposes. If this did not occur, buffer areas can be established by planting indigenous perennial plants along shorelines. There is no set formula for buffer zone width; the width is dependent on factors such as slope, soil, climate, vegetative cover (crops and buffer vegetation), and total drainage area. The buffer zone also protects stream banks from eroding and provides riparian habitat and a floodplain during times of high water flow.

Critical Area Planting. Critical area planting involves planting vegetation, such as trees, shrubs, vines, grasses, or legumes, on highly erodible or critically eroding areas (Ongley, 1996). It reduces soil erosion and sedimentation into surface waters. The plants may take up nutrients, reducing the amount washed into surface waters. During the initial stages of planting, large quantities of sediment and associated chemicals may be transported by runoff prior to plant establishment (USEPA, 1993).

Residue Use. Crop residues (such as leaves and remnant stalks) left or spread on cultivated fields protects soil during critical erosion periods (Ongley, 1996). Crop residues reduce erosion by intercepting rainfall, thereby decreasing soil dispersion and soil compaction. Microbial and bacterial action within the residue takes up nutrients and pesticides, delaying their entrance to surface waters.

Delayed Seedbed Preparation. All crop residue and naturally occurring vegetation can be maintained on the soil surface until shortly before the succeeding crop is planted. This reduces the period that the soil is exposed and susceptible to erosion (Ongley, 1996). Delayed seedbed preparation maintains vegetative cover as long as practical to minimize splash erosion and nonpoint source pollution during critical erosion periods such as the rainy season. Additionally, moisture is conserved, water quality improved, and soil infiltration increased.

Indigenous Weed Management. Indigenous weed management is the practice of allowing weeds to grow in fallowed fields, or intercropping or seeding them. Indigenous farmers have instinctively understood that weeds should be left to grow while crops are young. Weeds cover the soil, prevent it from heating up or drying out excessively, induce a positive competition that stimulates crop growth, and reduce erosion due to rainfall. As the crop matures and weed competition causes a negative impact, farmers hoe the weeds, leaving a protective mulch on the surface to recycle nutrients and naturally fertilize the crop. This natural fertilization is referred to as “green manuring.” Compost, leaves, and grass may all be used for fertilization.

Mulching. Mulching is a temporary soil stabilization or erosion control practice in which materials such as cut grass, wood chips, wood fibers, or straw are placed on the soil surface to temporarily stabilize disturbed areas until a seeded crop or vegetation is established (USVI Conservation District, 1995). The benefits of mulching stem from reducing the direct impact of rain, maintaining maximum soil infiltration, and decreasing the quantity, velocity, and transport capacity of runoff water (Manrique, 1993). Mulching is also an effective water conservation tool. It provides added benefits to the crop by holding seeds, fertilizers, and topsoils in place; retaining moisture; and insulating seedlings against high temperatures. It is inexpensive and easy to implement. Mulching provides a method of weed control, and organic mulch is biodegradable. On steep or highly erodible slopes, mulch should be used with some type of anchoring system, such as netting.

Mulching is also an alternative to tilling or hoeing, which has been a common form of weed control. A typical practice is to slash the weeds three to four times a year, leaving a weed mulch on the surface to help avoid soil erosion and to delay weed growth (FAO, 1994). This practice, of course, does not eliminate weeds but inhibits weed growth while cultivated crops gain dominance.

Mulching materials can also be obtained from the crop itself. In banana production, common mulching materials are dead banana leaves, pruned suckers, and old stems (FAO, 1994). In the case of bananas, however, mulch should be used only in vacant rows. Mulch should not be allowed to come into contact with the banana stems since it can create moist conditions that can encourage the entry of banana weevils (FAO, 1994).

Although using mulch has many benefits, certain drawbacks do exist. Mulch can intercept light rains, which evaporate prior to reaching the crop roots. In addition, decaying mulch can immobilize fertilizers and reduce the availability of nutrients to plants.

Strip Cropping. Strip cropping is growing crops in a systematic arrangement of strips or bands across the general slope (not on the contour) to reduce water erosion. Crops are arranged so that a strip of grass or close-growing crop is alternated with a clean-tilled crop or fallow (Ongley, 1996). This method is mainly suited for gentle slopes and areas of lower rainfall (Sheng, 1988).

Conservation Cropping. Conservation cropping is a sequence of crop rotations designed to provide adequate organic residue for maintenance of soil tilth. This practice reduces erosion by increasing organic matter, resulting in a reduction of sediment and associated pollutants to surface waters (USEPA, 1993). It can also disrupt disease and insect and weed reproduction cycles, thereby reducing the need for pesticides. Legumes and grasses are the typical species planted in the rotation (Ongley, 1996).

4.2.4.2 Erosion and Sediment Controls for Livestock Areas

Deferred Grazing. Deferred grazing, also called rotational grazing, removes livestock from an area for a prescribed period of time. This practice reduces nutrient loads from manure and allows vegetation to recover for a period of time. This practice can also be used as a planned grazing system, in which two or more grazing units are alternately rested and grazed for a planned period of time (USEPA, 1993).

Heavy Use Area Protection. Heavy use areas can be protected by using any of three methods—establishing vegetative cover, surfacing the area with suitable materials, or installing structures (USEPA, 1993). This practice may result in a general improvement of surface water quality through the reduction of erosion and sedimentation. Heavy use areas include livestock feeding, shade, and watering areas; pathways leading to water bodies; and similar areas that livestock frequently use.

4.2.5 Pesticide/Nutrient Control

Most BMPs for pesticide and nutrient control are considered nonstructural. However, many of the structural BMPs outlined for erosion and sediment control can also reduce losses of pesticides and nutrients. With minimal effort, the probability of chemical accidents can also be drastically reduced. As with erosion and sediment control, the actual effectiveness of the following BMPs depends on site-specific variables such as soil type, crop rotation, topography, tillage, and harvesting method (USEPA, 1993), as well as education of the farmworkers.

Good Housekeeping Practices. “Good housekeeping” practices are one of the easiest BMPs to incorporate into an agricultural regime. The best way to avoid a problem is to prevent it at its source (USVI Conservation District, 1995). These practices include any preventive measures taken to reduce the possibility of accidental introduction of pesticides or fertilizers to the environment. A few simple steps can be taken to greatly reduce the potential of surface water contamination due to pesticides or nutrients.

- The area where chemical products are stored is a major source of risk: since mishandling of materials or accidental spills may occur in storage areas. Proper storage and handling of chemicals reduces safety hazards.   To reduce the risks of misusing chemical pesticides or fertilizers, the materials should be handled as infrequently as possible and all handling or disposal instructions should be carefully followed. Pesticides and fertilizers should always be stored in a dry, covered area, and the recommended application rates and methods need to be followed.

- To reduce the risks of nutrient pollution, fertilizers should be applied only when needed, fertilizer applications should be limited to the necessary area and the minimum recommended amount, fertilizers should be worked into the soil to reduce nonpoint source pollution, seeding and fertilizing should be done in one application, and good erosion and sediment control practices should be implemented to help reduce the amount of sediment and fertilizers that leaves the site (USVI Conservation District, 1995).

- Just as pesticides differ in their effectiveness on a variety of pests, they also differ in their potential to contaminate surface water. Using the appropriate pesticide in a controlled manner with soil conservation practices reduces the likelihood of pesticides being carried into neighboring waterways. Pesticides and fertilizers should never be applied immediately prior to irrigation.

- Used pesticide containers should be disposed of properly.

In any location where intensive agriculture or livestock farming produces serious risks of nitrogen pollution, the following minimal steps should be taken at the farm level (Ongley, 1996):

- Rational nitrogen application. Overfertilization should be avoided.

- Vegetation cover. As discussed in Section 4.2.4, the maintenance of vegetative cover inhibits the build-up of soluble nitrogen by absorbing mineralized nitrogen and preventing leaching during periods of rain.

- Management of the area between crops. Organic debris produced by harvesting is easily mineralized into leachable nitrogen. Steps to reduce leachable nitrogen include planting of “green manure” crops and delaying the ploughing of straw, roots, and leaves into the soil.

- Rational irrigation. Poor irrigation has one of the worst impacts on water quality, whereas precision irrigation is one of the least polluting practices as well as a reducer of the net cost of supplied water.

- Optimization of other cultivation techniques. The highest yields with minimum water quality impacts require optimization of practices such as weed, pest, and disease control; liming; and fertilization.

- Agricultural planning. Erosion control techniques that complement topographic and soil conditions should be implemented.

- Proper record keeping. Accurate records of nutrients or pesticides used, when used, quantity used, and on which crop used should be maintained to establish patterns and needs of the crop being cultivated.

Plant and Soil Analysis. Plant and soil analysis is helpful in determining fertilizer and pesticide usage. It can help in the following ways:

- *Nutrients.* Soil and plant analyses are helpful in determining the types of fertilizers needed to produce a high yield of a crop with minimal environmental impacts. For example, if soil is tested for pH and the levels of phosphorus, potassium, and nitrogen, and the nutrient requirements of the plant are known (e.g., the plant is a high nitrogen-demanding plant), fertilizers can be applied to the area based on the deficiencies indicated from the soil test.

- *Pesticides.* Soil and site analyses are helpful in determining proper pesticide usage. Before pesticide use, certain characteristics of the soil should be determined. Locations of aquifers, drinking water wells, sinkholes, drainage wells, and other features that allow surface water and its contents to enter and contaminate the ground water should be identified. The runoff potential, which is increased by steep slopes and highly erodible soils, determines how fast pesticides that can be carried in runoff will leave the site. Pesticides should not be applied in areas directly adjacent to surface waters. A buffer between the site of application and the surface water body should be left untreated. Soils with low adsorptive capacity have a lower ability to bind applied pesticides and prevent them from running off or leaching into the ground water. Highly permeable soils tend to allow water (and, therefore, pesticides) to rapidly percolate through to the ground water.

Nutrient Management Plan. A nutrient management plan provides information to help control or reduce the amount of fertilizers used on a crop. The following practices, components, and sources of information should be considered in the development of such a plan (USEPA, 1993):

- Use of soil surveys and soil testing in determining soil productivity and identifying environmentally sensitive areas. Soil testing should include pH, phosphorus, potassium, and nitrogen data.

- Plant tissue testing.

- Use of proper timing, formulation, and application methods for nutrients that maximize plant utilization of nutrients and minimize loss to the environment, including split application and banding of the nutrients, use of nitrification inhibitors and slow-release fertilizers, and incorporation or injection of fertilizers, manures, and other organic sources.

- Use of cover crops.

- Use of buffer areas.

- Control of phosphorus losses from fields through a combination of erosion and sediment control measures.

Integrated Pest Management. Integrated pest management (IPM), a mixture of chemical and other nonpesticide methods to control pests, has been shown to reduce pesticide use (USEPA, 1994). It promotes the health of crops and animals by using natural and cultural control processes and methods. IPM emphasizes the following strategies (USEPA, 1993):

- Use of biological controls:
  - Introduction and fostering of natural enemies
  - Preservation of predator habitats
  - Release of sterilized male insects
  - Use of bait and trap crops

- Use of pheromones:
  - For monitoring populations
  - For mass trapping
  - For disrupting mating or other behaviors of pests
  - For attracting predators/parasites

- Use of crop rotation to reduce pest problems.

- Use of mixed cropping.

- Use of improved tillage practices.

- Destruction of pest breeding and refuge sites (which may result in loss of crop residue cover and an increased potential for erosion).

- Use of mechanical destruction of weed seed.

- Pest scouting and parasite/predator monitoring.

- Use of pest resistant crop strains.

- Pesticide application based on economic thresholds; i.e., applying pesticides when an economic threshold level has been reached as opposed to applying pesticides in anticipation of pest problems.

- Use of less environmentally persistent, toxic, and/or mobile pesticides.

- Use of timing of field operations (planting, cultivation, harvesting, irrigation) to minimize application and/or runoff of pesticides.

- Use of more efficient application methods (e.g., spot spraying as opposed to aerial spraying).

- Management of weed hosts.

IPM uses chemical pesticides only where and when the measures listed above fail to keep pests below damaging levels. It involves all stages of agricultural production from site selection to harvest.

A sound pesticide management program matches the pesticide with the pest. This involves proper identification of the pest and then selection of the pesticide, rate, and application method most effective for control (Yelverton, 1993). The need for pesticides, particularly herbicides, can be reduced through proper land preparation before planting. Removing problem weeds prior to planting reduces the need for large quantities of herbicides during the growing season.

IPM not only prevents environmental degradation but also may lead to economic gain for the farmer. Table 4-3 summarizes estimates of reductions in pesticide loss using various management practices and combinations of practices in cotton (North Carolina State University, 1984, cited in USEPA, 1993). Reductions in losses equate to reductions in amount used and therefore a cost-savings.

Proper Application of Nitrogen and Phosphorus. Surface application of nitrogen and phosphorus without incorporation into the soil is the least desirable method of applying fertilizer (Lilly, 1995). Due to the soil bonding properties of phosphorus, it should be incorporated into the soil by tilling, or a similar method, prior to planting. Phosphorus is stable once it is mixed into the soil. Nitrogen, however, is very mobile. Ideally, nitrogen should be applied frequently in small amounts tailored to the crop's immediate needs (Lilly, 1995). For most crops, nitrogen may be applied in split applications that coincide with the uptake or growth pattern of the crop. A broadcast method of fertilizer (and pesticide) application should not be used when strong winds are present. Wind can cause drift from applicators and misplacement of materials.

Table 4-3. Estimates of potential reductions in field losses of pesticides for cotton compared to a conventionally or traditionally cropped field[a]

Management Practices	Transport Route(s)	Range of Pesticide Loss Reduction (%)[b]
Optimal Application Techniques[c]	All Routes[d]	40 to 80 A
Nonchemical Methods	All Routes	
Scouting Economic Thresholds	All Routes	40 to 65 A 0 to 30 B
Crop Rotations	All Routes	0 to 20 B 0 to 30 B

Pest-Resistant Varieties	All Routes	0 to 60 A 0 to 30 B
Alternative Pesticides	All Routes	60 to 95 A 0 to 20 B

[a] The hypothetical traditionally cropped comparison field uses the following management system:
(1) conventional tillage without other soil and water conservation practices;
(2) aerial application of all pesticides with timing based only on field operation convenience;
(3) 10 insecticide treatments annually with a total application of 12 kg/ha based on a prescribed schedule;
(4) cotton grown in 3 out of 4 years; and
(5) long-season cotton varieties.

[b] Assumes field loss reductions are proportional to application rate reductions.
A = insecticides (toxaphene, methylparathion, synthetic pyrethroids).
B = herbicides (trifluralin, fluometron).
Ranges allow for variation in production region, climate, slope, and soils.

[c] Defined for cotton as ground application using optimal droplet or granular size ranges with spraying restricted to calm periods in late afternoon or at night when precipitation is not imminent.

[d] Particularly drift and volatilization.

Source: North Carolina State University, 1984, cited in USEPA, 1993.

Aerial Spray Zones. In some areas, pesticides are applied from airplanes flying low over crops and releasing pesticides. This allows for maximum coverage in minimum time. Care should be taken to minimize release of pesticides to surface waters by establishing aerial “buffer” zones where no spraying would occur within a certain distance of surface waters and populated areas. For example, in Costa Rica, no spray zones have been established within 15 metres of surface waters and 100 metres of populated areas. The limits of the zones can be established by something as simple as markers on poles and trees or something as sophisticated as geographic positioning systems (GPS).

Realistic Yield Goals. All fertilizer recommendations assume a certain yield goal for the crop to be grown. Nutrients should not be overapplied in the quest for an unrealistic yield (Lilly, 1995). Excessive applications or amounts of fertilizer waste money and contribute to water pollution.

Use of Natural Fertilizers. Manure and other waste or by-product materials can be used as natural fertilizers if applied correctly. This practice minimizes the need for chemical fertilizers. For example, farms that grow both sugar and coffee can use a mixture of coffee bean shells and animal manure (e.g., chicken manure) to make fertilizers. Although the natural fertilizer might need to be supplemented with chemical fertilizers, the amount of chemical fertilizer needed is reduced. This approach also helps address the issue of waste disposal from the coffee processing.

Leguminous Plants in Rotation. The planting of grasses and leguminous plants, either individually or together, reduces runoff and provides a source of organic nitrogen, thereby reducing fertilization needs. During the period of rotation when the grasses and legumes are growing, they will take up more phosphorus (USEPA, 1993). They also provide an opportunity for animal waste management because manures and other wastes may be applied for an extended period of time due to the nutrient uptake by the grass and legume species.

4.2.6 Pathogens

Because they are the primary agricultural source of pathogens, pathogen controls focus on livestock and manure management.

Proper Grazing Management. Proper grazing management includes determining the maximum number of animals per hectare based on the amount of manure that can be safely applied per hectare of land. For a sound grazing management system to function properly and to provide for a sustained level of productivity, the following should be considered (USEPA, 1993):

- Know the key factors of plant species management, plant growth habits, and their response to different seasons and degrees of use by various kinds and classes of livestock.

- Know the amount of plant residue or grazing height that should be left to protect grazing land soils from wind and water erosion, to provide for plant regrowth, and to provide the riparian vegetation height desired to trap sediment or other pollutants.

- Know the range site production capabilities and the pasture suitability so an initial stocking rate can be established.

- Know how to use livestock as a tool in range management to ensure the health and vigor of plants, soil tilth, proper nutrient cycling, erosion control, and riparian management, while at the same time meeting the nutritional requirements of the livestock.

- Establish grazing unit sizes, watering, shade, and feed locations to optimize livestock distribution and proper vegetation use.

- Provide for livestock herding to protect sensitive areas from excess use.

Livestock Exclusion. The exclusion of livestock from areas such as waterways and stream banks reduces the amount of sediment and manure that can enter surface waters. Livestock exclusion prevents livestock from entering a water body or walking down its banks, thereby preventing soil compaction and water quality problems due to manure deposition. Alternative shade and water sources should be provided for livestock.

Disposal of Dead Livestock. Dead livestock should be disposed of properly to reduce the potential for ground and surface water contamination from pathogens and nutrients. They should be removed from streams or fields and isolated until disposal is possible. Proper disposal methods include composting and incineration. The general composting guidelines described in Section 4.2.5 can be used when developing composting facilities for dead animals. Incineration facilities require more detailed planning and need to be developed under the consultation of local and national authorities to ensure proper construction, operation, and maintenance. When animals die from contagious diseases, special care should be taken, such as worker protection, quarantine, and similar measures, so as not to contaminate workers or other animals.

Manure Management. It is important to consider manure management and the potential for fly, odor, and water quality impacts when raising livestock. A complete manure management system involves collection, storage (temporary or long-term), and ultimate disposal or use (Graves, 1992). A manure management plan should establish fertilizer plans to use manure effectively

(Ongley, 1996). Sometimes a small number of animals can cause more difficulties than a large herd, especially when animals are confined in buildings or on small lots (Graves, 1992).

Manure can be stored for later use as a fertilizer. Regular cleaning of a manure storage area reduces the opportunity for insect breeding and odor production. Storage areas should be designed and managed to exclude rodents and to keep rain and surface waters away from the manure (Graves, 1992).

Grazing animals distribute their manure throughout the pasture. Problems result, however, when too many animals exist in too small an area. Animals congregate along streams or watering areas and around feeding troughs and shady areas. Soil erosion and excess manure deposition are likely when the population levels are excessive. Reducing stocking density, moving feeding areas, and paving areas around waterers can reduce these problems (Graves, 1992). It might be necessary to develop alternative watering areas and erect fencing if a stream is present within the pasture.

Waste Utilization. Waste utilization is the practice of using agricultural waste on land in an environmentally acceptable manner while maintaining or improving soil and plant resources (USEPA, 1993). This waste can be in the form of manure or runoff water from agricultural lands. Waste utilization helps to reduce the transport of sediment and related pollutants to surface waters. Proper site selection, timing of application, and rate of application can reduce the potential for degradation of surface and ground water (USEPA, 1993). Additionally, waste utilization may cause microbial reactions in the soil that assist in controlling pesticides and other pollutants by keeping them in place.

4.2.7 Solid Waste

Managing solid waste is an issue of control. Solid waste management not only protects farmers and farmworkers from disease, rodents, and flies but also maintains an aesthetically pleasing environment.

Integrated Waste Management. Solid waste can be managed through an integrated waste management system composed of reducing, reusing, and recycling solid waste used or generated on site. This management system must be supervised, and responsibility for tasks must be assigned to individuals. In implementing an effective waste management plan, an agricultural facility must determine which items are not necessary, which can be reused (e.g., pesticide containers), and what can be recycled. Recycling can be accomplished in a variety of ways. For example, twine and banana bags from a banana plantation were recycled and fashioned into the footbridge below. Items that cannot be reused or recycled should be disposed of at a landfill or other appropriate alternative.

Composting. Organic waste from an agricultural production facility can be composted to be used as mulch or fertilizer. Composting is a controlled process of degrading organic matter by micro-organisms (USEPA, 1993). The organic waste (e.g., leaves, stumps, peels) can be stored in a large garbage can, a constructed structure, or a lined hole that remains dark and allows decomposition to occur. The storage structure should be secured to protect from rodents and odor. As the waste decomposes, it evolves into a humus-like substance that can be used as fertilizer or mulch. Little maintenance is needed, but lime might need to be added to the compost to reduce acidity prior to application on fields.

4.3 Structural BMPS

Structural BMPs are practices related to something constructed or built. There are a variety of structural BMPs and most require some level of routine maintenance to continue working effectively. The physical structures described in the following subsections are primarily concerned with changing slope characteristics to reduce the amount and velocity of runoff (Manrique, 1993). Slope management, based on a combination of simple and inexpensive cropping practices, can be highly effective in maintaining or improving crop productivity with minimal erosion risk (Manrique, 1993). Physical structures are also used to trap sediment and pollutants before they enter surface waters.

4.3.1 Erosion and Sediment Controls

The ability of a country to sustain its agricultural productivity is closely related to topsoil quality and depth, both of which are reduced by soil erosion (Hwang et al., 1994). The focus of any agricultural erosion and sediment control (ESC) plan should be to prevent erosion before it starts. Sediment controls are used to trap the sediment that erodes off the land. An effective ESC plan should minimize the amount of disturbed soil, slow runoff flowing across the site, remove sediment from runoff before it leaves the site, and plan soil disturbance for the dry season (USVI Conservation District, 1995). The BMPs employed must be site-specific to achieve desired effectiveness levels. The actual effectiveness of a BMP depends on site-specific variables such as soil type, crop rotation, topography, tillage, and harvesting method (USEPA, 1993). The following erosion and sediment control techniques also provide beneficial results in relation to nutrient, pesticide, and pathogen control. Combinations of these BMPs can be used to further ensure reductions in nonpoint source runoff of sediment, nutrients, pesticides, and pathogens.

4.3.1.1 Erosion Controls

Contour Farming. Contour farming is the use of ploughing, planting, and other management practices that are carried out along land contours (Ongley, 1996). It includes following established grades, terraces, or diversions. Contour farming reduces erosion and sediment production, which, in turn, reduces the transport of related pollutants to receiving water bodies.

The following is an example of contour planting. Every 10 meters, a farmer marks a contoured, baseline row across the field using an A-frame or an equivalently simple level. Parallel to this level baseline, the farmer then plants five parallel rows uphill and downhill. The short rows are re-leveled and fit into the remaining spaces. The farmer’s planting, cultivating, and hilling-up (sometimes 30 cm high) of each row forms many absorption ditches on the contour. Absorption ditches are expected to store the rain that falls between the rows. The contour planting and hilling-up practices can eliminate 80 to 90 percent of the erosion occurring, even on steep mountain soils. The effectiveness of the method depends on the soil’s infiltration rate; the intensity and duration of rainfall; the steepness and length of the slope; and the human factor, which includes the accuracy of layout and uniformity of height of the ridges (Aldedge, 1988). Contour planting has been successful in many Latin American and Caribbean countries, especially Guatemala, Saint Vincent, Barbados, Puerto Rico, and the Virgin Islands (Aldedge, 1988).

Diversions. Diversions are channels constructed across the slope with a supporting ridge on the lower side. By controlling downslope runoff, erosion is reduced and the infiltration into the ground water is enhanced (Ongley, 1996). Maintaining drainage channels prevents or reduces erosion and takes up nutrients. Diversions are particularly effective in preventing sheet and rill erosion by reducing the length of the slope (USEPA, 1993). Figure 4-1 illustrates this concept.

Terracing. Terraces are constructed earthen embankments that retard runoff and reduce erosion by breaking the slope into numerous flat surfaces separated by slopes that are protected with permanent vegetation or are constructed from stone or other materials. Terracing is carried out on very steep slopes and on long, gentle slopes where terraces are very broad (Ongley, 1996). Terracing can actually increase the land area in production. On slopes of 30 degrees, bench terracing increases the productive land surface by 25 percent. Therefore, for every 4 hectares of bench terraces, a farmer gains a fifth hectare. Flatter slopes produce less of an increase in land area; inversely, steeper slopes provide more (Aldedge, 1988).

Construction of bench terraces requires considerable labor, but maintenance is minimal. In Venezuela, terracing is accomplished by the "controlled-erosion" construction method—building strong rock walls along the contours of the slopes and allowing the normal actions of erosion and cultivation to level the surface (Williams and Walter, 1988) (Figure 4-2). An adequate terrace is exactly level along the front edge and the base of the slope. The cultivated bench must be inclined into the mountain enough to store rainfall (15 percent or more). Protection of the backslope is maintained by a rock wall or planting of perennial species (Aldedge, 1988). "Controlled-erosion" bench terraces are constructed by controlling the natural process of erosion. Rock retaining walls (no higher than 1 to 1.5 meters for gentle slopes, higher for steeper slopes), constructed along the contours of a slope at 10- to 40-meter intervals, provide a block to eroding material. Thereafter, erosion and downslope ploughing provide the fill behind the retaining wall (Williams and Walter, 1988). However, the process takes an extended period of time to evolve naturally and achieving level terraces is delayed indefinitely. The advantage to this form of terrace construction compared with conventional bench terracing is the reduction in the work required for moving soil and subsoil. In addition, it tends to provide cultivation surfaces that are relatively large and stable (Williams and Walter, 1988). In the Venezuela example (Figure 4-2), the rock for the retaining walls was obtained from the field. If rock were not immediately available, labor and transportation costs would be great. Level bench terracing has been successful in several Latin American and Caribbean countries (Aldedge, 1988).

Simple terracing systems such as intermittent terraces, convertible terraces, orchard terraces, and hillside ditches are alternatives to the more expensive bench terrace. Intermittent terraces are used for larger tree crops, while orchard terraces are narrower terraces built for a single tree or bush. The cost of these simple terracing systems is approximately one-fifth to one-third the cost of bench terraces, and their effectiveness appears reliable. Runoff studies in Jamaica have shown that hillside ditches with contour mounds or ridges reduce soil erosion by 80 percent in runoff plots under yam cultivation (Manrique, 1993). However, terraces can also have a detrimental effect on water quality if they concentrate and accelerate delivery of nutrients and pesticide pollutants to surface waters (USEPA, 1993).

Wind Erosion Control. Wind erosion controls reduce erosion and nutrient runoff due to wind transport of sediment by protecting crops against winds and stabilizing soil vulnerable to erosion. Common wind breaks include shrubs and trees planted in borders or along property boundaries. Once established, wind breaks become permanent and fruit crops such as bananas are most benefited due to reduced plant stress (Palada, 1992).

Fencing. Fencing encloses or divides an area of land with a suitable permanent structure that acts as a barrier to livestock. It can be built on the contour or up and down the slope. When built across the slope, fencing slows down runoff and causes deposition of coarser-grained materials, reducing the amount of sediment delivered downslope. Fencing can be placed to protect water bodies from livestock activity and, with the proper vegetation along the fencerow, serves as a trap to sediments and solid waste.

4.3.1.2 Sediment Controls

Field Borders. Field borders are strips of perennial herbaceous vegetation or shrubs established along the edges of fields. They slow runoff and trap coarser sediment. However, field borders are generally not effective for fine sediment and associated pollutants (Ongley, 1996). This method is mainly suited for gentle slopes and areas of lower rainfall (Sheng, 1988).

Field borders serve as "anchoring points" for contour rows, terraces, diversions, and contour strip cropping. By eliminating the practice of tilling and planting the ends up and down slopes, erosion from concentrated flow in furrows and long rows may be reduced (USEPA, 1993).

Filter Strips. Filter strips are areas of vegetation for removing sediment, organic matter, and other pollutants from runoff (USEPA, 1993). Like field borders (which are typically grasses), filter strips trap coarser-grained sediment and might not be effective on suspended fine-grained materials. Filter strips are most effective when downslope runoff flows across them as sheet flow, causing the deposition of sediment and polluted runoff.

Grassed Waterways. Grassed waterways, or swales, are natural or constructed channels that are vegetated, graded, and shaped so as to inhibit channel erosion. The vegetation also traps sediment that is washed in from adjacent fields (Ongley, 1996). Grassed waterways require little maintenance, but they must be graded so as to move the runoff off the site.

Sediment Basins. A sediment basin is constructed to remove and store sediment from runoff during rainfall events. Runoff flows to the basin and is held for a period of time, allowing the sediment to drop out of suspension. Sediment basins need to be cleaned out periodically to ensure proper functioning. Their effectiveness is affected by the length of the flow path of the runoff and, therefore, may be reduced when clays and steep slopes are present (J. Wright, Cooperative Extension Service, University of the Virgin Islands, personal communication, February 12, 1998).

As discussed previously, using erosion and sediment control BMPs may result in the control of nutrients and pesticides as well. Table 4-4 summarizes estimates of reductions in pesticide loss from cotton fields using various ESC practices and combinations of practices in cotton.

4.3.2 Pathogens

Management of animal wastes and dead animals can reduce leaching of nutrients, ammonia emission, and health risks due to contamination of surface and ground waters. A variety of measures, including those BMPs referenced in Sections 4.2 and 4.3.1 can be implemented to control animal wastes and contamination from dead animals in runoff.

Waste Storage Ponds. Waste storage ponds are impoundments designed and excavated for the temporary storage of animal or other agricultural waste. This practice reduces the direct delivery of polluted water, which includes any runoff from manure stacking areas, feedlots, and barnyards, to surface waters (USEPA, 1993).

Table 4-4. Estimates of potential reductions in field losses of pesticides for cotton compared to a conventionally or traditionally cropped field[a]

Management Practices	Transport Route(s)	Range of Pesticide Loss Reduction (%)[b]
Terracing	SR and SL	0 to (20)[c]
Contouring	SR and SL	0 to (20)[c]
Reduced Tillage	SR and SL	-40 to +20 AB
Grassed Waterways	SR and SL	0 to 10 AB
Sediment Basins	SR	0 to 10 AB
Filter Strips	SR	0 to -10 A
Cover Crops	SR and SL	-20 to +10 B

SR = surface runoff.
SL = soil leaching.
[a] The hypothetical traditionally cropped comparison field uses the following management system:
(1) conventional tillage without other soil and water conservation practices;
(2) aerial application of all pesticides with timing based only on field operation convenience;
(3) 10 insecticide treatments annually with a total application of 12 kg/ha based on a prescribed schedule;
(4) cotton grown in 3 out of 4 years; and
(5) long-season cotton varieties.
[b] Assumes field loss reductions are proportional to application rate reductions.
A = insecticides (toxaphene, methylparathion, synthetic pyrethroids).
B = herbicides (trifluralin, fluometron).
Ranges allow for variation in production region, climate, slope, and soils.
[c] Refers to estimated increases in movement through soil profile.
Source: North Carolina State University, 1984, cited in USEPA, 1993.

Stream Crossing. A stream crossing is a stabilized area to provide access across a stream for livestock and farm machinery (USEPA, 1993). The purpose is to provide a controlled crossing or watering access point for livestock, thereby controlling bank and streambed erosion, reducing sedimentation, and enhancing water quality.

4.3.3 Solid Waste

Catchment Basins. A catchment basin is a BMP similar to a sediment basin. It traps waste prior to its entering a water body.

River Traps. River traps may also be used to inhibit the flow of solid waste off site, but they cannot be used in streams or rivers with a high velocity of flow. Catchment basins are also effective at preventing the transport of large amounts of organic waste off site.

4.3.4 Siting Structural BMPs

For structural BMPs to be effective in controlling nonpoint source pollution, they must be properly designed, sited, installed, and maintained. Proper design includes making sure the selected BMP will achieve the desired result (e.g., erosion protection). The BMP should be sited in the best location to achieve the maximum pollutant removal and installed in such a manner that it will function properly. If the intended purpose of the BMP is to trap sediment, it should be located in an area where sediment-laden runoff drains and before the runoff leaves the site. Maintenance is critical to BMP effectiveness. If structures are not maintained (e.g., kept free of trash and debris, moving parts kept operable), they will most certainly fail. Sediment needs to be removed from sediment basins and traps, "trash" fences need to be checked to make sure there are no breaks, and contoured areas need to be regraded from time to time.

4.4 Monitoring

Monitoring is defined as "the measurement of a pollutant or its effects on either man or marine resources for the purposes of assessing and controlling exposure to that pollutant" (UNEP, 1985, cited in Coté, 1988). Monitoring is necessary to determine whether the predicted benefits of treatment or other management instruments have occurred to assess the need for further treatment and management, and to provide a basis for new management strategies and instruments to reduce the impact of similar activities that might be proposed in the future (Coté, 1988).

It is important to know whether the BMPs used as part of an overall plan are effective in controlling nonpoint source pollution and in preventing environmental degradation. There are two general types of monitoring—water quality monitoring and program monitoring. Water quality monitoring looks at the levels of specific pollutants or contaminants in a water body and measures the change in pollutant level over time. Program monitoring provides an evaluation of the programs being implemented and allows an evaluation of the types of programs being used to control the impacts of agricultural nonpoint source pollution. Monitoring is done to evaluate the effectiveness of an overall program and to identify areas where improvement or changes are needed. Without monitoring, it is uncertain whether there is pollutant reduction or environmental benefit associated with a given effort.

For monitoring to be effective, a monitoring plan should be developed. The plan contains the goals and objectives for the monitoring program (e.g., to determine the extent to which nitrogen is being reduced in a bay, to determine whether countries are implementing agricultural nonpoint source pollution control education programs), procedures for carrying out the monitoring (e.g., frequency of data collection, methods used), data collection, data analysis, and program evaluation (e.g., whether there a is reduction in nitrogen in the bay, whether country X has developed and implemented an education program).

Water quality monitoring provides specific information on pollutants that are being reduced. Program monitoring (sometimes called technology monitoring) is based on the assumption that structural and nonstructural BMPs are effective at reducing nonpoint source pollutant loadings and that through their implementation, pollutant reduction does occur. For some countries and farm operations, it might be more practical to develop and implement a program monitoring plan. A program monitoring plan in conjunction with a biological monitoring program may also be a cost-effective approach to an evaluation program for BMPs.

Additional information on monitoring technologies and plan development can be obtained from local extension services and nongovernmental organizations. Appendix C contains additional resources that can be consulted.

4.5 Socioeconomic Factors and Implementation

In 1990, the Latin American and Caribbean Commission on Development and the Environment (LACCDE) formulated a strategy to increase productivity and to assess the present and potential environmental impact caused by particular agricultural practices. The strategy proposed adopting the following measures to reduce nonpoint source pollution:

Prudent use of agrochemicals, assigning preference, for example, to such practices as integrated pest management and the use of organic fertilizers.

Promotion of tillage techniques patterned on nature's own methods, such as multicropping and agroforestry.

Farm subsidy programs to restore watersheds and deteriorated ecosystems.

Regulation of land use, promoting ecologically suitable crops congruent with land management planning.

Soil conservation to control erosion produced by wind and water.

Fixing of a fair price for irrigation water to avoid waste (LACCDE, 1990).

The introduction of a BMP program would be the first step toward achieving the goals of this strategy. To effectively incorporate the use of BMPs into the agricultural sector, however, three major questions need to be answered (Sheng, 1992):

1. Which government agency or agencies should be responsible for enforcing or encouraging the use of BMPs?
2. How can farmers be effectively motivated to participate in a BMP program?
3. What necessary assistance should be given to farmers once they agree to use BMPs?

The need for each country to develop a national policy and a program of measures addressing agricultural nonpoint source pollution is evident. Once achieved, such policies and programs will address the questions listed above.

It is generally recognized that the greatest barriers to the widespread use of soil and water conservation measures in developing countries are socioeconomic. They include insecure tenure, high discount rates, the costs to the farmer of implementing the practices, and government policies that promote nonsustaining farming practices (Hwang et. al., 1994). Several barriers prevent the countries of the WCR from answering the questions above and implementing an effective BMP program. They include insufficient financial or physical resources to control nonpoint source pollution; inadequate institutions, such as laws and policies; and lack of recognition of land-based marine pollution, specifically nonpoint source pollution, as an environmental problem (Hoagland et al., 1995). Land tenure and educational issues also play a major role. Land tenure is an important issue when considering the effective implementation of a BMP program. Many farmers are tenants and have no vested interest in investing in long-term agricultural productivity (DeGeorges, 1990).

Few quantitative studies have been conducted of the relative cost-effectiveness of different erosion control techniques (Hwang et al., 1994) and BMPs in general. According to research conducted in Haiti, the implementation of BMPs may save farmers money (Section 5.4). Through education, the adoption of BMPs, even on tenant farms, might be perceived as more acceptable if an economic gain can be achieved. Furthermore, the study determined that successful adoption of soil conservation techniques and BMPs occurred voluntarily among tenant farmers only when the result increased economic gain, not because of soil conservation per se (White and Jickling, 1995).

Research conducted in two agricultural areas in Haiti found that the implementation of some common BMPs produced much greater economic returns to the farmer (White and Jickling, 1995). Researchers found that the addition of BMPs was beneficial, in terms of both land and labor investments (Table 4-5).

The success of the Haitian program was primarily due to the use of indigenous techniques and subsidies in the form of seed and saplings.

Table 4-5. Economic returns from soil conservation in Maissade, Haiti

Land Use Option	NPV/ha	Return to Labor	Benefit-Cost Ratio
Pure agriculture (no BMPs)	5656	6.1	2.5
Pure agriculture + contour, trash barrier	11,185 (98%)	16.9 (177%)	3.4
Pure agriculture + indigenous trash barrier, hedgerow	12,607 (123%)	22.3 (266%)	3.0

NPV = net present value.
Figures in parentheses indicate percent increase from the pure agriculture (no treatment) case.
Source: White and Jickling, 1995.

SECTION 5. CASE STUDIES

5.1 The Better Bananas Program—Implementing Pollution Reduction Measures

In 1992, the Rainforest Alliance, an international nonprofit organization that develops and promotes economically viable and socially desirable alternatives for resource management, developed the ECO-O.K. certification program to help reduce the adverse environmental impacts of tropical agriculture. The program develops ways for the growers of crops such as bananas and coffee to do business with minimal damage to natural resources. A component of this project is the Better Bananas program. The goal of the program is to transform banana export production so that its impact on the environment is minimized without sacrificing quality, supply, worker safety, or economic opportunities. To reach this goal, the program awards an "ecological seal of approval" to farms that adhere to a series of standards, which permits the promotion of their produce as having been grown and harvested under conditions of limited environmental impact.

The Problems

As discussed in Section 3.2.1 of this report, there are a variety of environmental issues related to banana production. These include land erosion, misapplication of pesticides and fertilizers, solid waste production and improper waste disposal, and storage and handling of hazardous materials. In some areas, the land needs to be drained for banana production. This can lead to erosion of ditches and canals and excess sediment loading to receiving waters and ultimately near-coastal waters. Pesticides and fertilizers, if applied incorrectly or in overabundance, can run off during rainfall events and wash to receiving waters. Plastic bags used in the banana ripening process are often left on the ground after a harvest. They wash off the plantation and end up in estuaries and on beaches. The recognition of these and other problems has led to the development of low-cost/low-technology options for controlling pollution from banana plantations.

The Solution

The Better Bananas program arose out of a growing environmental awareness in the United States, Canada, and Europe, where consumers have begun to demand more sustainable systems of agricultural production. Certification is awarded based on meeting General Production Standards for socioenvironmental agricultural production (updated August 1997). Appendix D contains the most recent standards for the Better Bananas program. The standards resulted from collaboration among farmers, conservation groups, scientists, and government representatives, and they will be updated periodically as environmental advances, new technologies, and market demand warrant.

The Standards

Standards were developed for six general categories of activities—legislation, natural resource management, crop management, solid and liquid waste management, environmental education, and prevailing social and work conditions. Within these categories, subcategories of activities and resource areas are addressed, such as forested areas, fertilization programs, and equipment management. Goals are established, with criteria (specific activities) for meeting each goal outlined. (See Appendix D.)

Implementation

Currently, 85 banana farmers are participating in the program. For example, Plantera Rio Sixaola, S.A., was the initial farm to participate in the program. Chiquita International implements the program on all of its plantations in Costa Rica and requires, as a contract condition, that all of its independent growers become certified. Other companies participating in the program include Banandex in Colombia (13 farms certified), Chiriqui Land Company in Panama (32 farms certified), and COBAL in Costa Rica (29 farms certified). Activities include planting the ditch and canal banks on the plantation to prevent erosion, educating workers on ecologically sound ways for growing bananas, leaving plant cuttings on the ground instead of removing them from the site, treating wastewater at the banana packing facility, and recycling plastic materials.

Several farms have extensive recycling programs for the plastic bags and twine used on the farms. The recycled plastic is used in a variety of ways, including making “bricks” for walkways throughout the farms to help prevent soil erosion, manufacturing packing materials for shipping bananas overseas, and making fuel pellets for the local cement plant.

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5.2 Plan Sierra—The Benefits of Outreach and Education

Plan Sierra is an area and a program on the north slope of the Cordillera Central where sugar cane and coffee are grown. Plan Sierra was created through a grant from the government of the Dominican Republic in 1979 to address the needs of the rural poor. It is an autonomous civil institution with 400 employees, and it receives an annual appropriation from the Dominican Congress. Its objectives are as follows:

- To create a demonstration project for managing upland and mountainous agriculture.
- To develop a coordinating mechanism to link existing management institutions to address the problems of the sierra.
- To respond in a timely and flexible manner to the needs of small-farm operators.

Plan Sierra has conducted activities in infrastructure development, health, education, and agriculture. Reducing soil erosion is a central focus of the agricultural aspect of the program.

The Problem

The erosion rate in the Dominican Republic is estimated to be 300 ton/hectare/year (133 ton/acre/year). More than half of the topography is mountainous and much of the land has been stripped of trees, which have been harvested for fuel. The creation of Plan Sierra was motivated by a realization that hydroelectric development projects in Haiti were being seriously compromised by rapid sedimentation of reservoirs, a result of the massive deforestation occurring in the mountainous regions.

The Solution

Plan Sierra focuses on a variety of economic activities, including the promotion of ecologically stable open food plots, reforestation and the sustainable management of existing forests, social forestry schemes, and the diffusion of integrated systems of food crops and coffee. Important instruments for its growth and development were the development and involvement of grass-roots organizations, a focus on infrastructure development, experimentation with new technological alternatives for sustainable food plots, creation of credit schemes, subsidized sales of tree seedlings, provision of technical assistance, a food-for-work program for the adoption of soil conservation techniques, and development and use of training programs. Plan Sierra conducts on-site visits to farmers and offers training at the Los Montones demonstration farm.

Acceptance and Accomplishment

In a survey of farmers, all who had adopted the soil conservation measures under Plan Sierra felt that their farms had benefited. Generally, the benefits are in the form of increased crop yields, increased longevity of soil use, improved soil moisture, erosion control, and increased soil fertility. Ninety-five percent of Plan Sierra participants were using soil and water conservation practices, versus 25 percent of nonparticipants. And once adopted, soil and water conservation practices are consistently used by farmers who have participated in the plan.

Training at the Los Montones demonstration farm also has an impact on the number of options a farmer is willing to try and plays an important role in the dissemination of agricultural and conservation innovations. It also forms a stronger bond between the farmers and Plan Sierra. Farmers who receive training at the farm are more likely to use soil and water conservation practices on all of their land holdings rather than just some of their land; to use live barriers; to perceive soil and water conservation practices as beneficial; and to realize that using soil and water conservation practices not only improves productivity, but also controls erosion. Soil conservation practices such as contour plowing and terraces are twice as likely to be used by farmers who have received both on-site visits by Plan Sierra employees and soil conservation training at the Los Montones demonstration farm than by those who received only one of those types of assistance under Plan Sierra.

Another success of the program is that, when faced with questions or problems, farmers involved with Plan Sierra generally turned to it for assistance, implying trust and a willingness to adopt improved measures for soil conservation. More than 50 percent of Plan Sierra participants attribute their knowledge of Plan Sierra to outreach activities, and nearly half of those 50 percent think that onsite visits and training at the Los Montones demonstration farm were the most useful sources of information regarding soil and water conservation practices.

5.3 Technical Improvements to Local Innovations in Haiti

Peasant farmers in Haiti have produced many innovations for annual cropping, including the following:

- *Zare*: soil and stubble formed into mini-catchments to retain water for rice cultivation.
- *Sakle en woulo*: weeds hoed into closely spaced contour ridges prior to planting.
- *Ramp pay*: contour trash barriers covered with soil.
- *Kleonaj*: wattling constructed in ravines to retain sediment for banana, taro, or yam cultivation.
- *Bit*: contour bands for sweet potato cultivation.

With the help of technical assistance, these innovations were improved to increase soil retention.

The Problems

In Haiti, environmental degradation and rural poverty are extreme. Only 32 percent of the land in Haiti is deemed arable, but over 60 percent of the land is under agricultural use. Most hillsides are eroded, and one-third of the land is severely degraded. There are three principal causes of soil erosion and deforestation in the nation:

1. Limited access to production resources, i.e., land and capital
2. Few opportunities for off-farm employment
3. Social and economic insecurity

A breakup of plantations into small, individually owned farms led people to move to more mountainous parts of the country in search of farmland. The average farm in Haiti is too small to provide for a minimal standard of living, and farming is very intensive so as to reap as much harvest as possible for a family. The denuded landscape in the mountainous terrain has led to severe degradation of the land and intensive soil erosion. Soil conservation measures employed by peasant farmers are inadequate or not practiced widely enough to slow the degradation of the land, and they are generally used to retain moisture and increase agricultural production, not to retain soil per se. Soil conservation measures had been introduced by international groups, but these focused on long-term ecological or downstream benefits. They failed to provide a short-term, recognizable incentive for their adoption to the farmer who was being asked to use them.

The Solution

Technical improvements to the existing practices included vegetative techniques such as contour hedgerows, wattling, and gully plugs. For example, *ramp pay* were improved by placing them along contours and supporting them with planted hedgerows, and *kleonaj* were improved by planting live stakes and perennials downslope of them. These improved techniques have been widely adopted and are maintained by farmers without external incentives.

Contour hedgerows with *Leucaena leucocephala* and gully plugs with *Pencaena leucocephala* are especially popular. Hedgerows serve three purposes:

4. To support the *ramp pay* structure and protect the sediment that accumulates behind it and the moisture that it retains.

5. To reduce labor investments by avoiding the annual reconstruction of the *ramp pay* after they decay.

6. To provide livestock forage material during the dry season.

Hundreds of kilometers of hedgerows have been planted since their introduction.

The local innovations for soil retention that were improved by technical assistance require low labor inputs and result in short-term net financial gain to farmers that adopt them. Generally, farmers realize benefits in the same season in which the measures are adopted. Successful adoption of the techniques can also be attributed to the fact that they can be altered or combined to meet the landowner's specific site conditions and management objectives. Techniques introduced by international groups often require complex designs that must be adhered to in order to function properly. The improved techniques that are now being widely adopted by farmers provide many benefits beyond soil retention—forage for livestock, wood for fuel, and increased agricultural production.

Results

Sediment retention of 50 centimeters in height in a season behind the improved *ramp pay* is common. One study showed that the improved technique increased production of corn by 51 percent and sorghum by 28 percent in the first year of their use, and by 22 percent and 32 percent, respectively, in the second year. The study also showed that the average amount of soil retained by the improved soil conservation measures was 101 tons per hectare in the first year.

The same study also showed that all types of soil conservation being practiced by the farmers are beneficial. The net returns from a small farm are increased 100 percent with the addition of any soil conservation measure. However, the combination of *ramp pay* with hedgerows was the most profitable.

Lessons Learned

The direct lessons of the acceptance and benefits of the improved local innovations for soil conservation are as follows:

- Acceptable measures combine components that are familiar to peasants (e.g., *ramp pay* and hedgerows) and compatible with other agricultural and social activities.

- Measures need to be simple and require low and non-financial installment costs.

- To be adopted, the measures must provide short-term economic returns, usually in the same season as their installation.

- Measures need to be adaptable to farmer-specific site conditions, management objectives, and preferences. These factors facilitate a sense of ownership of the measures when the measures are used on an individual farm.

- Successful measures are those which can be adopted sequentially, at a pace consistent with the farmer's acquisition of knowledge and level of comfort with making changes.

Most importantly, erosion control measures in Haiti have been adopted only when they were shown to result in economic gain to a farmer in the short term, not because they save soil. The improved *ramp pay* with hedgerows were successful because they were a low-cost investment and peasants could quickly determine whether the improvement was worth their time; that is, economic benefits were noticeable in the first season of their use.

SECTION 6. MEETING SUMMARY

This section provides a summary of the discussions at the Agricultural Nonpoint Source Pollution Experts Meeting held on January 22 and 23, 1998, in Castries, St. Lucia, to discuss best management practices (BMPs) for controlling agricultural nonpoint source (NPS) pollution in the Wider Caribbean (as defined by UNEP). The purpose of the meeting was to gather expert input from professionals in the WCR who are involved with agricultural nonpoint source pollution control and have an understanding of the technical, economic, and social issues in the region. Their input is necessary to assist UNEP-CAR/RCU, as Secretariat to the Cartagena Convention and its protocols, in developing a draft Annex on appropriate controls for agricultural nonpoint source pollution under the protocol on marine pollution from land-based sources and activities. The experts discussed a draft report on agricultural BMPs prepared prior to the meeting and provided input and comments on the draft report. Changes have been made to the report based on appropriate comments. The experts identified issues that need to be addressed by negotiators of the land-based sources protocol under the Cartagena Convention. Issues identified included environmental impacts of agricultural nonpoint source pollution; pollutants of concern, causes, sources, and control practices; and obstacles for controlling agricultural nonpoint source pollution in the region and potential solutions. This summary is *not* the minutes of the meeting but rather a compilation of comments and discussions. A list of the invitees and participants is provided in Section 6.8.

Report Comments

The following general comments on the draft report were offered. Specific report comments are as follows:

- The report should be organized according to pollutants, sources, and measures for controlling them, not by crop because most of the pollutants and control measures are not crop-specific.
- More case studies are needed. (Experts were asked to provide these.)
- A better matrix for BMP selection needs to be developed.
- Most "problems" come from small farms; therefore, the report should distinguish between small, medium, and large farms.
- Livestock should be added.
- Grey literature should also be used, including recommendations from the experts.
- The fact that monitoring BMP implementation and effectiveness should be part of a nonpoint source pollution control and monitoring plan needs to be included in the report.

- The link between the “greening” of consumers and controlling nonpoint source pollution should be discussed, as well as how farmers/countries can capitalize on this for economic and environmental purposes.

Additional Issues

The following issues should be conveyed to the annex negotiators as concerns/issues raised by the group:

- Nonagricultural pesticides can be a source of nonpoint pollution and need to be addressed (e.g., mosquito control measures).
- Agriculture-related point sources (e.g., sugar refining, coffee processing) need to be addressed.
- National land planning activities are needed.
- There is a lack of an “inventory” of environmental impairments due to agricultural nonpoint source pollution.
- Funding for pollution control programs continues to be a problem.
- There is a need for more consistent pesticide regulations among the countries.
- Trade standards impact prices and therefore impact growing conditions.
- Regional monitoring programs are needed, including development of monitoring procedures and protocols specific to tropical environments.

Problems Related to Agricultural Nonpoint Source Pollution

Several environmental problems related to agricultural nonpoint source pollution were identified:

- Decreased biodiversity
- Loss of coral reefs, fisheries, and seagrass beds
- Bacterial contamination
- Increased turbidity
- Algal blooms
- Siltation
- Increased cost of remediation
- Soil depletion*
- Loss of mangroves*
- Reduction in river base flow*
- Flash floods*

(* Caused by physical alteration of the environment, not pollutant loading.)

Contaminants/Pollutants, Sources, Causes, and Practices for Control

The experts spent a considerable amount of time determining the main environmental contaminants related to agricultural nonpoint source pollution, their sources, their causes, and practices for controlling them. The practices identified were focused on low-cost, low-tech options and were categorized as source reduction practices or pollutant transport reduction practices. The experts agreed that the primary contaminants/pollutants related to agriculture are sediment, nutrients, pesticides, pathogens, and solid waste. The information in Table 6-1 will provide the basis for the guidance provided in the final report.

Obstacles and Potential Solutions

The experts identified four main obstacles for implementing controls to agricultural nonpoint source pollution. These obstacles were considered to be related to education/public awareness, economics, natural resource assets, and legislation and national/international policy. The experts also recommended possible ways to overcome these obstacles. This discussion became the basis for developing the Annex for agricultural nonpoint source control. Table 6-2 provides a summary of the discussion.

Recommendations from the Meeting

The following is a summary of the recommendations made by the experts that they felt should be incorporated into the draft Annex addressing agricultural nonpoint source pollution in the WCR.

- Each country should develop a National Action Programme for the control of agricultural nonpoint source pollution. Such a plan should contain, at a minimum, the following components:

  – Assessment of water quality impairments due to agricultural nonpoint source pollution.

  – Inventory of land resources and land use for identification of areas most suitable for agriculture.

  – Development of an education, awareness, and outreach program explaining the importance of natural resources, problems related to agricultural nonpoint source pollution, and structural and nonstructural BMPs for control of agricultural nonpoint source pollution.

  – Requirements for implementation of appropriate BMPs on small, medium, and large farm operations.

  – Development of economic incentives for implementation of agricultural BMPs.

  – Survey of existing legislation and policies related to controlling agricultural nonpoint source pollution and those responsible for implementation, including land use policies and legislation.

Table 6-1. Contaminants/pollutants of concern, sources, causes, and practices for control
(Practices were classified as source reduction (**sr**), transport control (**t**), or both and are indicated as such on the table.)

Contaminant	**Source(s)**	**Cause(s)**	**Practices for Control**
Nutrients (including N and P)	· Fertilizers	· Artificial drainage · Placement of fertilizer (in soil vs. on soil) · Overfertilization · Poor crop siting (land use) · Lack of buffers · Timing of fertilization · Erosion (adsorbed nutrients) · Leakage from containers	· Soil and plant analysis **(sr)** · Nutrient management **(sr)** - timing, application, type, placement, handling, and container disposal · Ground covers (including drainageways) **(sr/t)** · Buffer zones and reforestation of riverbanks **(t)** · Leguminous plants **(sr)** · Proper water management **(t)** · Proper use of organic fertilizers **(sr)** · Erosion control measures **(sr/t)** · Good housekeeping practices (including record keeping) **(sr)**
	· Soil miner	· Irrigation techniques	· Proper water management **(t)**

Contaminant	**Source(s)**	**Cause(s)**	**Practices for Control**
	· Manure	· Animals in drainage ways · Confined animal facilities · Volatilization of animal waste	· Exclusion of animals from drainageways **(sr/t)** · Waste management **(sr/t)** · Proper grazing management **(sr)**
Sediment	· Eroded str	· Planting on steep slopes · Deforestation · Clear-cutting · Improper tillage methods · Improper timing of site preparation · Animal trampling · Improper irrigation methods and water management practices · Channelization and artificial drainage	· Ground covers (including drainageways) **(sr/t)** · Buffer zones and reforestation of riverbanks **(t)** · Proper water management **(sr/t)** · Erosion control measures **(sr)** · Proper grazing practices **(sr)** · Conservation tillage **(sr)** · Terracing in proper areas **(t)** · Wind erosion controls **(t)** · Sediment basins **(t)** · Use of organic "trash" (e.g., palm and banana fronds) as sediment fences **(t)** · Diversions **(t)** · Grassed waterways **(t)** · Contour farming **(t)** · Contour drains **(t)**

Table 6-1. (continued)

Contaminant	Source(s)	Cause(s)	Practices for Control
Pesticides	Pesticides	· Improper application (timing, method, amount, etc.) · Sedimentation · Cropping systems (e.g., monocultures) · Improper equipment washdown · Spilling · Inappropriate selection · Inappropriate handling, storage, and disposal · Leaching · Improper water management · Artificial drainage · Volatilization	· Education of workers and farm management **(sr/t)** · IPM **(sr)** - timing, application method, type, placement, handling, and container disposal; need to triple-rinse containers · Soil and site analysis **(sr)** · Ground covers (including drainage ways) **(sr/t)** · Use of biodegradable pesticides **(sr)** · Buffer zones and reforestation of riverbanks **(t)** · Proper water management (including reuse of rinse water) **(sr)** · Erosion control measures **(sr)** · Good housekeeping practices (including record keeping) **(sr)** · Crop rotation, including fallow **(sr)** · Mixed cropping **(sr)** · Use of resistant pesticide varieties (biotechnology) **(sr)** · Pesticide rotation **(sr)** · Aerial buffer (no spray) zones (e.g.,100 m from populated areas; 15 m from surface waters) **(t)**
Pathogens	· Animal Waste (manure and manure used as fertilizer)	· Animal use of water sources · Improper location of animals · Improper application of manure	· Proper grazing management **(sr/t)** · Exclusion of livestock from drainage ways **(sr/t)** · Manure management **(sr)** · Provision of alternative shade and water for livestock **(sr)**
	· Dead animals	· Improper handling and disposal	Composting and proper disposal of dead animals **(sr)**
Solid Waste	· Plastics (bags, twine, mulch, containers, etc.)	· Improper handling and disposal of plastics · Lack of disposal alternatives	· Integrated waste management (reduce, reuse, recycle, remediate) **(sr)** · Catchment basins **(t)** · River traps (on small-flow rivers) **(t)**
	· Organics	• Improper disposal of waste ag products (e.g., waste bananas)	· Composting facilities **(t)** · Catchment basins **(t)**

Table 6-2. Obstacles to implementation and suggested solutions

Obstacles	Solutions
Education/Awareness	
· Lack of technical expertise and good extension ices (technology transfer) · Lack of understanding by decision makers, ers, and the general public on the importance of ral resources and the impact of nonpoint source ition on these resources · Overcoming cultural barriers as they relate to propriate agricultural practices · Inadequate user knowledge on environmentally id farming practices · Lack of understanding of the link between sm and agricultural pollution control · Lack of research and *available* data	· Development of national plans and program strategies for ation. Plans may include (but need not be limited to): - community education programs - field demonstrations and follow-up site visits - school and community workshops - more aggressive outreach and extension programs, luding courses for workers - use of media (TV, radio, videos, etc.) - required school environmental education curriculum · Education of political and policy leaders in the WCR · Development of a commission or similar mechanism for dinating educational policy for the region · Appointment of one responsible coordinating agency , Ministry of Agriculture) · Use of nongovernment organizations (NGOs) · Economic incentives for implementing education rams · Assessment of environmental impairments due to ultural nonpoint source pollution
Economics	
· World commodity prices · Poor resource allocation · Small scale of some farms · Foreign debt · Inequity of benefit allocation (poverty) · Land tenure	· Development of incentives for implementing agricultural oint source pollution control programs (e.g., tax breaks, al “environmentally sensitive” farms, etc.) · Allocation of government resources for agricultural oint source pollution control program
Natural Resource Assets	
· Steep topography · Climate · Soil suitability (fertility/infertility) · Availability of land suitable for agriculture (being for other purposes) · Pest diversity	· Development of a resource and land use inventory to help ify the areas most suitable for agricultural use · Development of national land use plans · Compilation of a list of traditional practices that are vative and based on sustainability for use in the education ram

Table 6-2. (continued)

Obstacles	Solutions
Legislation and National/International Policy	
· Tariffs and quota systems · International quality standards · Subsidies that are detrimental to environmental ty (both production- and crop-related subsidies) · Lack of enforcement of existing regulations and ementation of existing programs · Overlap in governmental responsibility · Lack of interagency cooperation	· Survey and review of relevant existing legislation, ies, and responsibilities for their effectiveness in controlling ultural nonpoint source pollution · Development and implementation of plans to fy/create legislation (including enforcement) for agricultural pollution control

- Education of decision makers, farmworkers, and the general public should be coordinated and standardized at the regional and national levels.

- The private sector needs to be involved in the control of agricultural nonpoint source pollution.

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SECTION 7. CONCLUSION

The draft Protocol on Marine Pollution from Land-based Sources and Activities (the LBSMP Protocol) developed under the Cartagena Convention recognizes the need and desire of governmental and nongovernmental organizations throughout the WCR to address the issues of agricultural nonpoint source pollution as a major category of land-based source pollution in the WCR. With this recognition, the next step in effectively reducing or preventing land-based sources of pollution is to develop and implement a program to educate and aid the agricultural sectors of the countries and territories of the WCR in the art and science of controlling agricultural nonpoint source pollution, including implementation of BMPs. The need to improve the institutional structures, managerial performance, and technical expertise of the small farm sector is evident (CCA and IRF, 1991); however, participation by the large commercial production plantations is also necessary. Currently, the WCR is characterized by a lack of sufficient incentives, extension services, soil conservation investment subsidies, and marketing assistance to further diversify the agricultural base away from its current emphasis on annual subsistence and semiperennial export crops (CCA and IRF, 1991). Furthermore, and perhaps most importantly, the prevalence of land tenure insecurity among small farmers, who in the absence of other incentives are unwilling to pursue costly land conservation strategies (CCA and IRF, 1991), inhibits the implementation of a BMP program that, in the long term, could lower farmers' production costs and improve production yields.

Educating farmers about the costs and benefits of implementing just one or two low-cost, low-tech BMPs has the potential to prevent the degradation of the coastal and marine environment of the WCR. Depending on the existing conditions of the site, the implementation of BMPs can be an economically viable solution to runoff problems. One or two BMPs used in conjunction can prevent runoff of a variety of land-based agricultural pollutants (Table 7-1). The BMPs do not have to be expensive or technologically advanced. For example, mulching can prevent soil erosion. Mulch can be obtained by composting animal waste and vegetative solid waste. Compost used as a mulch provides a natural fertilizer to enhance crop growth and stabilizes soils. This approach reduces the use of inorganic fertilizers. Therefore, two BMPs—mulching and composting—can reduce soil erosion, the runoff of animal waste and solid waste, and the use of inorganic fertilizers.

Other issues and concerns within the WCR that require resolution if a BMP program is to be effective include the inadequacy of quantitative data on agrochemicals (importation, use, impacts) upon which to base informed decisions. At present, a failure to effectively implement existing pesticide legislation or to provide up-to-date pesticide control regulations and monitoring procedures is apparent (CCA and IRF, 1991). Additionally, not only do quantitative data regarding agrochemicals not exist but quantitative data regarding the water quality of the region are minimal. Although limited data are available, a baseline needs to be established to effectively quantify the success or, possibly, the failure of implementing a BMP program.

Finally, the establishment of consistent and adequate land use planning or zoning restrictions in the agricultural sector is needed to ensure the continued availability of environmentally suitable and economically productive lands for cultivation.

Table 7-1. Agricultural BMPs that can be applied to various management measures

Management Measures	BMPs	
	Structural	**Nonstructural**
Erosion and Sediment Control	terraces, diversions, sediment basins, contour farming, wind erosion controls, field borders, filter strips, grassed waterways, contour drains, fencing, sediment basins, stream crossings, sediment fences	Education, water management, ground cover (conservation cover/stabilization, cover crop, critical area planting, delayed seedbed operation, indigenous weed management, mulching, heavy use area protection, residue use) conservation tillage, strip-cropping, crop rotation, conservation cropping, buffer zones, water management, good housekeeping practices, deferred grazing, leguminous plants in rotation, proper grazing management, livestock exclusion
Nutrient Management	terraces, diversions, sediment basins, contour farming, wind erosion controls, field borders, filter strips, grassed waterways, contour drains, sediment basins, stream crossings, sediment fences	Education, water management, nutrient management plan, good housekeeping practices, plant and soil analysis, ground cover (conservation cover/stabilization, cover crop, critical area planting, delayed seedbed operation, indigenous weed management, mulching, heavy use area protection, residue use), proper application of nitrogen and phosphorus, realistic yield goals, use of natural fertilizers, leguminous plants in rotation, manure management, waste utilization, buffer zones, composting, waste storage ponds
Pesticide Management	terraces, diversions, sediment basins, contour farming, wind erosion controls, field borders, filter strips, grassed waterways, contour drains, sediment basins, stream crossings, sediment fences	Education, water management, integrated pest management, good housekeeping practices, nutrient and soil analysis, plant and soil analysis, ground cover (conservation cover/stabilization, cover crop, critical area planting, delayed seedbed operation, indigenous weed management, mulching, heavy use area protection, residue use), buffer zones
Pathogens	terraces, diversions, sediment basins, field borders, filter strips, grassed waterways, contour drains, sediment basins, stream crossings, sediment fences, terraces, diversions, grassed waterways, waste storage ponds, fencing	Education, water management, waste utilization, manure management, livestock exclusion, deferred grazing, heavy use area protection, critical area planting, composting, conservation cover/stabilization, critical area planting, mulching, designated feeding and watering areas, buffer zones
Solid Waste Management	catchment basins, fencing	Education, integrated waste management, composting

Source: Adapted from USEPA (1993).

GLOSSARY

Agriculture Cultivating soil, producing crops, and/or raising livestock.

Best management practice (BMP) A practice or combination of practices that are determined to be the most effective and practicable (including technological, economic, and institutional considerations) means of controlling point and nonpoint pollutants at levels compatible with environmental quality goals (USEPA, 1993).

Composting A controlled process of degrading organic matter by microorganisms (USEPA, 1993). Controlled methods of composting include mechanical mixing and aerating, ventilating the materials by dropping them through a vertical series of aerated chambers, or placing the compost in piles out in the open air and mixing it or turning it periodically (USEPA, 1996).

Contour An imaginary line on the land connecting points of the same elevation; a line drawn on a map to show the location of points at the same elevation; a series of such contours serving to delineate the topography of the land (USVI Conservation District, 1995).

Cover crop A close-growing crop grown primarily for the purpose of protecting and improving soil between periods of regular crop production or between trees and vines in orchards and vineyards (USEPA, 1993).

Crop residue The portion of a plant or crop left in the field after harvest (USEPA, 1993).

Crop rotation The growing of different crops in recurring succession on the same land (USEPA, 1993).

Deposition The accumulation of material dropped out of the transporting agent (water or wind) due to the slowing of the travel of that agent (USVI Conservation District, 1995).

Disturbed area An area where the natural vegetative and soil cover has been removed or altered and that is, therefore, susceptible to erosion (USVI Conservation District, 1995).

Diversion A channel, embankment, or other man-made structure constructed to divert water from one area to another (USEPA, 1993).

Erosion Wearing away of the land surface by running water, glaciers, winds, and waves. The term *erosion* is usually preceded by a definitive term denoting the type or source of erosion such as gully erosion, sheet erosion, or bank erosion (USEPA, 1993).

Eutrophication The process by which a body of water becomes rich in dissolved nutrients (specifically, nitrogen and phosphorus), promoting the overgrowth of aquatic vegetation and leading to a subsequent deficiency in dissolved oxygen (USVI Conservation District, 1995).

Fertilizer Materials such as nitrogen and phosphorus that provide nutrients for plants (USVI Conservation District, 1995); any organic or inorganic material of natural or synthetic origin that is added to a soil to supply elements essential to plant growth (USEPA, 1993).

Habitat The sum total of environmental conditions of a specific place that is occupied by an organism, a population, or a community (UNEP, 1996).

Herbicide A chemical substance designed to kill or inhibit the growth of plants, especially weeds (USEPA, 1993).

Infiltration The penetration of water through the ground surface into subsurface soil (USEPA, 1993).

Insecticide A pesticide compound specifically used to kill or control the growth of insects (USEPA, 1993).

Integrated Pest Management (IPM) A pest population management system that anticipates and prevents pests from reaching damaging levels by using all suitable tactics including natural enemies, pest-resistant plants, cultural management, and the judicious use of pesticides, leading to an economically sound and environmentally safe agriculture (USEPA, 1993).

Irrigation Application of water to lands for agricultural purposes (USEPA, 1993).

Leaching The removal from the soil in solution of the more soluble materials by percolating waters (USEPA, 1993).

Legume A member of a large family that includes many valuable food and forage species, such as peas, beans, peanuts, clovers, alfalfas, sweet clovers, lespedezas, vetches, and kudzu (USEPA, 1993).

Livestock Domestic animals (USEPA, 1993).

Manure The fecal and urinary defecation of livestock; may include spilled feed, bedding litter, or soil (USEPA, 1993).

Nonpoint source pollution Pollutants emanating from an unconfined or unchanneled source, including agricultural runoff, drainage, or seepage, and air contamination from landfills or surface impoundments (UNEP, 1996).

Nutrients Elements, or compounds, essential as raw materials for organism growth and development, such as carbon, nitrogen, phosphorus, etc. (USEPA, 1993).

Perennial plant A plant that has a life span of 3 or more years (USEPA, 1993).

Pesticide Any chemical agent used for control of plant or animal pests. Pesticides include insecticides, herbicides, fungicides, nematocides, and rodenticides.

Pollutants Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, geological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water (Section 502(6) of the Clean Water Act as amended by the Water Quality Act of 1987).

Point source pollution Any pollution from a confined and discrete conveyance such as a pipe, ditch, channel tunnel, well, fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft (UNEP, 1996)

Raceme A long flower cluster on which individual flowers each bloom on a small stalk all along a common, larger, central stalk (Niering, 1992). Bananas are the flower of a banana tree.

Runoff Water which, having fallen, flows across the surface of the ground, picking up materials such as soil, agricultural chemicals, and other transportable materials and continuing into a watercourse (UNEP, 1996).

Sediment The product of erosion processes; the solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice (USEPA, 1993).

Sedimentation The accumulation of earthly matter (soil and mineral particles) washed into a river or other water body (normally by erosion) that settles on the bottom (UNEP, 1996).

Siltation The process by which silt or mud is deposited in a reservoir, lake, seabed, river, or overflow area. The deposition or accumulation of silt.

Slope The degree of deviation of a surface from horizontal, measured as a percentage, as a numerical ratio, or in degrees (USEPA, 1993).

Tillage The operation of implements through the soil to prepare seedbeds and rootbeds, control weeds and brush, aerate the soil, and cause faster breakdown of organic matter and minerals to release plant foods (USEPA, 1993).

Tilth The physical condition of the soil as related to its ease of tillage, its fitness as a seedbed, and its impedance to seedling emergence and root penetration (USEPA, 1994).

Topography The physical features of a surface area including its relief (or slope), relative elevations, and the position of natural and man-made features (USVI Con-servation District, 1995).

Turbidity The cloudiness of water used as a measure of the amount of particles (suspended sediment and other particles) in a water body (USVI Conservation District, 1995).

Waste Material that has no original value or no value for the ordinary or main purpose or use; damaged or defective articles of manufacture; or superfluous or rejected matter or refuse (USEPA, 1993).

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Title: The adoption of soil conservation technology in El Salvador: Linking productivity and conservation
Authors: Gustavo E. Sain and Hector J. Barreto
Source: *Journal of Soil and Water Conservation* 51(4): 313-321, 1996.
Abstract: Soil conservation practices were successfully disseminated and adopted among farmers in Guaymango, El Salvador, whereas farmers in two similar areas failed to adopt them. Adoption was successful in Guaymango for two reasons. First, a recommendation was developed that combined both productivity-improving and soil conservation components. Second, these components were linked by economic and institutional incentives that encouraged adoption of both components. Issues crucial to long-term success of soil conservation recommendations are discussed, particularly the need for the recommendation to be compatible with the farming system and effective in minimizing soil degradation. Potential implications for research, extension, and policy are examined, with emphasis on technical requirements for developing system-management recommendations embodying productivity and conservation components.

Title: *Agriculture and Coastal Water Quality*
Author: J. Paul Lilly
Source: North Carolina State University, North Carolina, 1996.
Abstract: Degraded streams cannot support (or can only partially support) their original functions. Many are unsuitable as sources of drinking water and can no longer sustain certain forms of marine life, and still others have become unattractive to recreational users.

Title: Agriculture in the Wider Caribbean
Author: F.A. Gumbs
Source: *Ambio*, Vol. 10, No. 6, pp. 335-339, 1981.
Abstract: Agricultural production has been declining in the Caribbean, and some parts of the region are now dependent on imports of food. A counterproductive system of land tenure and heavy dependence on export-crop monoculture are two of the factors involved.

Title: *Animal Manure—Managing Sheep and Goat Manure*
Author: R.E. Graves
Source: Pennsylvania State University, 1992.
Abstract: This is one in a series of fact sheets produced by the Pennsylvania State University.

Title: *Background Document for the Development of a Protocol Concerning Land-Based Sources of Marine Pollution to the Cartagena Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region*
Author: United Nations Environment Programme.
Source: United Nations Environment Programme, Kingston, Jamaica, 1991.
Abstract: This document was prepared by the Regional Coordinating Unit of the Caribbean Environment Programme as a contribution to the initiative of the Advisory Committee on Protection of the Sea (ACOPS) for a global legal framework for the regulation of land-based sources of marine pollution. This initiative was undertaken by ACOPS as part of the process leading to the United Nations Conference on Environment and Development.

Title: *Background Paper: Land-based Sources (LBS) of Pollution as the Dominant Marine Pollution Problem in the Wider Caribbean Region*

Authors: J. Diamante, M. Varela, B. Wood-Thomas, and P. Gelabert.
Source: U.S. Environmental Protection Agency, Office of International Activities, Caribbean Field Office, 1991.
Abstract: The lack of adequate marine water quality survey and monitoring data in the WCR delayed for some time the recognition of the magnitude of the total contribution to regional marine pollution problems from land-based sources of all types of pollution. The growing accumulation of site-by-site surveys on a country-by-country basis of identifiable land-based sources and the observable relationship of these sources to nearby marine environmental damage and wider regional implications have caused a general consensus to emerge among experts that as much as 90 percent or more of the WCR's marine pollution problems are attributable to land-based sources of all kinds.

Title: Banana and Plantain Production in Latin America and the Caribbean
Author: Ramiro C. Jaramillo
Source: In *Banana and Plantain Breeding Strategies*, Australian Centre for International Agricultural Research, Cairns, Australia, October 13-17, 1986, pp. 39-43.
Abstract: The cultivation of banana and plantain in tropical America and the Caribbean countries has a special importance, not only because they are part of the diet, but also in view of the economic benefits derived from the production activities, through contribution to the gross national product, the establishment of employment sources, and the generation of foreign currency and fiscal earnings.

Title: *Belize National Environmental Action Plan*
Author: The Government of Belize
Source: The Government of Belize, June, 1996.
Abstract: This National Environmental Action Plan aims at providing an overview of the major environmental issues facing Belize and at guiding the government in the prudent use and management of natural resources. It focuses on the issues, policies, and programs that are considered most critical to Belize. The document should provide a blueprint for the Government of Belize to address the environment problems in Belize and to identify possible areas of assistance that could be provided by donor agencies.

Title: *Best Management Practices for Agricultural Nutrients*
Author: J.P. Lilly
Source: Publication Number AG-439-20. North Carolina Cooperative Extension Service, North Carolina State University, Raleigh, 1995.
Abstract: About 20 elemental nutrients are essential for plant growth. Some of these nutrients are supplied naturally by air, water, and soil. Fertilizers and manures are used to supplement the natural supplies. When nutrients are used correctly, they are very beneficial, but in the wrong place at the wrong time, they become pollutants. Both ground water and surface water are very vulnerable to pollution. Water is one of our most valuable resources, and protecting it is an important concern.

Title: *Conservation Extension with Small Farmers in Developing Countries*
Author: Ted C. Sheng
Source: In *Soil Conservation for Survival*, ed. K. Tato and H. Hurni, pp. 277-283. Soil and Water Conservation Society, Iowa, 1992.
Abstract: Conservation extension is extremely important where the majority of the conservation work is to be done by farmers. It is also an extremely difficult task where hundreds or thousands of small farmers are involved in a project and where government staff and resources are limited.

Title: *Control of Water Pollution.* FAO Irrigation and Drainage Paper 55
Author: Edwin D. Ongley
Source: Food and Agriculture Organization of the UN, Rome, Italy, 1996.
Abstract: This publication deals specifically with the role of agriculture in the field of freshwater quality. Categories of nonpoint source impacts—specifically sediment, pesticides, nutrients, and pathogens—are identified together with their ecological, public health, and, as appropriate, legal consequences. Recommendations are made on evaluation techniques and control measures. Much of the scientific literature on agricultural impacts on surface and groundwater quality is from developed countries, reflecting broad scientific concern and, in some cases, regulatory attention since the 1970s. The scientific findings and management principles are, however, generally applicable worldwide.

Title: Controlled-Erosion Terraces in Venezuela
Author: L.S. Williams and B.J. Walter
Source: In *Conservation Farming on Steep Lands*, ed. W.C. Moldenhauer and N.W. Hudson, pp. 177-187. Soil and Water Conservation Society, Iowa, 1988.
Abstract: In 1961 the Ministry of Agriculture in Venezuela initiated a major soil conservation program in several states in the central and western Andes. One of the projects focused on the construction of agricultural terraces in small highland valleys. Terracing was accomplished by building strong rock walls along the contours of the slopes and allowing the normal actions of erosion and cultivation to level the surface. This "controlled-erosion" construction method resulted in terraces large and stable enough to allow use of animals or machines for cultivation. Controlled-erosion terraces are durable, and they may be suitable where long-term soil conservation is a prime objective.

Title: Demonstrating Conservation Practices on Steep Lands in Jamaica
Author: T.C. Sheng
Source: In *Conservation Farming on Steep Lands*, ed. W.C. Moldenhauer and N.W. Hudson, pp. 207-214. Soil and Water Conservation Society, Iowa. 1988.
Abstract: This paper discusses the experience of setting up a demonstration project on public land (the Smithfield Demonstration Center and explains its results and impacts.

Title: Demonstration and Extension of Soil and Water Conservation Principles in Latin America
Author: J.E. Aldedge
Source: In *Conservation Farming on Steep Lands*, ed. W.C. Moldenhauer and N.W. Hudson, pp. 166-171. Soil and Water Conservation Society, Iowa, 1988.
Abstract: The primary intent of this paper is to offer some conservation ideas, philosophy, principles, and guidelines for individuals and groups working in developing countries.

The soil and water conservation system described has been applied in many areas in Central and South America and in the Caribbean.

Title: Dominica Banana Rehabilitation Project Pesticide Assessment
Authors: William E. Rainey, Elizabeth D. Pierson, and Edward L. Towle.
Source: *Final Report on the Impact on Dominican Wildlife of Pesticides Used in the Banana Disease Control Program of the Dominica Banana Marketing Association (DBMA).* Island Resources Foundation, St. Thomas, U.S. Virgin Islands, 1987.
Abstract: This report reviews the geographical pattern of pesticide use in the banana industry, toxicology of the pesticides emphasizing data relevant to wildlife, and the major wildlife groups on Dominica, noting species of special concern. Observations on land and pesticide use in the banana industry relating to wildlife, how the use of habitat (including agricultural areas) use by wildlife influences the likelihood of pesticide exposure, and evaluation of the impact of the banana industry on wildlife are presented.

Title: *Environmental Agenda for the 1990's: A Synthesis of the Eastern Caribbean Country Environmental Profile Series*
Author: CCA and IRF
Source: Caribbean Conservation Association and The Island Resources Foundation. St. Thomas, U.S. Virgin Islands, 1991.
Abstract: This summary document attempts to synthesize the principle elements of a series of six Country Environmental Profiles and present the main issues and recommendations in an easily assimilated format. The approaches and recommendations offered in the document are intended to help in the creation of policy that will bring to the region the type of development that is sustainable.

Title: Evaluating and Managing the Environmental Impact of Banana Production in Costa Rica: A Systems Approach
Authors: Carlos E. Hernández and Scott G. Witter
Source: *Ambio*, Vol. 25, No. 3, pp. 171-178, 1996.
Abstract: This paper presents an overview of banana production in Costa Rica based on the importance of bananas as an export crop and the environmental impacts associated with their production. The paper takes a systems approach to identifying major environmental problems associated with banana production. Eco-management alternatives are recommended, based on what has been learned managing a 306-ha banana plantation at EARTH College. It is hoped that these experiences will help bring about a more balanced approach to the exploitation of Costa Rica's natural resources.

Title: Farmer Perception of Soils in the Mountains of the Dominican Republic
Author: Roy Ryder
Source: *Mountain Research and Development*, Vol. 14, No. 3, pp. 261-266, 1994.
Abstract: Scientists concerned with resource management in developing nations have been surprisingly reluctant to seek opinions of traditional farmers despite growing recognition of their skills. Farmer classifications of climate, soil, and vegetation can be very informative. The purpose of this paper is to examine farmer perception of soil in Las Cuevas, a mountainous region in the Central Cordiller of the Dominican Republic. A discussion of awareness of soil erosion and local soil taxonomy is followed by a comparison of opinions held by farmers and scientists on the importance of selected climatic edaphic criteria for agriculture.

Title: *Farming for the Future: An Introduction to Low-External Input and Sustainable Agriculture*
Authors: C. Reijntjes, B. Haverkort, and A. Waters-Bayer
Source: Macmillan, London, 1992.
Abstract: This document provides examples of indigenous practices illustrating how well farmers in the tropics learned to manipulate and derive advantage from local resources and natural processes, applying the principles of agroecology without knowing that this term exists.

Title: *Food Production and Environmental Quality*: Agricultural Nonpoint Source Issues
Author: C.F. Myers
Source: Agricultural Waste Utilization and Management, Proceedings of the Fifth International Symposium on Agricultural Wastes, Chicago Illinois, December 16-17, 1985, pp.16-18.
Abstract: Providing adequate and economical levels of food production must be accomplished while ensuring satisfactory environmental quality.

Title: *Groundwater Quality Protection for Livestock Feeding Operations*
Author: J.M. Sweeten
Source: Texas A&M University, 1993.
Abstract: This publication summarizes research results and management strategies for ground water pollution control for open feedlots, holding ponds, and lagoons, and land on which manure and wastewater are applied.

Title: *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*. EPA-840-B-92-002.
Author: U.S. Environmental Protection Agency
Source: U.S. Environmental Protection Agency, Washington, DC, 1993.
Abstract: This document contains guidance specifying management measures for sources of nonpoint pollution in coastal waters. The guidance addresses five source categories of nonpoint pollution: agriculture, silviculture, urban, marinas, and hydromodification. A suite of management measures is provided for each source category.

Title: *Guidelines for Integrated Planning and Management of Coastal and Marine Areas in the Wider Caribbean*
Author: United Nations Environment Programme
Source: UNEP Caribbean Environment Programme, Kingston, Jamaica, 1996.
Abstract: The adoption of an integrated approach in the process of planning and management of coastal and marine resources is fundamental to achieve sustainable development of coastal areas. Such an approach allows for balanced development of socioeconomic activities, without compromising the potential and protection of the natural resources.

Title: *Guidelines for Sediment Control Practices in the Insular Caribbean.* CEP Technical Report No. 32.
Author: United Nations Environment Programme
Source: UNEP Caribbean Environment Programme, Kingston, Jamaica, 1994.
Abstract: The purpose of this document is to describe methods of anticipating, assessing, and minimizing erosion and sediment impacts from site development. It is hoped that by outlining the processes of erosion and sedimentation, describing the principles behind erosion and sediment control, and providing examples of effective erosion and sediment

control strategies, this handbook will support efforts to plan and implement construction activities in the insular Caribbean with a minimum of environmental damage.

Title: *The Impact of Land-based Sources of Pollution on the Marine Environment*
Author: Arther B. Archer
Source: South and West Coast Sewerage Project, Barbados, 1987.
Abstract: This paper provides overviews regarding the environmental and economic features of the Caribbean combined with information regarding coastal and marine ecosystems. An overview of land-based pollutants and their impact on coastal ecosystems analyzes sources of land-based pollution identified or suspected of imposing stresses with damaging effects on coastal and marine ecosystems.

Title: *Impact of Pollution on Coastal and Marine Ecosystems Generated by the Utilization of Pesticides on Rice Crops in Cartagena, Colombia*
Author: J.G. Tinoco
Source: In *IOC Workshop Report No. 109*, IOC, San Jose, Costa Rica, April 14, 1994, p. 8., 1994.
Abstract: In Colombia more than 600 different pesticides are used, which represent near 33,000 tonnes per year. Mainly organochlorates, phosphorates, and carbamates, these substances are used in banana, cotton, rice, fruit, and other crops along the Magdalena River basin, the most extensive in the country. This document corresponds to the final report of the Colombian pilot project carried out by CIOX with the cooperation of INDERENA (Cartagena) and the support of UNESCO/IOC/UNEP. An inventory, complete and actualized with qualification of the pesticides used in the Colombian Caribbean rivers, is given, with special emphasis on the cienaga de la Virgen and its surrounding zone. Also, organoclorate compound levels in water, sediments, and important commercial species of the cienaga are analyzed. Measures for the rational use of these compounds and recommendations to increase the quality of the waters of the cienaga are also presented.

Title: *Land-based Pollution and Its Impact on Coral Reefs and Related Ecosystems: The Caribbean Experience Implications for East African Coastal Tourism*
Author: Paul A. DeGeorges
Source: U.S. Agency for International Development, East & Southern Africa, 1990.
Abstract: Land-based pollution is believed to be the major cause of coral reef degradation throughout the Caribbean. This is primarily through nutrient enrichment of nearshore marine waters associated with improperly treated domestic sewage originating from major urban areas and from tourism developments. The world's tropical waters are normally nutrient-poor and are ecologically thrown out of balance by this enrichment. Pollutants associated with agricultural runoff, including sediment, pesticides, and fertilizers, are believed to be Second in importance in causing coastal degradation second in importance in causing coastal degradation

Title: *The Management of Land-based Sources of Pollutants in Small Island States: The Caribbean Case*
Author: R.P. Coté
Source: School for Resource and Environmental Studies, Dalhousie University, Halifax, Nova Scotia.
Abstract: The increasing attention being given to land-based sources of marine pollutants by national governments is especially problematic for small island states. In particular,

pressure to reduce the discharges of persistent chemicals has implications for the strategies that can be employed in such locations. Water quality standards, emission standards, and planning approaches, especially siting requirements, can be employed in the management of land-based sources. This paper argues that the effective application of these strategies must be supported by appropriate monitoring programs to ensure that amenities and coastal resources are not being detrimentally affected. Because these strategies and monitoring programs are scientifically and financially onerous, more emphasis should be placed on reducing the generation of residuals. Such a policy, supported by national governments and international development funds, will be particularly beneficial to small island states in reducing the environmental and health impacts of land-based sources of marine pollution.

Title: *Managing Nonpoint Source Pollution from Agriculture, Pointer No. 6*. EPA841-F-96-004F.
Author: U.S. Environmental Protection Agency
Source: U.S. Environmental Protection Agency, Washington, DC, undated.
Abstract: This is one in a series of fact sheets regarding nonpoint source pollution.

Title: No-Till Cotton Production
Author: Alan C. York, Keith L. Edmisten, George C. Naderman, and Jack S. Bacheler
Source: *1993 Cotton Information*. North Carolina State University, Raleigh, 1993.
Abstract: No-tillage planting is the most effective conservation method to protect against soil erosion, and in most cases, it is the most practical methodology to adopt to meet the conservation compliance requirements on erodible soils. No-tillage planting into a residue offers the additional benefits of conserving moisture on drought-prone soils and protecting young cotton seedlings from sandblasting.

Title: *Peasants, Experts, and Land Use in Haiti: Lessons from Indigenous and Project Technology*
Author: T. A. White and J.L. Jickling
Source: *Journal of Soil and Water Conservation*, pp. 7-14, 1995.
Abstract: Development planners have frequently identified a lack of appropriate land-use technology as a key cause of degradation, and consequently, most projects have focused on encouraging rural people to adopt soil conservation or forestry techniques. Development experts have gained an appreciation for indigenous farmer knowledge and local innovations, and a new generation of projects is seeking to develop and promote techniques that combine the knowledge of both farmers and scientists.

Title: *Procedural Guide for the Development of Farm-Level Best Management Practice Plans for Phosphorus Control in the Everglades Agricultural Area, Version 1.1*. Circular 1177.
Author: A. B. Bottcher, F.T. Izuno, and E.A. Hanlon
Source: University of Florida Cooperative Extension Service, Gainesville, FL, undated.
Abstract: Heightened concerns in recent years about the impact of the quantity and quality of drainage waters from the Everglades Agricultural Area (EAA) on the Everglades have prompted the South Florida Water Management District (SFWMD) to develop both an EAA regulatory program and plans for a series of storm water treatment areas (STAs). The procedural guide addresses the concerns regarding the reduction of phosphorus loads in drainage water leaving the EAA. The information provided can be applied to any agricultural area composed primarily of organic soils or histosols.

Title: Protecting Water Quality and Reducing Pesticide Exposure
Author: Fred H. Yelverton
Source: *1993 Cotton Information*. North Carolina State University, Raleigh, 1993.
Abstract: Measures that can be taken by cotton producers to reduce or minimize pesticide threat to water quality include crop rotation, proper site selection, the use of thresholds where available, promoting a healthy and vigorous crop with good cultural practices, and proper fertilization. Protection both surface and ground water from nutrients and pesticide residues should be a goal for every farmer.

Title: *Regional Overview of Land-Based Sources of Pollution in the Wider Caribbean Regions. CEP Technical Report No. 33*
Author: UNEP
Source: UNEP Caribbean Environment Programme. Kingston, Jamaica, 1994.
Abstract: This report summarizes the results of the UNEP-CEP Programme for Marine Pollution Assessment and Control (CEPPOL) activity and provides information on the inventories of land-based sources of pollution taken in 25 countries of the WCR. This comprehensive information has been compiled from national land-based source pollution inventories, mainly from point sources, together with the assessment of the types and amounts of major pollutants reaching the coastal and marine environment as well as information on legislative and administrative measures relevant for their control.

Title: Soil Conservation Constraints on Sustained Agricultural Productivity in Tropical Latin America
Author: Ildefonsol Pla Sentis
Source: In *Soil Conservation for Survival*, ed. K. Tato and H. Hurni, pp. 277-283. Soil and Water Conservation Society, Iowa, 1992.
Abstract: Land degradation, which affects both increase in production and greater productivity per acre, has emerged as one of the major constraints on further expansion and intensification of agriculture. There are equally serious off-farm impacts (water pollution, sedimentation, flooding) associated with on-site soil degradation. Large-scale introduction of cash crops, sometimes to supply foreign markets, has led to agricultural intensification and extension to new areas of marginal land, resulting in environmental impacts in most cases.

Title: Soil Conservation Practices and Farm Income in the Dominican Republic
Author: San Won Hwang, Jeffrey Alwang, and George W. Norton
Source: *Agricultural Systems* 46 (1994): 59-77.
Abstract: A method is presented for determining least-cost strategies for meeting soil conservation targets on small, steeply sloped farms in the Dominican Republic. An easily replicated farm decision-making model using linear programming was employed to assess the relative costs of using a variety of erosion control practices including grass strips, hillside ditches and bench terraces. The effects of agricultural policy reform and secure land tenure on the cost of reducing erosion were also estimated. Grass strips were found to be the least costly means of reducing erosion. Policy reforms, in general, will reduce the cost to the farmer of complying with soil loss restrictions.

Title: Soil Management and Conservation in the Tropics: Indigenous and Adapted Technology
Author: Luis A. Manrique
Source: *Communications in Soil Science and Plant Analysis*, Vol. 24, No. 13&14, pp. 1617-1644, 1993.
Abstract: Past and current soil management and conservation technologies were reviewed to assess their effectiveness in managing soil erosion in the tropics. Slope management emerged as the most critical component determining success or failure of efforts to counteract soil losses and productivity decline. Slope management based on physical structures was found to be ineffective; combining simple cropping practices such as contour, strip, or alley cropping with soil management practices, including zero or minimum tillage, mulching, and green or organic manuring, was found to be highly effective in managing runoff and soil losses.

Title: *Soil Moisture Conservation Methods for Sustainable Agriculture in the U.S. Virgin Islands*
Author: Manuel C. Palada
Source: Workshop on Drip Irrigation, Cooperative Extension Service, University of the Virgin Islands, St. Thomas, USVI, January 1992.
Abstract: In semi-arid climates such as the USVI, conserving water and soil moisture is essential for sustainable crop production. The amount of rainfall received annually in the Virgin Islands is sufficient to grow many field and vegetable crops if techniques for conserving water are used.

Title: Sustainable Adoption of Conservation Practices by Upland Farmers in the Dominican Republic
Author: S.G. Witter, M.P. Robotham, and D.A. Carrasco
Source: *Journal of Soil and Water Conservation*, Vol. 51, No. 3, 249-254, 1996.
Abstract: This study focuses on Plan Sierra, a large nongovernmental organization located in the north-central section of the Dominican Republic. Plan Sierra has successfully promoted the use of soil and water conservation technologies to upland farmers since 1979. This research is based on data collected from interviews with 161 Plan Sierra farmers regarding the relationship between planned outreach communication channels, adoption of conservation practices and sustained use of such practices. The analysis identified a statistically significant association between farmer interaction with Plan Sierra and the three outreach communication channels used to gain the adoption and maintenance of soil and water conservation practices.

Title: Sustainable Agricultural Development in Latin America: Exploring the Possibilities
Author: Miguel A. Altieri
Source: *Agriculture, Ecosystems and Environment*, Vol. 39, Nos. 1 and 2, pp. 1-21, 1991.
Abstract: This paper concentrates on what are perceived as critical issues that should be addressed if a productive and sustainable agriculture is to be achieved in Latin America. The attainment of such an agriculture is dependent on new technological innovations, policy changes, and more socio-equitable economic schemes.

By using several examples of biological control and integrated pest management programs as case studies, ways of promoting the transition of chemical-intensive commercial agriculture to low-input management are explored. Similarly, the paper describes nongovernmental efforts using the agroecological approach to help the great mass of resource-poor farmers, mostly confined to marginal soils, hillsides, and rainfed areas, to achieve year-round food self-sufficiency, reduce their reliance on scarce and expensive agricultural chemical inputs and develop production systems that rebuild the productive capacities of their small holdings.

Title: *A Systems Method for Evaluating the Sustainability of Ag-Production: An Evaluation of Banana Production in Costa Rica*
Author: C.E. Hernández
Source: Ph.D. dissertation, Michigan State University, 1997.
Abstract: This dissertation proposes a method for evaluating the sustainable performance of agricultural production practices. It uses Costa Rica's banana production industry as a case to test the method. It presents an overview of banana production in Costa Rica based on the importance of bananas as an export crop and the environmental and social impacts associated with their production.

The paper takes a systems approach to define the banana production system and explicates it with a model. Cause-and-effect relationships are identified. The intensities of these relationships are derived using hard data when available and expert opinion when no data exist.

A panel of experts rates the conventional production practices and the alternative production practices. A mathematical method is structured to aggregate ratings into sustainable performance indices. Best available alternative practices are recommended, based on the resulting indices. It is hoped that these recommendations will help bring about a more balanced approach to the use of Costa Rica's natural and human resources.

Title: *Terms of Environment.* EPA175-B-94-075.
Author: U.S. Environmental Protection Agency
Source: U.S. Environmental Protection Agency, Washington, DC, 1994
Abstract: This document is a compilation of definitions of environmental terms.

Title: Threats to the Terrestrial Resources of the Caribbean
Author: A. Melville Gajraj
Source: *Ambio*, Vol. 10, No. 6, pp. 307-311, 1981.
Abstract: The most serious constraint encountered in the attempt to meet these objectives is the inadequacy of the soil resources for agricultural purposes—a problem compounded by mismanagement. Inappropriate use and mismanagement has led to severe erosion and loss of fertility.

Title: *Tillage Methods and Soil and Water Conservation Methods in the Caribbean*
Author: F. A. Gumbs
Source: Soil and Tillage Research, Vol 27, pp. 341-354, 1993.

Abstract: This review describes the tillage methods and soil conservation methods currently used in the Commonwealth Caribbean on a range of slopes. A high percentage of the land has slopes that exceed 20 degrees minimum. In these circumstances, tillage is carried out with hand tools and is frequently combined with conservation contour drains or/and barriers of cut vegetation laid across the contour. Many farmers form ridges and furrows on the contour with hand tools, and a significant number do not use any conservation measures. Tillage on flat or gently sloping land is done largely by tractor-drawn implements, and the tillage method is mainly determined by the crop to be grown and the soil type. The tillage methods used for the cultivation of sugarcane, rice, bananas, vegetables, and other row crops are described. The agronomic, cultural, and engineering practices used to conserve the soil against water erosion are also described.

Title: *Toward an Effective Protocol on Land-Based Marine Pollution in the Wider Caribbean Region*. Technical Report WHOI-95-10.
Authors: P. Hoagland, M.E. Schumacher, and A.G. Gaines, Jr.
Source: Marine Policy Center, Woods Hole Oceanographic Institute, Woods Hole, MA, 1995.
Abstract: In this report, the potential for the design and implementation of an effective protocol governing the prevention, reduction, and control of land-based sources of marine pollution in the WCR is analyzed. Lessons learned from a study of other regional agreements to control land-based marine pollution in the North Sea, Baltic, and Mediterranean are also included.

Title: *Virgin Islands Environmental Protection Handbook: A Guide to Assist in the Implementation of Environmental Protection Laws of the United States Virgin Islands*
Author: U.S. Virgin Islands Conservation District
Source: University of the Virgin Islands, Cooperative Extension Service, 1995.

Title: *Weed Management for Developing Countries*
Author: Food and Agriculture Organization of the United Nations
Source: Food and Agriculture Organization of the United Nations, Rome, Italy, 1994.
Abstract: Weed control is but one practice that determines the productivity of important crops such as bananas, cotton, and sugarcane. This document summarizes the problems related to weeds in these crops and identifies methods of weed management that have practical relevance for all types of production systems.

SITE VISITS

During the week of November 17, 1997, site visits were conducted in Costa Rica to observe some of the agricultural best management practices (BMPs) being implemented in tropical climates. Four operations were observed, and the site visits are summarized below.

EARTH School

The Escuela de Agricultura de la Region Tropical Humida (EARTH School) is a private, nonprofit 4-year higher educational facility in the eastern coastal plain section of Costa Rica. It was started in 1990. The majority of the students are from countries throughout Latin America and attend on scholarships. Upon graduation, the students return to their countries and implement what they have learned at the EARTH School.

A small banana plantation where students and faculty are researching different pesticide uses, cultivation practices, harvesting methods, and packing methods was observed. The EARTH School is also conducting research on ways to control and recycle the solid waste from banana plantations. Traditionally, banana plantation have produced large volumes of solid waste. Plastic bags are placed over each banana raceme, and trees are supported with plastic twine. The plastics and the stems from banana stalks are traditionally discarded in the fields and left to wash into streams, which eventually flow to coastal waters. The bags and twine can be recycled. The “field waste” (leaf cuttings, prunings, etc.) can be left on the ground near the banana plants to help control erosion and keep weeds from growing, and the banana stems can be recycled into paper.

Direccion de Investigation y Extension de al Caña de Azucar (DIECA)
(Sugarcane Extension Center)

DIECA is doing extensive research in biological pest control for sugarcane. One of the biggest threats to the sugarcane crop is nematodes. DIECA is doing research on ways to control nematodes and other pests using a species of wasp that preys on the nematodes during a portion of their life cycle. By using biological pest controls, the need for chemical pesticides is reduced. In addition, DIECA conducts outreach activities for farmers and schoolchildren, helping them to understand the value of the land and the need for using environmentally sound farming practices. DIECA is working with farmers on implementing ways to control erosion from the sugarcane fields.

Chiquita Banana Plantation

Chiquita Brands International is working with the Rainforest Alliance to implement the Better Bananas program. (See Section 5.1.) During a tour of a Chiquita-owned plantation, observers saw how bananas are cultivated and how Chiquita is implementing the Better Bananas program. A common nonpoint source pollution problem with banana plantations has been the amount of solid waste produced. The plastic bags and twine used in banana cultivation and harvest traditionally had been left in the field, from which they washed away into rivers and out to coastal waters. Chiquita is recycling the plastics and making a variety of products, such as packaging and shipping materials and "bricks" for walkways in the plantation to prevent erosion. In the past, waste bananas and crop residue were thrown into canals and streams, leading to high biological oxygen demand and other water quality problems. During the tour, observers saw a landfill that Chiquita has constructed to compost organic waste to help prevent water quality degradation. Chiquita is also actively vegetating the banks of the drainage canals and the plantation floor to help prevent erosion and increased suspended solids loadings to streams, rivers, and coastal waters.

Hacienda Juan Viñas

Hacienda Juan Viñas is a large plantation in east-central Costa Rica. Because of the different crops growing and harvesting cycles, the farm produces both coffee and sugar. The BMPs and other measures being used by Juan Viñas include the following:

- Using fertilizers that the plantation produces from organic waste material, such as the shells of coffee beans. These are mixed with poultry guano and some inorganic fertilizers and used on the farm as well as sold to other farmers in the area.
- Planting fast-growing vegetation along unstable banks to help prevent erosion.
- Constructing an upgraded wastewater treatment plant for the sugar processing operation.
- Leaving natural vegetative buffers along waterways and along very steep slopes.
- Planting shade trees in portions of the coffee fields. Although this is done primarily to enhance the flavor of the coffee, it also provides additional habitat.

Institution	Programs/Projects
United Nations Agencies:	
Pan American Health Organization (PAHO)	• Environmental Health in Sustainable Tourism Development
United Nations Development Programme (UNDP)	• Land Use Planning, Human Settlement and Terrestrial Protection Capacity 21 Fund
United Nations Centre for Human Settlements (UNCHS)	• Land Use Planning and Human Settlements Development-Organization of Eastern Caribbean States (OECS)
United Nations Food and Agriculture Organization (FAO)	• Tropical Forestry Action Plans (CARICOM)
United Nations Economic Commission for Latin America and the Caribbean (ECLAC)	• Environmental Management Issues in Tourism • Regional Sewage Disposal and Coastal Conservation Studies
United Nations Environment Programme (UNEP)	• Caribbean Environment Programme
Multilateral Development Institutions:	
Caribbean Development Bank (CDB)	• National Environmental Action Plans (NEAPs) • OECW Waste Management Project • Pesticide Pollution in the Windward Islands
European Investment Bank (EIB)	• OECS Waste Management
European Community (EC)	• CARIFORUM Regional Environment Programme under Lomé IV
Inter-American Development Bank (IDB)	• Management of Coastal/Marine Resources—Wider Caribbean
Organization of American States (OAS)	• Natural Resources Management—includes parks, protected areas system plans • Environmental and Tourism Awareness
World Bank	• National Environmental Action Plans (NEAPs) • OECW Waste Management Project • Wider Caribbean Initiative for Ship-generated Waste (WCISW)
Bilateral Development Agencies:	
British Development Division (BDD)	• Renewable Natural Resources Programme-Tropical Forestry Action Plans • National Environmental Action Plans
Canadian International Development Agency (CIDA)	• Caribbean Basin Management Training • Natural Resources Management Data Base Project-OECS/Barbados/BVI • Environmental Training Programme
German Agency for Technical Cooperation (GTZ)	• Public Health Education-CARICOM countries • Information System Development-CEHI
Japanese Policy and Human Resources	• National Environmental Action Plans (NEAPs) through

Development Fund (PHRD)	World Bank-OECS
United States Agency for International Development	• Environment and Coastal Resources Management (ENCORE)-OECS • Eastern Caribbean Policy Project-OECS
Regional Environmental Institutions:	
United Nations Environment Programme, Regional Coordinating Unit for the Caribbean (UNEP/RCU)	• Coordination of UNEP's Regional Seas Programme for the Caribbean; support for Caribbean Environment Programme (CEO)
UNDP	• Coordination of GEF NGO Small Grants Activity
University of the West Indies: • Department of Biology, Engineering, Geology, and Zoology • Marine Resources and Environment Management Programme (MAREMP) • Caribbean Law Institute (CLI) • Centre for Environment and Development (UWICED)	• Courses in environment-related studies • Research in marine resources conservation and management • Analysis of environmental laws and regulations • Training, research and information systems development in environment and development
Caribbean Environmental Health Institute (CEHI)	• Provision of technical and advisory services in environmental management (e.g., water supply, liquid and solid waste management, pesticides control); collection and dissemination of environmental data
Escuela de Agricultura de la Region Tropical Humeda (EARTH School)	• Education and research in sustainable agriculture and natural resource management
OECS Natural Resources Management Unit (NRMU)	• Coordination of natural resources management programs for the OECS
Institute of Marine Affairs	• Research in marine resources management and pollution control
Tropical Forestry Action Programme (TFAP)	• Technical assistance for national forestry resources, protected areas, and wildlife management programs
Caribbean Conservation Association (CCA)	• Advocacy, project preparation and implementation, institution building, public awareness, and education
Caribbean Natural Resources Institute (CANARI)	• Research, training, and extension, in the field of community participation and comanagement of natural resources
Caribbean Agricultural Research and Development Institute (CARDI)	• Covers environmental impacts in the course of its research on agricultural activities
CARICOM Fisheries Resources Assessment and Management Programme (CFRAMP)	• Studies the marine fisheries resources of the region
Inter American Institute for Agriculture Cooperation (IICA)	• Agriculture and resources development
Tropical Agriculture Center for Research and Education (CATIE)	• Agriculture and natural resources research and training

OECS Fisheries Unit	• Studies OECS subregional resources
Bellairs Research Institute of McGill University	• Covers marine and coastal resource monitoring and assessment
Caribbean Centre for Administration Development (CARICAD)	• Covers institutional analysis and development

Source: adapted from World Bank (1994), cited in Hoagland (1995).

AGURICULTURAL CERTIFICATION PROGRAM

<PICTURE>

Better Bananas
Rainforst Alliance
C E R T I F I E D

GENERAL PRODUCTION STANDARDS

(Updated August, 1997)

TABLE OF CONTENTS

INTRODUCTION

Global population growth has resulted in a steady increase in the demand for food and raw materials originating in natural ecosystems. In tile process of meeting that growing demand, conventional agricultural systems have devastated millions of hectares of natural forests, replacing them with extensive monocultures. At the same time, large quantities of synthetic chemicals have been used to combat pests and fertilize those crops, in the constant effort to raise levels of production. Such simplification of natural ecosystems and accumulation of synthetic chemicals has resulted in serious socio-environmental imbalances which threaten both future productivity and the current well being of human populations.

In reaction to the socio-environmental deterioration caused by conventional agricultural production, and inspired by the growing awareness in the markets of the United States, Canada and Europe, where consumers have begun to demand more sustainable systems of agricultural production, the Fundaci6n Ambio (a Costa Rican non-profit N.G.O.) and the Rainforest Alliance (a non-profit N.G.O. based in New York) initiated a program of socioenvironmental agricultural cerdfication in 1991, the objective of which is to modify traditional agricultural practices and decrease the negative socioenvironmental impact of agricultural activity. To reach this goal, the program awards an ecological seal of approval to those farms that adhere to a series of standards, which permits the promotion of their produce as having been grown and harvested under conditions of limited environmental impact and in a more just and dignified social situation.

With this document we present the Better Bananas certification program's general standards for socio-environmental agricultural production. These standards are the product of collaboration between farmers, conservation groups, scientists and government representatives. The standards in the document will probably change in the future in response to environmental advances on the farms, new technological discoveries and market demand.

GENERAL PRODUCTION STANDARDS

1.LEGISLATION

1.1. COMPLIANCE WITH LEGISLATION

Comply with national legislation corresponding to natural resource management, agrochemical use, solid and liquid waste management, labor conditions and human rights in all activities related to agricultural production systems.

Criteria:

1. Comply with local legislation.

2. Comply with accords and treaties related to socio-enviromnental aspects of production that the country is a signatory of.

3. Acquire legal operating permits.

4. Compliance with certification standards is obligatory, nevertheless, in those aspects where the local legislation is more stringent than the certification program's standards, farms should comply with what is stipulated by the law.

2 NATURAL RESOURCE MANAGEMENT

2. 1. FORESTS

Conserve and recuperate forested areas in a manner that ensures the socio-environmental benefits they offer.

Criteria:

1. Do not establish new plantations in areas where the vegetal cover consists of primary forest, secondary forest or any type of forestry management.

2. Prohibit cutting trees within the jurisdiction of the farm.

3. Use native species for reforestation programs in order to improve wildlife habitat. In cases where it is determined that native species constitute a serious limitation to crop development or in which there is a lack of propagative material, it is permissible to use exotic species that have adapted to the zone.

4. Conserve vegetation and reforest along the banks of rivers and streams adjacent to or flowing through the plantation in a minimum area of 15 meters, measured horizontally from the river bank to the edge of the plantation, when the terrain is flat, and 50 meters where the terrain is steep (30% incline or greater).

5. Maintain and unite forest fragments by planting trees to establish biological corridors.

6. Conserve and reforest the edges of public roads that border or cross the plantation in an area with a minimum width of 10 meters, measured horizontally from the edge of the road to the border of the plantation.

7. Conserve and reforest areas with a radius of 100 meters around permanent springs.

8. Implement programs for the reforestation and recuperation of natural forests in those areas that, according to studies for potential land use (see appendix), are inappropriate for agricultural activity.

9. Plant, in established farms, vegetational barriers 30 meters thick around housing nuclei, health centers, schools and any other infrastructure where there is human activity, and which fall under the jurisdiction of the farm.

10. Do not use wood for construction of platforms and other infrastructure that was cut illegally in wild areas.

11. Prohibit the extraction of wild flora and fauna from areas within the jurisdiction of the farm..

2.2. WATER RESOURCES

Protect water resources by adopting measures of control in agricultural, industrial and domestic activities.

Criteria:

1. Maintain periodic monitoring of the physical, chemical and biological characteristics of potable and waste water in order to ensure the quality of the resource. The points and frequency of sampling should be defined by the certification program's technical team (see appendix 2).

2. Implement the use of clean technologies that are appropriate for the tropics in the treatment of waste water produced by all activities on the farm.

3. Do not mix agrochemicals nor clean equipment in drainage ditches, rivers, lakes or running water.

4. Do not use natural wetlands for water treatment purposes.

5. Do not alter (by construction of canals) the natural hydrological system.

6. Design irrigation systems in a manner that balances the crop's water deficit with the hydrological requirements and precipitation of the ecosystem.

2.3 SOILS

Promote a system of soil conservation that ensures that resources' functions of support and nutrition over the short, medium and long term.

Criteria:

1. Complete and present systematic annual analyses of physical and chemical conditions (see appendix 3).

2 Develop a soil conservation program for your farm that takes into consideration the topography of the terrain and the agricultural practices that accompany the crop.

3. Do not use products for disinfecting soil that have high residual power.

4. Restrict chop and bum land clearing practices (see appendix 4.).

5. When preparing land for the crop, avoid irreversible alterations of soil structure and possible risk of erosion.

2.4. AIR

Avoid the production of solid particles, dust, smoke, gases, odors, noise and other atmospheric pollution.

Criteria:

1. Undertake periodic measurements that ensure air quality in terms of odors, noise, gases and smoke.

2. Use technologies and techniques that prevent or mitigate air pollution.

3. CROP MANAGEMENT

3.1. PLANNING AND ESTABLISHING CROPS

Establish plantations at those sites most appropriate for agriculture, where the desired yields can be obtained while minimizing socio-environmental impacts.

Criteria:

1. Complete a diagnosis of the activity's socio-environmental characteristics (see appendix 5).

2. Undertake a study of land use potential before establishing new plantations (see Appendix 1).

3. Plan measures to correct the terrain's limiting factors (determined by the study of land use potential).

4. Plan crop location and measures for soil conservation based on a topographic evaluation of the terrain.

3.2 FERTILIZATION PROGRAMS

Base fertilization program on the conservation and -increased productivity of the land, while protecting human health and the environment.

Criteria:

1. Determine fertilization programs and use of compensation according to current soil studies, the climactic characteristics of the region and foliage analysis of the plantation.

2. Apply in a localized and fractional manner.

3. Promote the adequate use of organic fertilizers.

3.3 CONTROLING PEST POPULATIONS

Base control of pest populations on the principles of Integrated Pest Management in such a way that reduces the environmental impact caused by pesticides, improves the biodiversity of the plantation and increases the farm's productivity.

Criteria:

1. Use physical practices for sanitary control of the crop: (pruning, thinning, clipping, windbreaks).

2. Implement methods of biological and ethological (use of pheromones) control of pest populations, after having completed studies that determine the efficiency of natural enemies.

3. Implement a program to establish a ground cover in order to reduce the use of herbicides.

4. Make use of monitoring systems and evaluation of pests to determine the economic thresholds of damage for the application of chemical products.

5. Apply chemical products only when pest populations exceed the previously established application thresholds, to avoid the preventive use of pesticides.

3.4 HANDLING AGROCHEMICALS

Decrease agrochemical use through the utilization of less toxic products in order to reduce damage to human health and the environment.

Criteria:

3.4.1. General considerations

1. Only use chemical products that are registered for use in the United States, Canada and Europe.

2. Restrict and prohibit the use of chemical products as specified by the norms of the certification program (see Appendix 6).

3. Restrict the use of products listed under category I (extremely toxic).

4. Allow pesticides to be handled only by men between the ages of 18 and 60.

5. Maintain up to date files on the characteristics of the products being used, such as toxicological and environmental information, and treatment in case of intoxication (labels).

6. Maintain up to date files on application equipment and protective gear.

7. All products should have original labels in the local language.

8. All people who come in contact with agrochernicals should make use of protective gear, shower and laundry areas (see Appendix 7).

9. Establish protocols for all operations, especially those that involve the handling of agrochernicals, monitoring the environment and human health. Familiarize all personnel with those protocols.

10. Promote the use of recyclable, reusable and biodegradable containers.

3.4.2 Transport of Agrochemicals

Criteria:

Transport to the farm

1. Demand that suppliers and drivers comply with the following security standards in the handling and transport of agrochemicals.

- Only transport agrochemicals in the rear part of the vehicle.
- Protect and secure the cargo for transport and check it several times during the trip.
- Transport agrochemicals in their original containers and inspect them before loading and unloading.
- Carry copies of safety information for every agrochernical being transported.
- Place warning signs on vehicle indicating the type of cargo being transported.
- Carry an insurance policy that covers civil responsibility.
  Locate products according to their function, biocide action, toxicity and chemical formula.
- Observe safety measures when loading and unloading.
- Load and unload in areas set up for that purpose.
- Take safety measures in case of spills or accidents.

3.4.3. Storage of agrochemicals

Warehouse location

1. The storage area should be located the following minimum distances:

- 60 meters from buildings (residential area, administration buildings, schools, etc.)
- 120 meters from rivers and lakes
- 60 meters from canals
- 200 meters from wells and springs
- 50 meters from fuel storage tanks
- 100 meters from public roads

2. Take advantage of natural ventilation by allowing permanent circulation of air.

3. The storage area's location should facilitate the process of loading and unloading.

4. Protect the storage area from rain and flooding.

Characteristics with which the storage area should comply

1. It should be used to store agrochemicals exclusively. In cases when fertilizers and pesticides are stored in the same building, they should be kept completely separate.

2. Permit only authorized personnel to enter.

3. Secure the building against robbery and vandalism.

4. The storeroom must have warning signs communicating the danger to human health and the environment represented by the products in storage that should be legible from a distance of 20 meters and comprehensible by illiterate people.

5. Permanently close any drains in the storeroom floor.

6. There should be a minimum of 3 meters between the floor and the ceiling, with solid walls no higher than I meter, and the remaining wall space enclosed with bars, chain-link fencing, or another material that permits constant circulation of air.

7. It should have excellent ventilation, illumination and remain dry.

8. The area dedicated to ventilation and illumination should be the equivalent of 2096 of the total area of the floor and be distributed in equal percentages and in an alternating form.

9. Entrance(s) to the storeroom should include a retaining doorstep to prevent liquids from escaping.

10. The floor should be impermeable and have a minimum incline of 1%.

11. The design should permit, in case of an accident, that the superficial water be confined to a specific area for collection and treatment.

12. Limits of storage areas and passage ways should be delineated on the floor.

13. Passage ways should have a minimum width of 80 centimeters.

14. An empty area of 30 centimeters should be maintained between the walls and storage space.

15. The storeroom should be equipped with stands and shelves -- well labeled and built of an impermeable and non-absorbent material -- so that products aren't in contact with the floor.

16. Store containers holding liquids on lower shelves.

17. Use stands and shelves with enough capacity to hold all the agrochemicals used in the operations.

18. Separate pesticides according to their biocide action, toxicity, and chemical formula.

19. Follow the handling instructions on the labels.

20. Mark on the wall the maximum height for storage (3/4 of the total height).

21. Keep shelves placed more than one meter away from lights or other sources of heat.

22. Provide one type A-B-C portable fire extinguisher for every 125 square meters.

23. Insure that there is always access to the building from both sides for fire fighters.

24. Place an emergency shower and an eye wash in areas used to store liquid products and in the areas for mixing and decanting.

25. There should be a separate storage area for empty containers which have been rinsed (3 times) and are awaiting disposal or recycling.

26. There should not be an office in the storeroom, and in case there is, it should be completely segregated and kept well ventilated.

Operating Guidelines for Storage Area

1. Prohibit eating, drinking and smoking in the agrochemical storeroom.

2. Keep original labels on containers. If a container is damaged and its contents must be transferred to another container, it should be sealed and the original label should be pasted on it, or a new label should be made with all the original information.

3. The storeroom should have a first aid kit with carefully ordered and identified medicines.

4. Keep only the amount of agrochemicals needed during the time of application.

5. Maintain a clean and orderly storage site in such a way that:

   - the labels of all products are visible
   - problems such as leaks and deterioration of containers are easily detectable.
   - doorways are unobstructed and fire fighting equipment is easily accessible.

6. Decanting and transferring should be done using appropriate equipment, guaranteeing proper safety.

7. There should be absorbent material (sand or sawdust) and protective gear for cleaning up spills inside the storeroom.

8. There should be a manual of procedures and the necessary equipment for dealing with accidents.

9. Establish emergency plans and familiarize all personnel with them.

10. Keep an inventory of the exact quantity of agrochemicals, their characteristics and safety measures for their use.

11. Use products before their expiration date.

12. Establish a system for exact location of agrochernicals within the storage area.

13. Keep a list of emergency telephone numbers.

3.4.4. Application of agrochemicals

1. Prohibit eating, drinking or smoking during the application of agrochemicals.

2. Apply agrochernicals according to the specifications listed on the product's label.

3. When applying agrochernicals, avoid exposing workers and neighbors to those chemicals.

4. Comply with the intervals of restricted entry stipulated on the label of every pesticide in the areas of application (see appendix 9).

5. Locate signs and pictographs prohibiting entrance to the area during and after application of pesticides.

6. Maintain a buffer zone 10 meters around the area of pesticide application.

7. Demarcate the limits for application of agrochernicals around sources of water, housing, packing zones and schools.

8. Use mechanical and automatic methods of application of post-harvest products in the packing process in a way that avoids worker contact with chemicals and reduces the dosage applied.

3.4.5. Crop Dusting

1. Inform community organizations a minimum of 72 hours before application about the possible risks and the principal cautions that should be taken during crop dusting.

2. Comply with the specifications for use, transport and storage of pesticides described in the sections 3.4.1., 3.4.2., 3.4.3., and 3.4.4. of this manual.

3. Comply with the specifications for fuel storage described in section 3.5.1. of this manual.

3.4.6. Showers and changing areas

1. This area should be used by all personnel coming in contact with agrochemicals.

2. It should include two areas, entrance and exit, which are connected via the showers.

3. There should be a treatment system for residue.

3.4.7. Uniform cleaning zones

1. Establish an area exclusively for washing protective gear.

2. Establish directives for the transport of clothing contaminated with agrochemicals from the shower area to the laundry area.

3. Wash all uniforms used by workers who apply agrochemicals in the laundry area.

4. Eliminate uniforms in poor condition.

5. Demand that workers in the laundry area also wear protective gear.

6. Establish an area for washing boots.

3.4.8. Maintenance of application and protective equipment

1. Inspect and repair that equipment previous to every application.

2. Prohibit the use of equipment in poor condition.

3. Wash and dry equipment according to the specifications in appendix 10.

4. Designate a specific area for washing application equipment.

5. Protective gear should be worn when providing maintenance for application equipment.

3.5 AGRICULTURAL MACHINERY

Maintain safety measures in the storage area for fuel and lubricants and in the workshops that reduce the risk of accidents and problems with environmental contamination.

3.5.1. Fuel and lubricant storage

Criteria:

1. Establish a program for handling fuel and lubricants that includes:
- Construction of a retaining wall around the area where fuel storage tanks are located to contain any type of spill. The height of that barrier should be proportional to the volume of the storage tanks.

- The floor of the area where fuel tanks are located should be made of cement or a completely impermeable material.

- There should be an absorbent material (sawdust or sand) and equipment for the clean up and treatment of spills in areas where fuel and lubricants are handled.

2. Prohibit the use of ovens, fires or machinery that creates sparks in areas of fuel and lubricant storage.

3. Keep dangerous products and materials in fuel cans inside a storeroom or other conveniently isolated locations.

4. Store only quantities necessary for maintaining continuity of operations.

5. Maintain strict security measures against robbery, vandalism, etc.

6. Insure that there is always access to the storage area from both sides for fire fighters.

7. Prohibit eating, drinking and smoking in the fuel and lubricant storage areas.

8. Mark areas with signs indicating the type of substances being stored and the minimum safety measures necessary.

3.5.2. Equipment maintenance and storage area

1. The floor and walls should be made of cement or an impermeable and incombustible material.

2. Work areas and passage ways should be delineated on the floor.

3. There should be one portable A-B-C Fire extinguisher for every 125 square meters.

4. Insure that there is always access to the area from both sides for fire fighters.

5. There should be an absorbent material (sawdust or sand) and equipment for clean up and treatment of spills.

6. Deposit materials impregnated with oil, grease or highly inflammable substances, as well as residues of dangerous materials and products, in incombustible recipients that can be hermetically sealed, which should be distributed around the work area in adequate quantities.

7. Comply with the rules established by the local electrical code.

8. Make the use of protective gear mandatory during operation of machinery (welders, saws, drills, etc.).

9. Keep the area clean and orderly in a way that decreases the probability of accidents.

10 The area should be secured against robbery and vandalism.

11. There should be a first aid kit in the area (see Appendix 8).

3.6. MANAGING THE CARDBOARD STORAGE AREA

Design the cardboard storage area according to safety standards that decrease the probability of accidents and damage to the health of workers.

Criteria:

1. It should be built of an impermeable and incombustible material.

2. The minimum height of the storeroom should be three meters from floor to ceiling.

3. Delineate storage areas and passage ways on the floor.

4. Passage ways should have a minimum width of 80 centimeters.

5. An empty area of 30 centimeters should be maintained between the walls and storage space.

6. Mark on the wall the maximum height for stacking.

7. Take advantage of natural ventilation by allowing permanent circulation of air.

8. Dedicate an equivalent of 20% of the total area of the floor to ventilation and illumination.

9. Do not exceed the maximum noise levels permitted by local legislation.

10. Comply with the requirements established by the local electrical code.

11. Provide one type A-B-C portable fire extinguisher for every 125 square meters.

12. Place clearly visible signs explaining safety measures inside and outside the storeroom.

13. Insure that there is always access to the building from both sides for fire fighters.

14. Create a separate space for assembling boxes that provides a minimum work area of 2 square meters for each person.

4. SOLID AND LIQUID WASTE MANAGEMENT

Establish an integral plan for solid and liquid waste management based on reduction, reuse, recycling and ecologically adequate disposal.

Criteria:

1. Design and carry out an integral plan -- approved by the technical team of the certification program - for handling, separation and treatment of solid and liquid waste generated by all agricultural, industrial and domestic activity within the company's jurisdiction.

2. Prohibit burning or disposal of solid waste in open pits, rivers or streams.

3. Before creating a landfill or an incinerator, technical studies must be completed to determine the size, optimal location and mitigating measures to minimize the socio-environmental impact during the phases of construction and operation.

4. Establish a strategy, approved by the certification program's technical team, for handling empty agrochemical containers.

5. ENVIRONMENTAL EDUCATION PROGRAM

Implement a permanent educational process for workers and their families with the goal of helping them accept values, clarify concepts, and develop the abilities and attitudes necessary for establishing a harmonious coexistence between human beings, their culture and the environment.

Criteria:

1. The training program should include the themes described in the Agricultural Certification Program's Environmental Education Manual.

2. Involve all personnel in the environmental education program a minimum of once a year.

3. Train all pesticide handlers before each cycle of application.

4. There should be specific educational plans catering to the different interlocutors of the program: (managers, supervisors, field workers, etc.)

5. Organize educational sessions for the families that live on the farm.

6. PREVAILING SOCIAL AND WORK CONDITIONS

Improve the quality of life for workers and their families

Criteria:

6.1. Neighboring Populations

1. Locate new plantations more than 1 kilometer away from human settlements.

2. Respect the natural resources that benefit neighboring populations (don't pollute rivers or subterranean waters, don't damage wildlife when crop dusting).

3. Respect the culture of neighboring populations and farm employees.

6.2. Living Quarters of Farm Employees.

1. Worker camps and houses should comply with the minimum health requirements in treatment of drinking water, waste water (see Appendix 2.) and solid waste.

6.3. Occupational Health.

1. Implement occupational health policies approved by authorities and the technical team of the certification program.

2. Provide procedural manuals for the prevention of and responses to accidents.

3. All workers who apply pesticides should undergo colinesterase blood protein tests previous to exposure to organophosphorus and carbametes before each cycle of application.

4. Don't permit people who have handicaps or problems with drug addiction to apply agrochemicals (see appendix 11).

5. Supervise the work environment and provide advice to personnel about all factors that can affect health.

6. Ensure hygiene of sanitary installations in the work place and housing area.

7. Maintain adequate equipment and accessories for protection of workers.

8. Insure that all work areas are equipped with lavatories for both sexes and pissoirs that are supplied with sufficient water and toilet paper.

9. There should be at least one lavatory for every 20 male workers and one for every 15 female workers when the total number of workers is less than 100. When there are more than 100 workers, install an additional toilet for every 28 workers, and at least one pissoir for every twenty.

10. All lavatories and pissoirs should fill the following requirements:

- The walls separating toilets should be raised at least 30 centimeters off of the floor to permit the washing of floors.

- The floors and walls should be continuous, smooth and impermeable. Floors should be washed at least once a day.

- Disinfection, deodorization, ventilation, lighting and the slopes of floors should meet program's conditions.

- In cases where there is a sewage system, toilets should be connected to it, otherwise they should empty into septic tanks or some form of treatment system.

11 Establish a program of decorating in packing areas, warehouses, shower areas, housing areas, recreational areas and garbage disposal areas.

APPENDICES

APPENDIX 1. Methodology for the evaluation of land use potential

YET TO BE DETERMINED

APPENDIX 2. Parameters for monitoring the physical, chemical and biological characteristics of drinking and waste water.

CHARACTERISTICS OF DRINKING WATER

Chemical substances	**Units**	**Maximum admissible value**
Fecal coliforms		Negative
Chlorides	mg/1	250
Hardness	mg/1 CaCo3	400
Nitrates	mg/1	50
Sulfates	mg/1	250
Aluminum	mg/1	0.2
Calcium	mg/1 CaCo3	100
Copper	mg/1	2.0
Magnesium	mg/1	50
Sodium	mg/1	200
Potassium	mg/1	10
Zinc	mg/1	3.0
Iron	mg/1	0.3
Magnesium	mg/1	0.5
Fluoride	mg/1	0. to 1.5[b]
Lead	mg/1	0.01

[b] 1.5 mg/1tr for temperatures of 8 to 12^{o} C
0.7 mg./1tr for temperatures of 25 to 30^{o} C

CHARACTERISTICS OF WASTE WATER

Waste water is defined as that water which has been used and whose quality has somehow been modified through the incorporation of contaminating agents. There are two principal types of waste water:
Ordinary waste water that generated by human domestic activities (use of toilets, sinks. laundry, etc)
Special waste water: all waste water that is not ordinary waste water.

Maximum permissible limits for residues in waste water

PARAMETER	**Maximum permissible unit**
Biochemical Demand for Oxygen (BDO)	500
Chemical Demand of Oxygen (CDO)	800
Total Suspended Solids (TSS)	200
Grease/oil	30 mg/1
Hydrogen potential	5 to 9
Temperature	15^{o}C< T <40^{o}C
*Mercury	0.01 mg/1
*Aluminum	5 mg/1
*Arsenic	0.1 mg/1
*Boron	3 mg/l
*Chromium	1.5 mg/1
*Copper	0.5 mg/1
*Lead	0.5 mg/1
*Tin	2 mg/1
*Phenol	1 mg/1
*Zinc	5 mg/l
*Selenium	0.05 mg/1
*Sulfides	25 mg/l
*Fluorides	10 mg/l

APPENDIX 3. Parameters for evaluating the physical, chemical and microbiological characteristics of soils.

Physical Characteristics

CHARACTERISTIC	UNIT
Texture	
Apparent density	(gm/cm3)
Porosity	(%)

Chemical Characteristics

CHARACTERISTIC	UNIT
pH in water	10:25
Extractable Acidity	Cmol(+)1
Zn, Mn, Fe, Cu	Mg/1
S	Mg/1
B	Mg/1
N	%
P	(ppm)
Ca	Cmol(+)1
Mg	Cmol(+)1
K	Cmol(+)1
Na	Cmol(+)1
Organic material	(%)
Cationic exchange capacity	Cmol(+)L
Electrical conductivity	
% of saturation of bases	(%)

Limits for toxic substances

Compounds	Maximum admissible value up./I
Aluminum Chloride	20
Aldicarb	10
Aldrin/Dieldrin	0.03
Atrazine	2
Bentazone	30
Coarbofurano?	5
Chlordane	0.2
DDT	2
1, 2-dibromide-3,3-Chloropropane	30
2.4-D	20
1.2-dichloropropane	20
1.3-dichloropropane	0.03
Heptachlor	9
Heptachloroepoxide	2
Isoproturon?	2
Lindane	20
MCPA	10
Methoxychlor?	6
Methalochlor?	20
Molinate?	9
Pendimethalyne?	20
Pentachlorophenol	20
Permetrine?	100
Propanil?	2
Pyiridad?	20
Simazine	100
Trifluralin	100
Dichloroprop	9
2.4-DB	9
2.4.5-T	10

APPENDIX 4. Restrictions on clearing land using cut and burn methods

Before burning, land owners must comply with the following restrictions:

1. Request that the certification program's technical team authorize the bum.

2. Demonstrate to the certification team that burning is the best socio-environmental alternative for resolving the problem.

3. Define, through firebreaks, the area of the burn and the combustible materials that will be burned.

4. Cut a firebreak around the perimeter of the area you intend to bum, the width of which should be double the height of the combustible material that will be burned, and which should be no narrower than one meter.

5. Prepare enough water and tools (machete, rake, shovel) to extinguish the fire in case of emergency,

6. Depending on the zone where the burn takes place, additional measures may be necessary, among which could be:

- Advising the local police with anticipation of the date and hour of the planned burn.
- Burning down hill and between 4 p.m. and 7 a.m., suspending the bum if it is windy
- Do not abandon the area until the fire has completely gone out.

ANEXO 5. Evaluation parameters for the diagnosis of the socio-environmental characteristics of the agricultural activity.

1. General information about the legal entity completing the diagnosis (name of company, date of creation and registration information).

II. Justification of the activity's technical, social and environmental objectives.

111. Environmental Diagnosis Description of the environmental and social characteristics within the project's area.

A. Environmental Description
a.l.Project location (country, province, department, county, district, and town it lies within), indicate the location on a map 1:50,000 and provide a copy of the tide.

a.2 Characteristics of the physical environment
Provide a map that includes the aspects mentioned below.
-Soils: classes, current use, capacity.
-Climate: Regional and local descriptions (wind, precipitation, temperature, humidity)
-Hydrology: Description of the hydrological network, location of rivers, streams, springs, ponds and other bodies of water within the area of influence.
-Topography- General description of the terrain (relief, human activities).

a.3 Characteristics of the biological environment:
-Description of existing biological recourses (susceptible flora and fauna, endangered species, forested areas, abandoned areas, deforested areas, areas undergoing natural regeneration).

a.4 Characteristics of the human environment:
Predominant human settlements wdthin the area of influence.
Indicate distances from the plantation.
-Basic services: transportation, communication, health, education, garbage collection. potable water, sewage system.
Natural and cultural heritage of the area (archaeological and historical sites, relevant landscapes).
Productive and other types of activities.
-Labor conditions: temporary and permanent workers that fall under the jurisdiction of local labor laws, foreign workers of migratory status.

B. Detailed description of the Project

b.1 Type of crop, management, planting and harvest methods, total area and area of farm (in hectares).
b.2 Mechanical equipment use.
b.3 Agrochemical use (pesticides and fertilizers), type and form of application (manual, mechanical, from land. air, etc.)

b.4 Irrigation system.
b.5 Drainage system.
b.6 Access roads and their condition
b.7 Soil conservation practices.
b.8 Location and description of agrochernical storerooms, fuel tanks, packing plant, offices, bag opening area, cutting area, landfill, housing areas, treatment plant, etc.

C. Description of socio-environmental risks:
c.1 Natural: erosion, flooding, sedimentation, fires, drought, etc.
c.2 Anthropological: Spills and transport of agrochemicals, oil, fuel, fires, deviation of natural drainage, open air dumps, landfills, deforestation, etc.

D. Evaluation of positive and negative impacts:
d.1 Compliance with the Standards of the Agricultural Certification Program.
d.2 Actions planned by the company (development of strategies to minimize the negative effects of agrochemical use, implementation of waste treatment systems) including preventive and corrective measures, procedures and technologies to be used, as well as including corresponding maps.

APPENDIX 6. Lost of pesticides restricted or prohibited by the certification program

GENERIC NAME	CHEMICAL GROUP
* 2.4.5-T	PHENOXYACETIC ACID
* ALBICARB	CARBAMATE
* ALDRIN	ORGANOCHLORIDE?
**LEAD ARESENATE	ARSENICAL
**CAPTAPHOL?	PHTAL
**CIHEXANTIN?	STANNONS
*CLORDANE	ORGANOCHLORIDE?
**CLORDECONE?	ORGANOPHOSPHORUS
* CLORDIMEFORM7	FORMAMIDIN
*DDT	ORGANOCHLORIDE7
* DBCP (DIBROMOCHLOROPROPA)	HALOCARBIDE
* DIELDRIN	ORGANOCHLORIDE?
**DINOSED	NITROGENOUS
* ENDRIN	ORGANOCHLORIDE7
**EDB (ETHYLENE DIBROMADE)	BROMADE?
*HCH	ORGANOCHLORIDE7
* HEPTACHLOR	ORGANOCHLORIDE7
**MERCURY	MERCURIALS
* METHYLPARATHION	ORGANOCHLORIDE7
*TOXAPHENE	ORGANOCHLORIDE7
*LINDANE	ORGANOPHOSPHORUS
*PENTACHLOROPHENOL	ORGANOCHLORIDE7
*PARATHION	ORGANOPHOSPHORUS
*PARAQUAT	BIPIRIDILE compound?

* Products included in the DIRTY DOZEN according to the P.A.N.
**Products prohibited in Costa Rica

LIST OF PRODUCTS RESTRICTED BY THE AGRICULTURAL CERTIFICATION PROGRAM

GENERIC NAME	CHEMICAL GROUP
MTETHYLBROMIDE	ORGANIC
CARBORANE 48%	CARBAMETE
PHORATE 48 & 80%	ORGANOPHOSPHORUS
ALUMINUM PHOPHORUS	ORGANIC
MONOCROTOPHOS?	ORGANOPHOSPHORUS
M.A.F.A.	ARSENICAL
DAMINOCIDE?	??

APPENDIX 7. Protective equipment required for agrochemical use.

Application of nematicides:

Work cloths, jumper or long-sleeve shirt and long pants made of thick material.

Gas mask with a filter appropriate for the characteristics for the chemical used.

Protection for head (cap, hat, etc.)

Unlined rubber gloves that extend half way up the arm.

A vinyl protector for the back.

Unlined rubber boots.

Safety glasses with indirect ventilation for chemical substances.

Socks.

Application of herbicides:

Work cloths, jumper or long-sleeve shirt and long pants made of thick material.

Gas mask with a filter appropriate for the characteristics for the chemical used.

Protection for head (cap, hat, etc.)

Unlined rubber gloves that extend half way up the arm.

A vinyl protector for the back.

Unlined rubber boots.

Face shield or goggles with indirect ventilation.

Socks.

Application of fertilizers:

Apron

Unlined rubber gloves that extend half way up the arm.

Unlined rubber boots.
Socks.

Crop duster signaling -- "Bandereo:"

Work cloths, jumper or long-sleeve shirt and long pants made of thick material.

Gas mask with a filter appropriate for the characteristics for the chemical used.

Protection for head (cap, hat, etc.)

Raincoat, poncho or something similar made of impermeable material.

Unlined rubber gloves that extend half way up the arm.

Unlined rubber boots.

Face shield or goggles with indirect ventilation.

Socks.

Preparation of plastic bags soaked with insecticides:

Work cloths, jumper or long-sleeve shirt and long pants made of thick material.

Gas mask with a filter appropriate for the characteristics for the chemical used.

Unlined rubber gloves that extend half way up the arm.

Face shield or goggles with indirect ventilation.

Clean up of pesticide spills:

Work cloths, jumper or long-sleeve shirt and long pants made of thick material.

Gas mask with a filter appropriate for the characteristics for the chemical used.

Vinyl apron

Unlined rubber gloves that extend half way up the arm.

Unlined rubber boots.

Washing work cloths and equipment contaminated with pesticides:

Unlined rubber gloves that extend half way up the arm.

Unlined rubber boots.

Long impermeable apron

APPENDIX 8. Ust of medicines first aid kits should contain

ITEM	QUANTITY	INDICATIONS
10x10cm sterile dressing	24 units	Cover wounds
Silver Sulfadiacina	1 jar	Burn treatment
Guaze squares	1 package	Wound treatment
Absorbent cotton	460 grams	Wound treatment
Adhesive strips (bandaid)	1 box	Cover wounds
Rolls of guaze	2 3-inch rolls	Wrap wounds
	3 5-inch rolls	
Elastic bandage	3 3-inch rolls	Wrap sprains
	3 4-inch rolls	
Sterile tape	2 rolls	Secure bandages
Tincture of odine	1 bottle	External antiseptic
Distilled water	1 liter	Local desinfection
Neutral soap	1 bar	Local desinfection
Active Charcol	12 packets	Oral poisoning
Fuller's Earth	3 jars	Paraquat poisoning
Ofalgenol	2 jars	Ear pain
Antidiarrheic	120 ml	Diarrhea
Analgesic	24 tablets	Pain
Oral thermometers	2 units	Check temperature
Scissors	1 unit	Cutting
Tounge depressors	12 unites	Revision
Paper towels	1 package	Cleaning
Disposable cups	6 units	Specific use
Sterile latex gloves	1 box	Avoid contamination
Disposable 71/2 - 8 Small garbage bags	6 units	Vomit
Large garbage bags	6 units	Contaminated clothes
Individual sheets	2 units	Cleanliness
First Aid Manual	1 copy	Rapid consultation

APPENDIX 9. Intervals of restricted admission following application of agrochemicals

When no restrictions are described on the product label, the following intervals of restricted entrance are recommended following pesticide application.

Nematicides: a minimum of 26 hours following application
Insecticides: a minimum of 24 hours following application
Herbicides: a minimum of 12 hours following application
Fungicides: a minimum of 4 hours following application

The above mentioned periods of restriction apply to human beings and domestic animals.

APPENDIX 10. Guidelines for washing and drying equipment used in application of agrochemicals.

It is important that people who clean equipment used to apply agrochemicals wear protective gear when washing that equipment.

The cleaning procedures follow:

- Fill approximately on quarter of the tank with water. Close the cap and move it around, being careful not to splash.
- Spray some of the water, through the nozzle, back into the tank, to insure that the pump, hose and nozzle are clean.
- Empty the water out in the area reserved for cleaning equipment.
- Repeat the process at least three times.
- Rinse the equipment once using a small amount of soap.
- Disassemble the unit composed of the handle and nozzle, remove the filters and clean them by submerging them in a container of water. Do not blow through the pieces of the nozzle.
- Wash the exterior of the sprayer, including the shoulder straps, with soap and water.
- When storing the sprayer, remove the cap and hang it up side down to permit the water to run out of it, so hat it dries completely.

APPENDIX 11. People considered unable to apply agrochemicals

- Anyone younger than 18.
- Women who are pregnant or breast feeding.
- People considered mentally instable.
- Mentally retarded people.
- People suffering heart or bladder diseases.
- People with chronic diseases of the kidney or liver.
- Illiterate people.