ENVIRONMENTAL ISSUES AND BEST PRACTICES FOR AGRICULTURE AND WATERSHED MANAGEMENT

A. SOIL AND WATER CONSERVATION

Brief Description of the Sector

For decades, growing population pressures have led many smallholder farm families to eke out a subsistence livelihood on more and more marginal lands, such as the uplands of Latin America and Caribbean. There are some indications that the trend is beginning to reverse itself as a result of more robust economies and off-farm employment opportunities drawing families out of the hills, but soil and water conservation activities still have broad relevance.

In Latin America and the Caribbean, land degradation is perhaps the most widespread example of an environmental issue having a direct impact on human beings. Using traditional agricultural practices on environmentally fragile sites causes soil erosion and disrupts the hydrological cycle, contributing to a decline in productivity and undermining food security. As land degradation becomes more severe, farmers often have few options other than to seek another piece of land on which they can earn a livelihood. When marginal land is no longer available, they may have to migrate to tropical lowlands or to already overburdened urban areas.

Land degradation in many countries of the region is already leading to off-site consequences--flooding, siltation--that undermine other promising water-related development initiatives in irrigation, potable water supply, hydropower, and river transport. Likewise, the predominant land-use mosaic of small farms practicing unsustainable agriculture where erosion and run-off are commonplace heightens the vulnerability of parts of the region to severe weather, such as hurricanes. The undeniable links between poverty, hunger, and environmental degradation create the most compelling reason why environmental oversight must continue to be an important part of USAID s approach to rural development in Latin America and the Caribbean.

There are two broad categories of soil and water conservation technology, and they should be applied in combination (Table 8.1). Soil conservation practices

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aimed at treating slope conditions are structural engineering solutions usually established on the contour to block the flow of rainfall run-off and contain any soil erosion. Biological measures to improve or conserve soil soil involve the use of vegetative materials, living and dead, to avoid soil erosion and run-off and improve the quality of the topsoil.

Table 8.1 Soil and Water Conservation Technologies

Engineering or Structural Technologies	Vegetative Treatment Measures
Side Hill Ditches or Similar Diversion Structures Very typically separating higher, non-arable land from cultivated land below.	**Strip Cropping or Contour Farming** Orienting plowing and tilling along the contour to avoid run-off and erosion.
Contour Bunding or Ridges Built along the contour as part of the crop field layout from either stones or soil.	**Living Barriers** Planted along the contour to trap or filter run-off and retain soil, such as contour hedgerows or grass strips.
Grassed Waterways Carry away run-off that has been channeled by contour structures to a central downslope drain.	**Leguminous Cover Crops** Fix nitrogen, raise organic matter content, and protect the soil, such as green manure or mulch.
Terraces Radical conversion of sloped land into a series of graded steps approximating flat conditions.	**Zero or Low Tillage** Crop residues left on the site after harvest, while the next crop is dibbled into the soil with a minimum of disturbance.
Small-Scale Terracing Discontinuous use of terracing, usually small platforms on which to plant fruit trees.	**Adjustments to Agronomic Practices** Improved plant spacing and appropriate crop rotation, including inter-cropping.
Micro-Basins Pits or half-moon structures built in a pattern across the slope to trap rainfall, usually in drier areas.	**Compost Application** Improve the organic matter content of the soil, its tilth, and its ability to infiltrate rainfall.
Gully Plugs Barriers built perpendicular to the slope across drainage ways to slow water run-off and contain transported soils and silt.	**Agroforestry Practices** Addition of a tree crop to the farming system for conservation.

Potential Environmental Impacts

The applicability of soil and water conservation technologies and the avoidance of adverse environmental impacts are directly related to a sound understanding of land capability. The most common example of unsustainable agriculture is traditional open furrow agriculture and over-grazing on sloping lands, which leads to soil erosion and uncontrolled rainfall run-off. These consequences can be far-reaching, leading to both minor and major environmental impacts, including landslides, earth slumps, gully formation, siltation and sedimentation of water courses, and downstream flooding with significant loss of life and property.

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Some erosion or soil displacement is often the natural consequence of open furrow farming practices. But recognizing the conditions likely to lead to erosion and uncontrolled run-off is essential to predicting environmental impact and coping with smallholder soil and water conservation. Although many may be able to recognize the propensity for soil erosion under extreme conditions, even trained technicians need measurements to assess the scale of potential erosion and run-off. Slope, topsoil depth, and soil type all affect the potential for ero-

Table 8.2 A Land Capability Classification Scheme

Slope Class	Slope (%)	Soil Depth (cms)	Land Capability	Major Conservation Treatment	Applicable Tools	Land Use
1	0 12	>15	C1	Mainly agronomic conservation measures; simple terraces approaching 12%	Large machine or hand	Any crop
		<15	P	Grass cover		Pasture
2	12 27	>30	C2	Bench terraces and simple terraces	Medium machine or hand	Any crop
	27 36	<30	P	Hillside ditches		Pasture
3		>45	C3	Bench and simple terraces	Hand or small machine	Any crops
	36 47	<45	P	Hillside ditches, zero grazing, etc.		Pasture
4		>55	C4	Simple terraces and some benches	Hand or walking tractor	Annual and perennial crops
	47 58	<55	P	Hillside ditches, zero grazing, etc.		Pasture
5	>58	>60	FT	Orchard terraces	Hand	Tree crop
		<60	F or AF	Forest cover or agroforestry	Hand	Trees or tree crop
6		all depths	F	Forest cover		Forest only

Legend: C = cultivatable land; P = pasture; FT = land for food, fruit and tree crops; F = forest land; AF = agroforestry.
Source: Sheng 1989.

sion and dictate the appropriate conservation measures essential for controlling it. Table 8.2 presents a practical land capability classification system suggested for small farmers in the humid tropics.

In almost every case, application of soil and water conservation technologies is expected to have a positive impact on the environment, either by preventing erosion and run-off or by contributing to the rehabilitation of a degraded site. On the one hand, soil and water conservation technologies may make it possible to continue cultivating land that would otherwise be unsuitable for conventional or traditional agriculture. Elsewhere, as table 8.2 suggests, these practices may retain water on a site or improve the soil condition gradually to enhance growing conditions.

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Sector Design--Some Specific Guidance

Environmentally sound design and implementation of activities that produce positive returns for farmers while maintaining the fertility and stability of the site are the best safeguards against soil degradation and related environmental impacts. Similarly, where necessary, the application of soil and water conservation activities is highly unlikely to lead to adverse environmental impacts if properly designed and implemented. However, special considerations can add to the certainty that these activities will be successful, including:

Assessing the present state of natural resources within agricultural program areas. Many smallholder-oriented agricultural development activities presently being addressed with USAID resources occur in areas with heterogeneous site conditions that challenge the program designer to choose an appropriate array of interventions. Providing usable, geo-referenced maps to guide development efforts, rendered at a suitable scale (1:10,000, at a minimum) should be an important part of the design process. Geographic information and global positioning systems and high-resolution, small-scale satellite imagery (such as Ikonos) are efficient and effective means for obtaining this basic planning information.

Stratifying an area on the basis of slope, soil depth, and soil quality. Standard land capability parameters can be used to define specific intervention units. This will make it possible for a program to be fine-tuned according to specific needs, while anticipating the potential for unsustainable use resulting from mismatched land capability and land use. Doing so can add to a programmer s ability to see important interrelationships within the landscape that allow for a more integrated approach to natural resource use and development. At such a scale, intervention units enhance the capability for participation of concerned farmers and landowners by making it easier to identify those involved across an area. A geo-referenced database will facilitate program impact monitoring, whether used in a results framework or to ensure that mitigation measures achieve their desired effects.

Achieving results in practical realities of soil and water conservation. History shows that soil rehabilitation and restoration through soil and water conservation programs can be a lengthy, costly, difficult process, often beyond the means of small farmers. Practical realities about how these programs are designed and implemented can have a marked influence on their success, improving the sustainability of farming systems and ensuring returns to farmers.

Soil and water conservation must move beyond technologies and interventions that just treat the symptoms of degradation, toward approaches that actually foster improved land management.

Paramount among these considerations is a recognition that soil and water conservation must move beyond technologies and interventions that just treat the symptoms of degradation, toward approaches that actually foster improved land management. Degradation is the result of inappropriate land use, so there is a need to manage use, not just treat the land affected. If gullies are forming as a result of overgrazing and excessive run-off, planting trees to rehabilitate the degraded areas is not enough. Something must also be done to manage the grazing pressure, rather than just shifting it to other areas where it will accelerate degradation.

Managing land use, particularly in smallholder areas where population pressures are high and degradation is accelerating, can be a zero sum situation. Soil conservation and reforestation practices must be viewed against the backdrop of the other land uses they displace or production trade-offs they require. Under such circumstances, the benefits to society of improving environmental stability may be justification for a soil and water conservation incentives program to facilitate smallholder participation and a closely related companion program to help farmers intensify their agricultural production activities on the better lands. Conservation cannot be built solely on the backs of those least likely to be able to afford it.

Coming full circle with soil and water conservation. Many soil and water conservation programs focus exclusively on two types of practices: barriers (live and dead) that contain erosion and form (eventually) terraced conditions, and ditches and trenches that capture transported soil and water run-off to improve infiltration or manage drainage. Although these typically labor-intensive practices benefit production and the farmer community, their slow and often diffuse impact can be enhanced by adding a third category of activities aimed at investments for enhancing soil quality on the farmed plots between the barriers or ditches. Direct actions to improve and nurture the soil itself so that crops will grow better are activities that validate the investments in erosion control. These actions can include both biological and agronomic interventions--tillage and plowing techniques, green manuring, nitrogen-fixing legumes and cover crops, compost and animal manure, crop spacing, inter-cropping and improved crop rotation--and result increased organic matter and fertility levels.

Direct actions to improve and nurture the soil itself so that crops will grow better are activities that validate the investments in erosion control.

Making choices. This is not easy. Too many soil and water conservation and watershed projects fail because they attempt to do too many things. They spread capabilities, expertise, and resources too thinly, especially at the field level, and fail to generate the momentum needed for real change. This situation is often further complicated when technical staff understand the mechanisms of a particular intervention but not the environmental conditions of the sites under which it is optimally applied. Although an integrated approach is fundamental, it needs to be a manageable choice of interventions targeting priority problems identified by the local communities.

Avoiding the tendency to institutionalize subsistence agriculture. In many programs it has been discovered that farmers have priorities other than soil and water conservation or increased agricultural productivity, typically oriented to ensuring the destiny of their children or a wholesale change in rural infrastructure and access to the local economy. They signal a need for real change because they intuitively understand that linking their destiny to their land will not lead anywhere. Accordingly, soil and water conservation and agricultural development projects need to be wary of timid, minor changes that simply reinforce the status quo. Postponing the inevitable crash of a subsistence-based rural economy will in all likelihood lead to greater natural resource degradation and social disintegration.

Understanding that roads often contribute to erosion problems. One often overlooked cause of soil erosion is a misaligned road or path, which channels and concentrates run-off and leads to soil erosion and gully formation. In El Salvador, a study conducted by the FAO in the late 1970s found that as much as 25 percent of the erosion in upland watershed areas was caused by poorly designed roads and paths. This is especially important in agricultural development programs that propose to construct farm-to-market roads that improve the market access for local products. Building new roads requires careful attention to water management engineering and diversion structures (culverts and cut-offs) and is typically the subject of additional environmental review.

Environmental Mitigation and Monitoring Issues

Similar to the agroforestry technologies with which they are sometimes combined, soil and water conservation activities are normally mitigation measures to counter the adverse environmental impacts of conventional agricultural production practices on marginal land. If the right combination of technologies have been chosen, the results will include improved growing conditions for agricultural crops and increased productivity. These results, however, may take many years to manifest themselves, and causality may be confounded by the many variables of the sites, farmer aptitude for conservation, and enhanced agronomic practices that typically accompany such programs.

Environmental impact monitoring may best be accomplished if combined with performance- or results-based monitoring.

Accordingly, environmental impact monitoring may best be accomplished if combined with performance- or results-based monitoring designed to measure the success of the program. Again, similar to agroforestry, good baseline data and an ability to gauge farmer satisfaction--also through the use of para-technicians or lead farmers--should be part of the monitoring system. Additionally, a number of options are worth considering in monitoring programs for soil and water conservation technologies, including:

Formal soil erosion control plots. Assessing the benefits of soil and water conservation technologies in absolute terms may require controlled test plots to be set up that ensure a minimum of variables for reasoned analysis of cause and effect. Often, these are managed by agricultural research stations. Depending on a program s magnitude, if these stations do not already exist, it may be necessary to set them up and collect a few years of data to demonstrate impact.

Stream-gauging and meteorology stations. As soil and water conservation practices spread across the rural landscape, part of their impact can be seen and measured by the run-off of local streams. Soil erosion is typically proportional to rainfall, and, without localized data, it is difficult if not impossible to draw conclusions about the efficacy of erosion control measures. The importance of having good meteorological and hydrological data for agricultural development cannot be overemphasized. Almost any program in the sector can justify a weather station or, in the case of soil and water conservation or watershed management, a stream-gauging station. Such facilities will go a long way in helping define the cause and effect of weather on crop productivity and environmental stability. Such facilities should increasingly and routinely be a part of sector programs for both development planning and ecological monitoring purposes in the region. Finally, providing program technical staff with rain gear that allows them to get out into the elements can greatly assist in understanding erosion processes through firsthand observation.

Photo and video records and technologies. The intricate nature of the application of soil and water conservation technologies across a mosaic of farmer fields makes it extremely difficult to measure results. While sampling techniques can help overcome this constraint, a number of modern technological advances are well suited to collecting and managing data on changing site conditions. Seasonal conditions in the program area can be recorded using digital photography and videography, ideally taken from the same vantage point and at the same point in the agricultural calendar. The use of global positioning and information system equipment can make it easier to survey for changes in site conditions or land-use patterns that indicate whether the soil and water conservation technologies have actually taken hold. These tools also enhance the capability to train staff and participants and can be used to demonstrate results for public relations purposes.

Technology adoption, dissemination, and maintenance. One of the most appropriate proxy indicators of the success of soil and water conservation technologies is farmer satisfaction with the application. This is easily detected by gauging adoption rates, the extent of their spread to other farmers, and the degree to which they carry out the maintenance measures that are often critical for achieving optimal impact.

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A recent Inter-American Development Bank publication on their view of the needs for continuing development of the agriculture sector in Latin America.

Magdoff, F., and H. van Es. 2000. *Building Soils for Better Crops.* Sustainable Agriculture Network Handbook Series Book 4, Sustainable Agriculture Research and Education Program, USDA. Beltsville, Maryland.

Important information on the maintenance of soil fertility, emphasizing organic farming and introducing the reader to the Sustainable Agriculture Network.

Sheng, T.C. 1989. Soil Conservation for Small Farmers in the Humid Tropics. *FAO Soils Bulletin* 60: 104.

Although somewhat dated, considered by many as the most useful guide for a practical understanding and application of soil and water conservation practices.

SAN (Sustainable Agriculture Network). 1997. *Source Book of Sustainable Agriculture: A Guide to Books, Newsletters, Conference Proceedings, Bulletins, Videos and More.* Sustainable Agriculture Research and Education Program of USDA. Burlington, Vermont.

The key to finding additional information on improving small-farmer agriculture.

General Resources

Alternative Farming Systems Information Center.

Information resource for farmers and extension agents. Online: www.nal.usda.gov/afsic/csa.

ATTRA (Appropriate Technology Transfer for Rural Areas) network.

Another site providing assistance, publications and resources free to farmers, extension educators and other agriculture professionals. Online: www.attra.org.

CGIAR (Consultative Group for International Agricultural Research).

Environment and biodiversity conservation issues as well as the relationships between natural resource management and agricultural productivity have become important topics considered by the 16 international research centers that now form the CGIAR. Online: www.cgiar.org.

FAO (Food and Agriculture Organization of the United Nations).

The FAO Conservation Series, including Guide No. 13, *Watershed Management Field Manual,* includes five volumes treating the following topics: vegetation and soil treatment measures, gully control, slope treatment measures and practices, landslide prevention measures, and road design and construction in sensitive watersheds.

FAO *Soils Bulletins* include several titles of particular interest to soil and water conservation, including: No. 4, *Guide to 60 Soil Water Conservation*

Practices; No. 13, *Land Degradation*; No. 30, *Soil Conservation in Developing Countries*; No. 33, *Soil Conservation and Management in Developing Countries*; No. 34, *Assessing Soil Degradation*; No. 44, *Watershed Development with Special Reference to Soil and Water Conservation*; No. 49, *Application of Nitrogen-Fixing Systems in Soil Management*; No. 50, *Keeping the Land Alive: Soil Erosion, Its Causes and Cures*; and No. 53, *Improved Production Systems as an Alternative to Shifting Cultivation.*

IDRC (International Development Research Centre).

This Canadian institution is a constant source of information on sustainable agriculture in the developing world. Online: www.idrc.ca.

Rodale Institute.

Located in Pennsylvania, this institute is a source of a good deal of information on organic farming. Online: http://fadr.msu.ru/rodale.

SIDA (Swedish International Development Agency).

SIDA is a major international donor supporting soil and water conservation development programs in many countries. Online: www.sida.org.

USDA (United States Department of Agriculture).

A comprehensive list of USDA s agencies, services, and programs is available online: www.usda.gov/services.html

USDA s Sustainable Agriculture Research and Education (SARE) program is administered by the Cooperative State Research, Education and Extension Service. Although targeted at farming conditions in North America, the conceptual approach and many of its findings can be applied in Latin America and the Caribbean. Noteworthy publications include: *Building Soils for Better Crops, The Small Dairy Resource Book, Managing Cover Crops Profitably,* and *Source Book of Sustainable Agriculture.* These publications are available for purchase oline: www.sare.org/htdocs/pubs. They also operate a free e-mail discussion group; to subscribe, send a message to listserve@sare.org and in the body of the message write: subscribe sanet-mg.

A site similar to the SARE program s is the Small Farms@USDA Home Page. Online: www.usda.gov/oce/smallfarm/sfhome.htm.

The Natural Resources Conservation Service offers links to a broad spectrum of information about its programs and information sources related to soil, water and natural resource conservation. Online: www.nrcs.usda.gov.

US Soil and Water Conservation Society.

SWCS is an international organization with programs and publications of interest to those concerned with soil and water conservation and watershed management in the developing world. Online: www.swcs.org.

B. Stream Bank Protection and Restoration

Brief Description of Sector

Streambank protection and restoration activities have become more common in Latin America and the Caribbean as a result of watershed degradation and catastrophic rainfall events, such as Hurricane Mitch. As a watershed becomes degraded, less rainfall is absorbed and the run-off feeds the watercourses that drain the area, causing them to become more torrential, with higher floods and lower lows. The increasingly torrential streams and rivers break down the streambed and transport more material from the upper, steeper areas of the river system. Downstream, as the slope flattens or the stream meets more durable obstructions, these rocks, sand, and silt--and often human-made trash--are re-deposited elsewhere, frequently filling the stream channel. When the next highwater occurs the water has nowhere to flow and jumps the streambank, breaking it down and flooding adjacent areas.

The changing course of the rivers and streams and the flooding that accompanies it can have disastrous impacts, causing major destruction and loss of human life.

Siltation and sedimentation of the streambeds is a natural phenomena associated with the hydrological and geological processes. But in degrading watersheds and areas that are geologically young and subject to seismic activity, as in the Andes, this process becomes more problematic. Typically, streambank destruction and flooding of adjacent areas occur along the flatter stretches of the river course, where towns and villages are established. The changing course of the rivers and streams and the flooding that accompanies it can have disastrous impacts, causing major destruction and loss of human life. This has prompted many local authorities, governments, and donors to attempt to remediate the damage and avoid future flooding by rebuilding and restoring streambanks.

A variety of techniques are employed for this purpose, including sandbagging, building dikes along the margins of the watercourse, dredging the streambed, or employing sophisticated engineering options, such as building rock rubble, riprap margins, revetments, gabions, or even reinforced masonry, concrete, pilings or steel streambanks. These techniques are known as river training.

Potential Environmental Impacts

In a degrading watershed area, the torrent of the stream or river is likely to increase over time, exceeding all previous records of flood stage and therefore requiring even larger efforts to contain.

The whole matter of streambank restoration and river training is extremely complex, with a great deal of information built up over the years from similar experiences in the mountainous regions of Europe and North America. It is not an area of endeavor for amateurs or the faint of heart; rather, it is the purview of well-qualified hydraulic engineers who will design these structures on the basis of good data and information about the characteristics of the watercourse in question.

Their work is often complicated by two facts typical of these situations in developing countries. On the one hand, the paucity of stream-gauging stations along mountain watercourses means that the data and information required for the engineering calculations may be missing or inadequate. Water resource engineers building these structures usually plan for them to absorb the energies of what is called the hundred-year event --the highest flood conditions that have taken place over the course of the last century. But in a degrading watershed area, the torrent of the stream or river is likely to increase over time, exceeding all previous records of flood stage and therefore requiring even larger efforts to contain.

The most problematic adverse environmental impact of streambank protection and restoration is a failure to recognize that channeling water through an area

ENVIRONMENTALLY SOUND LAND USE IN HONDURAS

In Honduras, USAID's Land Use and Productivity Enhancement project (LUPE, 1981 98) improved hillside agriculture practices. Thirty-eight thousand hillside farm families adopted environmentally sustainable cultivation practices. As a result, soil erosion losses on steep slopes were reduced from 37 tons per acre to less than half a ton, saving an estimated five million tons of topsoil annually. Farmers increased their income by more than 50 percent.

LUPE's effectiveness was vividly demonstrated during Hurricane Mitch. Although soil erosion and landslides destroyed many farms, adjacent LUPE sites withstood the ravages of the storm. The LUPE approach has been adopted and spread by Central American governments and donors in their commitment to "build back better" after Mitch.

Oral testimony by Carl H. Leonard, Deputy Assistant Administrator, Bureau for Latin America and the Caribbean before the Senate Foreign Relations Subcommittee for the Western Hemisphere, July 25, 2000.

by engineering more stable banks may shift the potential for flooding downstream. Poorly engineered solutions can also exacerbate the damage in the area being corrected. It is not uncommon to find these structures undermined by the rushing waters and collapsing into the riverbed, diverting water directly onto the margins of the area they were supposed to protect.

Sector Design--Some Specific Guidance

The nature of streambank protection and restoration is extremely technical and there is a need for good data, solid information, and competent water resource engineering skills to address these issues. Additional points that should be considered include:

Ameliorating the conditions upstream. Few efforts to protect and restore streambanks will be successful if the conditions that give rise to the torrential nature of the water course are not also addressed. This involves a gradual but affirmative program to restore stability to the watershed that feeds the stream. It can be an enormous task, as the size of the river and the flooding it causes is directly proportional to the catchment it drains. Achieving watershed stability is usually a long-term effort directed at ensuring that land use matches land capability and that certain practices--cultivation on steep slopes, forest and brush fires, overgrazing, inappropriate mining operations, poorly designed roads and trails, destructive logging practices--are avoided. Interim measures that hold water on the land in the upper watershed may also be useful, such as gully plugging or the diversion of water away from the watercourse using contour ditches and drainage.

Few efforts to protect and restore streambanks will be successful if the conditions that give rise to the torrential nature of the water course are not also addressed.

Avoiding streamside setbacks. One of the constants for achieving success in protecting and restoring streambanks is to avoid human encroachment. Cultivation, livestock, and construction on the margins of streambanks that eliminate the natural vegetation and its root systems should be avoided at all costs. This recommendation also fits well with other recommendations for avoiding adverse environmental impacts in these areas. Buffer strips along streams--as much as 50 meters wide on both sides of the watercourse--prevents run-off, eroded soils, and similar causes of non-point source pollution. Such a strip may also protect important biodiversity assets that use the gallery forests along stream banks as habitats or corridors for movement.

Establishing stream-gauging stations. Good hydrological data has many uses, and rural development proponents should do more to ensure that this data and information is being routinely collected. In addition, a sound understanding of the flow characteristics of a stream is essential for planning engineering solutions--such as irrigation, hydropower, or potable water supply--in streambank protection and restoration.

Exploring likely downstream impacts. Every effort should be made to understand the likely consequences of streambank protection and restoration on the river or stream course below the treated area.

Recognizing the long-term nature of problems. Even in stable watersheds there is an ongoing hydrological process that may naturally contribute to siltation and sedimentation in a river course. In all probability this cannot be avoided, so, accordingly, one of the most important elements of streambank protection and restoration is a capacity and commitment to regular monitoring of the condition of structures near the course. In degraded watersheds that have been rehabilitated, flooding problems may continue for some time due to the debris and sediment that will continue to wash downstream, perhaps filling the stream bed and diverting water unpredictably.

A well-engineered protection or restoration intervention can stabilize a streambank and provide years of good service.

Environmental Mitigation and Monitoring Issues

A well-engineered protection or restoration intervention can stabilize a streambank and provide years of good service. But its durability should not be taken for granted. A number of important points on the sustainability of these works bear attention, including:

Assigning monitoring and maintenance responsibilities. Identifying someone responsible for monitoring and regular maintenance is a critical part of the implementation effort. Water has an insidious way of working slowly and silently to undermine human-made structures exposed to stream currents, often compromising the structures before it is observed. Early and simple actions, such as refilling an undercut bank with rocks or clearing a temporary dam formed by rubbish can save a structure and avoid costly repairs or replacement.

Building knowledge of stream flow and behavior. An understanding the relationships between weather and stream flow is important because good hydrological data may be absent. Monitoring the stream gauge and local meteorological stations is essential for building a model of stream behavior during rainfall events and predicting dangerous conditions. Using remote sensing techniques and a geographic information system to map the size and land-use dynamics of the watershed can enhance these tools. Changes in land-use patterns will affect stream behavior over time.

Ensuring sustainability. The real key to protecting and restoring stream banks is to reduce the torrential nature of the watercourse. This can best be achieved by ensuring that watershed management plans are being implemented in the upper catchment to bring greater stability to the hydrological regime and smooth out the peaks and lows of stream flow.

Monitoring downstream sites. The most critical concern with efforts to protect and restore stream banks or similar river-training activities is ensuring that damage is not being displaced downstream. Channeling the watercourse may inadvertently shift the force of the water to downstream areas also susceptible to streambank failure and flooding--an unacceptable adverse environmental impact.

References

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This is just one of the series within the FAO Conservation Guide Series with practical and engineering information on gully control.

U.S Army Corps of Engineers.

One of the best sources of information on streambank protection and restoration is the U.S. Army Corps of Engineers, whose Web site offers in-depth technical information. Online: www.hnd.usace.army.mil/techinfo.

C. Small-Scale Drainage and Irrigation Systems

Brief Description of the Sector

Small-scale irrigation has been one of the most important activities undertaken in much of Latin America and the Caribbean to counter the effects of chronic food security problems among rural communities.

Although USAID regulations do not specify the size of small-scale irrigation systems, for the purposes of these guidelines, they are considered schemes that water less than 100 hectares of cropland. The most common type of small-scale irrigation found in Latin America are gravity-driven sprinkler systems common in the highlands and used for producing horticultural crops. This type of system captures water from a spring or diverts it from a river or stream high in the catchment, sometimes storing it in a tank, and carries it by means of PVC pipes for dispersion over a small plot of land, for supplemental irrigation or dry season use.

There are several other types of irrigation systems:

- Diversion or offtake systems use the flow of a natural river or stream, diverting it into a canal system, with or without a control structure at the head of the system, and possibly a storage tank. Occasionally, a structure is constructed in the watercourse to enhance the amount of water that may be diverted. Primary canals, sometimes lined, can transport water long distances from high in the catchment areas to flatter croplands below.
- Similar, but less sophisticated, are spate systems, which make use of occasional flood level flows in a watercourse. They are typical in arid areas with intermittent streams that only flood during high rainfall. This type of system is less permanent than a true diversion system as it is dependent on opportunistic capture of flood waters.
- Storage systems are another simple form of small-scale irrigation, capturing water from a stream and storing it behind a dam for use during the dry season. Outlets in the dam channel water into canals leading to irrigated perimeters downstream, typically in the same valley.
- Lift systems involve the use of pumps, either manual or mechanical, to raise water out of a river course or well in combination with a surface irrigation channel. They can be used to feed surface irrigation systems or even sprinkler systems when combined with a storage tank to which the water is pumped.

Potential Environmental Impacts

Agricultural intensification under irrigated conditions, even at a small scale, presents significant challenges for sound environmental design because of a propensity for an array of negative environmental impacts, including:

Disruptions to the hydrological cycle. Irrigation affects all parts of the cycle, causing impacts on flow downstream, affecting other users, wetland, or watercourse habitat; inadvertent drawdown of the water table; and run-off or drainage from irrigated perimeters contaminating watercourses.

Altered wetlands. Demand for water can eliminate the water source that feeds wetlands, causing them to dry up and change their ecology significantly. Similarly, wetlands might actually be drained and used as sites for irrigated perimeters. There is also the potential for contamination of wetland ecosystems from run-off or drainage from irrigated fields carrying agricultural chemicals. All have a negative impact on some of the highly insular species that use wetland habitats and on migratory bird species.

Inefficient use of scarce water resources. Poor site choice (sloping lands within the perimeter leading to run-off) can create canal systems that leak, evaporation behind storage dams, and poor water management by farmers within the scheme--all of which become particularly acute under arid to semi-arid conditions.

Soil quality impacts. Irrigation can cause salinization of irrigated plots, waterlogging on site and in areas adjacent to irrigated perimeters, agrochemical contamination, and soil fertility depletion.

Environmental health threats. Even small-scale systems can create conditions that nurture vector borne diseases (malaria), water contact diseases (schistosomiasis), and water borne diseases (diarrhea, typhoid, guinea worm).

Social issues of equity and environmental justice. Planned projects to ensure the equitable distribution of developmental benefits and assurances that the environmental impacts are not borne disproportionately by the least powerful members of the community.

[1] Catterson, Steward, and Sandoval 1999.

Sector Design--Some Specific Guidance

Under USAID s Regulation 216, irrigation, no matter what scale, is considered to falls within the class of actions normally having a significant effect on the environment [216.2(d)] and therefore requiring a formal environmental assessment. A programmatic environmental assessment (PEA) carried out on activities in Guatemala and Ethiopia resulted in the development of a Checklist for Planning Environmentally Sound Small-Scale Irrigation. Because the irrigation program in Guatemala and Ethiopia covers a wide range of the different development scenarios, this checklist could be successfully applied in other countries of Latin America and the Caribbean with similar results.

Environmental Planning Checklist for Small-Scale Irrigation[1]

1 Small-Scale Irrigation Site Identification and Characteristics

- Date project planning began:__________
- Expected completion date:____________
- Present status:___________________________________
- Site/community name:____
- Location (region, department, village):_____________________________________
- Approximate altitude of scheme:__________________
- Agro-ecological zone: _________________________
- Cooperating sponsor____
- Brief project history (proposed by, how identified, by whom):_____________________

____

____

- Community concurrence:_____________ How reached:________________________
- Water user association established:__________________; How established:________

____Date:________

- Number of beneficiary participants in WUA:______________ Number of males:________
- Number of females:______________
- Percentage of total community to be included in scheme:_____________________________
- Area to be Irrigated:_________________(hectares)

Type of irrigation (spring, diversion, storage, spate, or lift):___________________________

- Average size of household irrigated plot:_____________ (hectares)
- Previous use of irrigated area:____
- Is this (Check all that apply): New scheme:________, Rehabilitation of traditional scheme:________, Upgrading of traditional scheme: ________, Rehabilitation of modern scheme: ________
- Proposed Crops Wet season:________________________; Dry season:________________________
- Average household holdings outside the scheme:_______________________________
- Other major infrastructure or investments linked to SSI (roads, potable water, watershed management):____
- Total cost of the scheme: ___________; Broken down by cash costs:______________
- Food aid cost equivalents:__________; Community contribution in labor and in kind:______________ (Estimate the costs in either US$ or local currency. Include all necessary investments required for the scheme to operate. Food aid costs should be calculated by multiplying the number of person/days of labor by the equivalent value of the day s ration. Community contribution should be accounted for, including contributed free labor if any and the estimated value of the materials provided stone, sand, soil, etc.)
- What is the expected unit cost per hectare of irrigable land within the command area during the dry season:____________ US$/hectare.
- What percentage of the annual operating budget, for the WUA or village:_________, for the local area:__________, for the program of the cooperating sponsor:______________________
- Include sketch map (to scale at 1:10,000 or larger).

2 Analyzing the Basic Parameters

Water Resource Availability

- How much water (lts/sec) is available for irrigation purposes?
- Is there an historical record of river/stream hydrology (yes/no) and how is it compiled?
- If not, how was amount calculated? Briefly describe method; an additional sheet showing calculations should be added.
- Are there upstream users of the water, or could there be? Explain.
- Are there downstream users and how do they use water?
- Are they actively pursuing irrigation; using water for potable water supply or for animal consumption? Estimate their requirements (lts/sec).
- How were downstream users consulted?
- What percentage of streamflow will be abstracted during lean period?

Other Uses and End Users

- Has the potential usage by people or animals been factored into the calculations of water use within the scheme, and if so, how so?
- Will the scheme attract additional herders and their animals in search of water, including from beyond the present community?
- Is there a need for maintaining minimum ecological flow during lean season? If not, why not?
- What precautions are being undertaken to guard against unnecessary leakage/evaporation within the scheme? Describe the methods by which extension agents and users will measure and learn about annual, seasonal, and periodic water availability.

Catchment Status

- What is the estimated size of the catchment that supplies water to this scheme in hectares?
- What is the present land-uses of the catchment? A sketch map may help to illustrate this point.
- What is the condition of the catchment (good or natural, slightly degraded, moderately degraded, highly degraded, being rehabilitated)?
- Do the present activities include rehabilitating/improving the catchment? If so what will they entail?
- What percentage of the catchment will be treated each year, and by whom?

3 Estimating Crop Water Requirements

- What crops will be planted and which season?
- Crop water requirements per hectare? An additional sheet describing likely crops and their water requirements in different seasons could be added.
- What source of information for the crop water requirements? Describe.
- Which publications are the basis for this estimate of crop water requirements, or how else were these amounts determined?
- What will be the likely percentage mix of main crops during the wet season and the dry season?
- How will the size of the command area change from wet season to dry season?
- Are there expectations/intentions about building up the command area during the break-in stage of implementation? Explain.
- Are these crops that are familiar to the users?
- In years of poorest rainfall, estimate what will be the area of irrigable land; and how will the cropping pattern change during the dry season? Explain.
- What are the expectations for production increases (percent)? in a good rainfall year and in a poor rainfall year? in a worst case scenario explain? Explain and give examples of the expectations for increases in yield, by crop.

4 Farm/Scheme Land and Water Management and Conservation

- Do the proposed users have experience with SSI?
- Will there have to be land redistribution (regularly, annually, periodically)?
- What sort of water management technology will be used within the irrigated plots?
- Will the users be able to maintain the fertility of their irrigated plots? How will they do so?
- What is the average slope of land within the command area?
- Will soil conservation measures within the scheme be required? If so, briefly describe.
- Are there indications of salinity problems in nearby similar SSI schemes?
- What did the measurements of water quality reveal (gms./lt)? Those of soil salinity (salinity class)?
- Is salinity likely to become a problem in this scheme? If so, what measures will be taken to manage the problem? Describe.

5 Post Construction Follow-Up and Technical Assistance

- Will the farmers have to depend on support from extension agents or the Ministry of Agriculture for extension services? Are they available?
- Have the extension agents been specifically trained in irrigated agriculture? Have they received training specific to this site and its operations?
- Do the extension agents need transport to reach the site and do they have it?
- Is there an operations manual to guide extension services?
- What other services will be provided by the extension agents?
- Briefly describe the training provided and planned for the Water Users Association officers and users.
- Is there a water user fee system? What are its principles? Briefly describe.
- Briefly describe the operations and maintenance requirements of the scheme and who will be charged with their implementation.
- What level of technical assistance from the cooperating sponsors will be required by the Water Users Association during the start-up phase of the irrigation activities? Have resources (staffing and budgetary) been set aside for this purpose?

6 Water-Related Disease Hazards

- Has an environmental health assessment been part of the planning for this scheme? If so, briefly discuss its results.
- Because of the importance of this particular theme, particularly at lower altitudes, the cooperating sponsor could provide a citation of the study findings as a supplement to their response to this section of the checklist.
- Is there a health baseline data set available for the community and what are its most important quantitative findings. Provide a list.
- Briefly discuss expectations regarding community vulnerability.
- Briefly discuss expectations regarding environmental receptivity.
- Briefly explain the status of health services in the community. Are there plans for upgrading these services? Describe these plans.
- What percentage of the community has access to potable water, and where do they normally obtain it (in wet season and in the dry season)?
- Does the program of the cooperating sponsor in this community include a potable water supply component? Briefly describe.
- Is there a community specific nutritional baseline available?
- What are the household level nutritional goals of the scheme? How will these goals explicitly be achieved? Describe.
- What measures will be taken for provision of potable water for the work force during construction and for training the work force on water-related disease hazards? Describe.

7 Displacement and Land-Use Changes

- Will there be displacement of farm plots as a result of scheme construction? If so, briefly describe (number of households affected, area of land affected).
- Will the command area change as a result of rehabilitation or upgrading? If so, briefly describe.
- What measures are planned to account for these changes?
- What percentage of the command area is likely to be devoted to cash crops? Which crops?
- Where and how will these cash crops be marketed, and by whom?
- What are the expectations for prices for these cash crops, transport and marketing costs, and returns to the farmers? Describe with as much quantitative data as possible.

8 Monitoring Plans

- What indicators will be monitored to ensure that the activities are not leading to unforeseen adverse environmental impacts?
- Which of the planned mitigative measures (see below) will require further specific monitoring to be sure they are effective? How will this be done?
- How will environmental monitoring be linked to performance monitoring to avoid needless duplication of efforts and meeting reporting requirements?

9 Mitigative Measures Planning

- Identify specific adverse environmental impacts foreseen during planning, and describe the mitigative measures for each.
- How have the costs of these measures been factored into the feasibility considerations for the scheme in question?
- Will there be resources available for post-construction mitigation measures? Who will provide for them?

Environmental Mitigation and Monitoring Issues

Table 8.3 Monitoring and Mitigation Issues for Small-Scale Irrigation Activities

Issue or Aspect of the Activity	Impact *The activity may cause ...*	Cause	Mitigation
Disruptions to the hydrological cycle	• Downstream shortages of water supplies to other communities • Drying up of intermittent streams • Community conflicts • Puddling along water courses and increased stagnant water	• Over-abstraction of water from surface water supplies • Poor understanding of stream flows and available water supply	• Carry out careful analysis of available surface water supplies using recognized formula • Ensure irrigation perimeter design compatible with water supply • Enhance national system of stream gauging and companion meteorological stations in the program areas • Improve understanding of stream and wetland ecology to be better able to gauge impacts • Promote a national wetlands conservation strategy
Inefficient use of scarce water resources	• Excessive system leakage • Soil salinization and water-logging • Tail-enders highly irregular water supply in irrigation system	• Poor understanding of stream flows and available water supply	• Institute a volume-based water-use fee system • Improve calibration and functioning of water management devices • Improve training of extension agents and farmers • Enhance national system of stream gauging and companion meteorological stations in the program areas
Soil quality impacts	• Observable salt deposits or water-logged areas within irrigated areas • Reductions in crop productivity	• Over-use of irrigation water • Poor system drainage • Lack of farmer understanding of irrigation regimes • Poor technical advice from extension staff	• Define crop water requirements • Ensure water-user association has viable irrigation schedule • Improve training of extension agents and farmers • Change irrigation system technology
Environment al health threats	• Community health surveys and records • Visual evidence of vectors (larvae or snails) • Blocked or silted canals	• Inappropriate design causing low flows or stagnant water • Inadequate system maintenance and cleaning • Shared use of irrigation water for drinking and washing	• Improved health facilities near irrigation systems • Local health awareness training programs, particularly for women community members • National spraying and immunization programs to control vectors

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Birley, M.J. 1989. *Guidelines for Forecasting the Vector-Borne Disease Implications of Water Resources Development.* Joint WHO/FAO/UNEP Panel of Experts on Environmental Management for Vector Control. VBC/89-6.

The premier source of information on the dangers of water and vector-borne diseases associated with the establishment of water resources development operations.

Catterson, T.M., S.O. Steward, and J. Sandoval. 1999. *Programmatic Environmental Assessment of Small-Scale Irrigation in Guatemala.* Catholic Relief Services and USAID/Ethiopia, Baltimore.

A recent environmental review of small-scale irrigation, oriented to horticulture-based farming typical of Central America scrutinized using USAID s Environmental Regulations (22 CFR 216). (Digital copy included.)

Dougherty, T.C., and A.W. Hall. 1995. *Environmental Impact Assessment of Irrigation and Drainage Projects.* Food and Agriculture Organization of the United Nations, Irrigation and Drainage Paper No. 53, Rome.

A technical manual for those interested in a wide variety of water resources development activities and their potential adverse environmental impacts.

General Resources

Agua Latina.

An online technical water magazine for Latin America, Agua Latina is published monthly with news and technical reports on topics including water supply and treatment, wastewater, contamination, storage, irrigation and hydroelectricity. Online: www.agua-latina.com.

International Water Management Institute (IWMI).

IWMI, one of the centers affiliated with the Consultative Group on International Agricultural Research, is a key resource for anyone concerned with irrigation. Online: www.cgiar.org/iwmi

D. Pesticides and Integrated Pest Management

Brief Description of the Sector Activity

Crops, forests, and domestic animals everywhere are subject to damage or destruction by pests--viruses, bacteria, fungi, plants, insects, mites, nematodes, birds, and other organisms. Field and post-harvest losses due to pests range from one-quarter to half of the crops worldwide, probably higher in the developing world. Crop losses due to pest outbreaks regularly devastate subsistence farmers and communities. Pests responsible for animal diseases may also infect humans, which inflict pain and suffering and diminish people s ability to work (UNEP 1992).

Field and post-harvest losses due to pests range from one-quarter to half of the crops worldwide, probably higher in the developing world.

Synthetic pesticides (herbicides, fungicides, insecticides, rodenticides, and other synthetic chemical controls) have been the dominant means of controlling pests in the industrialized world for more than 50 years. Since the Green Revolution of the 1960s, they have also been heavily used in the developing world. Three factors combine to promote increasing use of synthetic pesticides:

- Expanding populations fuel larger-scale, more intensive crop, forestry, and livestock production. Such conditions create ideal breeding grounds for pest outbreaks and require increased use of pest controls.
- Export markets increasingly demand aesthetic requirements for visually perfect food.
- The use of high-yield breeds are often essential to feeding growing populations or achieving cost competitiveness on international markets. But these varieties are often more susceptible to pests than traditional ones.

Potential Environmental Impacts

Chapter 22 of the Code of Federal Regulations, Section 216 (Reg. 216) provides specific guidance for projects that include the procurement and use of pesticides. Section 216.3 (10) (b) of Regulation 216 defines pesticide procedures for pesticides registered by the USEPA with and without restrictions. The reader is referred to Annex B: Regulation 216 in this manual for further guidance in preparing initial environmental examinations and subsequent environmental assessments or environmental impact statements.

Synthetic pesticides are potent chemicals ... [with] acute and chronic effects [that] vary from pesticide to pesticide in type and degree.

Intrinsic dangers. Synthetic pesticides are potent chemicals. Many pesticides, especially those that are used heavily in the developing world, are very hazardous to human health and the environment (National Research Council 1984). Their effects are often not specific to the pest on which they are used. They have broad and often unexpected effects on many living creatures--from beneficial insects and birds that act as natural pest controls to human beings--throughout their entire lifecycle--from manufacture, transport, and storage to application, consumption of residues in food, and disposal of outdated stocks. Acute and chronic exposure to pesticides can be extremely harmful.[2] Those at greatest risk are those who experience the greatest exposures--farmers, farm workers, and their families. These people are also often the poorest members of society. Acute and chronic effects vary from pesticide to pesticide in type and degree. Acute affects from pesticides include death, vomiting, severe headache, and skin damage. Chronic exposure can result in cancers, mutations in unborn children, immune system suppression, reduced fertility, and permanent damage to eyes, lungs, liver, and other organs. Among the synthetic pesticides currently in use are compounds known to have these affects.

In some cases, serious broad or unexpected effects came to light many years after a pesticide s introduction.

In some cases, serious broad or unexpected effects came to light many years after a pesticide s introduction. DDT is perhaps the most famous case. Found to accumulate in the food chain, DDT had unexpected reproductive and toxic effects. In such cases, the pesticide in question is typically banned in industrialized nations, but many continue to be sold, legally or illegally, in developing nations (National Research Council 1984).

Poor quality control. Almost a third of pesticides being sold in developing countries are of poor quality, containing dangerous impurities or excessively high concentrations of active ingredients (FAO/WHO 2001).

Poor use practices. Impacts from synthetic pesticides in the developing world are compounded by the manner in which they are used. Synthetic pesticides are intended to be used by trained people to combat identified pest problems with a material specified for use against that pest. The applicator uses special machinery, equipment, and clothing to protect him or herself and follows careful guidelines on quantity, frequency, and timing of application relative to harvest. In general, few of these controls are applied in the developing world.

A cycle of pest resistance and increased use. Use of synthetic pesticides selects for resistant members of the target organism, creating a cycle where more, and often more expensive, pesticides are needed to control the pest.

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2 Acute exposures are large doses of pesticide that are inhaled, ingested, or absorbed through the skin all at once. Chronic exposures are smaller amounts taken into the body over a long period of time.

Sector Program Design--Some Specific Guidance

Integrated pest management (IPM) is being promoted through out the world as an alternative approach to pest management. Core elements of all IPM approaches are minimizing pesticide use and minimizing health and environmental risk when pesticides are used.

Integrated pest management (IPM) is being promoted through out the world as an alternative approach to pest management.

There are many definitions of IPM. The World Bank s is concise and clear:

> IPM is a knowledge-intensive and farmer-based management approach that encourages natural control of pest populations by anticipating pest problems and preventing pests from reaching economically damaging levels. Appropriate techniques are used, such as enhancing natural enemies, planting pest-resistant crops, and adapting cultural management and, as a last resort, using pesticides judiciously (OECD 1999).

These guidelines seek to assist managers or project developers involved in technical assistance for small-scale farming. It is not intended as a technical guide to IPM, but rather to introduce key issues and program elements. It is closely based on the forthcoming *Beyond Compliance: Guidelines for Promoting Safe and Effective Pest Management in the Developing World* (Hruska 2000). This document, along with resources cited at the end of this guideline, should be consulted for more detailed information.

The Target Audience: Smallholders in Latin America and the Caribbean

All programs should be developed with a clear picture of the target audience and standard practices. Small holders in Latin America countries generally share the following characteristics:

- ***They use synthetic pesticides.*** Several studies in Latin America have found that 90 percent of farmers, raising a variety of crops, use synthetic pesticides. The reasons are simple: synthetic pesticides appear to be fast, cheap, and effective, are easy to obtain and use, and are culturally acceptable.
- ***They use dangerous pesticides, especially dangerous insecticides.*** Organophosphates and carbamates, two families of broad-spectrum pesticides, are among the pesticides small holders most frequently mention using. Organophosphates and carbamates can both cause acute and chronic neurological damage. The World Health Organization has classified some of these insecticides, such as methamidophos and methyl

parathion, as extremely or highly hazardous (Class I). Banned synthetic pesticides, such as DDT, and pesticides of poor quality are frequently sold in developing countries. Farmers tend to use more dangerous pesticides because they are generally cheaper, more potent, and work well against a broader spectrum of pests.

- ***They use synthetic pesticides in dangerous ways.*** Small holders do not and are unlikely to follow safe-handling practices, including, for example, using protective equipment and clothing, even when these practices are taught to them. In developing countries the economic and educational conditions make safe use at best a waste of time and at worst a dangerous myth (Hruska and Gladstone 2000). Pesticides also tend to be applied in excessive quantities.

Concern about the adverse health impacts of pesticide use on family and community and perhaps the local environment can create strong interest in adopting IPM.

- ***They know very little about the biology and ecology of many, mostly microscopic, pests, but may know a lot about larger animal pests.*** Pests that cannot be seen, such as viruses and bacteria, or insects that live in hidden habitats are generally unrecognized and not understood. This lack of knowledge can lead to pesticide misuse. Nearly a third of bean farmers in Honduras apply fungicides to combat golden mosaic virus (Hruska and Gladstone 2000). These farmers generally did not know about lifecycle metamorphoses--larva to juvenile to mature insect--and believed that mature pests are spontaneously generated from water or mud.

Conditions for IPM Adoption

For IPM to be adopted by small holders in Latin America and the Caribbean it must be effectively marketed. Not only must IPM actually be superior to current smallholder practice, the target audience must be convinced that this is so. The name integrated pest management is somewhat of a handicap, suggesting that IPM is a complicated process. For the resource-poor farmer what matters most is that the type of IPM being promoted improves pest management--or is at least equally effective--and requires no more time, energy, or cost to implement than current practice.

Concern about the adverse health impacts of pesticide use on family and community--and perhaps the local environment--can create strong interest in adopting IPM. This is especially true if health and environmental impacts are communicated in a moving and graphic way. But if IPM is not perceived as being at least equivalent in effectiveness to current pesticide-based practice, adoption rates will be low.

Beyond health and environmental benefits the strongest selling points for IPM are:

- IPM is more effective then synthetic pesticides in the long run.
- IPM generally requires less capital investment.
- IPM can be used preventatively and eliminate or minimize the need for responsive controls (that is, applying pesticides after a pest outbreak occurs and much damage is already done.)

The learning-by-doing and learning-by-discovery approaches for IPM are exemplified in the Farmer Field School model developed in Asia.

Effective Activities to Promote IPM

Learning-by-doing discovery training programs. The adoption of new techniques occurs most readily when participants acquire knowledge and skills through personal experience, observation, analysis, experimentation, decision-making, and practice.

The learning-by-doing and learning-by-discovery approaches for IPM are exemplified in the Farmer Field School model developed in Asia. During the cropping season weekly sessions are conducted by a trained instructor or extensionist for 10-20 farmers. Because these training sessions take place in the farmers fields, they can (1) take advantage of their own knowledge and (2) understand how IPM applies to their own farms.

Some of these IPM training sessions analyze the agro-ecosystem, identifying and describing conditions such as soil, weather, crop stage, and the number of pests and their natural enemies, and illustrating with drawings as necessary. Extensionists apply a Socratic method, guiding farmers with questions to discover important insights, and supplying information only when absolutely necessary.

Farmers may also experiment with insect zoos where they can observe natural predators of pests in action and the impact of pesticides on both (Knausenberger 1996). Most knowledge and skills necessary for applying IPM (identifying pests, understanding pest biology, parasitism and predation, and alternate hosts, identifying plant disease symptoms, sampling population size,

[3] Based on a draft decision tree from Mario Pareja, which has been recommended for inclusion in Hruska and Gladstone (2000).

and preparing seed beds) are best learned and understood through practice and observation.

Recovery of collective memory. Often pest problems emerge because traditional agricultural methods have been changed, and these problems may be eliminated if that change can be reversed. This approach seeks to identify what changes might have prompted the current pest problem through group discussion.

Smallholder support and discussion groups. Weekly meetings of small holders held during the cropping season to discuss pest and related problems can be useful for sharing the success of various control methods. Maintaining attendance is difficult except when there is a clear financial incentive, such as credit.

Demonstration projects. Subsidized experiments and field trials at selected farms can be very effective at promoting IPM in the local community. These pilots demonstrate IPM in action and allow comparisons to be made with traditional, synthetic, pesticide-supported cultivation.

Educational material. In many countries, basic written and photographic guides to pest identification and crop-specific management techniques are unavailable or out of date. But this material is essential. Videos depicting moving interviews and graphic pictures of the effects of acute and chronic pesticide exposure can be particularly effective. A study in Nicaragua found videos to be the most important factor in motivating farmers to adopt IPM.

Youth education. Promoting and improving the quality of programs for rural youth at technical schools on IPM and the risks of synthetic pesticides has been effective. In addition to being future farmers, these students can bring informed views back to their communities.

Organic food market incentive. Promoting organic certification for access to the lucrative and rapidly growing organic food market can be a strong incentive to adopt IPM.

Land tenure. The more secure people s sense of ownership of the land they cultivate, the more carefully they steward it.

Credit. Some credit programs specify the use of synthetic pesticides. Credit that permits, encourages, or requires framers to employ other methods, such as microbial controls, can facilitate adoption of IPM.

Partnering Successfully with Other Organizations on IPM

Many IPM projects are partnerships between two or more organizations--donors, governments, PVOs, and NGOs. If these partnerships are not forged with care, the entire project may be handicapped.

Confirm partner s commitment. Often, organizations make commitments they are do not intend to (or are unable to) fulfill completely. Good litmus tests of a potential partners level of commitment include:

- ***IPM program integration.*** The IPM program is likely to be part of a larger sustainable agriculture project, so IPM must fit into a partner s overall approach. The extent of this integration should be clearly expressed in the proposed work plan.
- ***Cost Sharing.*** The availability of cash or other resources is a good measure of a potential partner s genuine level of commitment.
- ***Participation of key IPM personnel.*** Large organizations should have dedicated expert IPM staff who will be actively involved in the partnership.

Articulate partnership s vision of IPM. Organizations may forge partnerships based on a common commitment to IPM--only to discover too late that that their visions of IPM differ considerably. It is important that partners articulate a common, detailed vision of IPM, centered on the crops and conditions that will be encountered.

One Approach to the IPM Process[3]

There are many varieties of--and opinions about--IPM. Some all but exclude the use of synthetic pesticides, emphasizing the use of physical and biological controls. Others take a more pragmatic approach, seeking to minimize the use of synthetic pesticides in general and the most hazardous pesticides in particular, but not to the extent that unreasonably complex or expensive controls are imposed that undermine farmers confidence in IPM.

The following illustrates an IPM evaluation and implementation process that should be generally applicable. It includes measures for minimizing risk if synthetic pesticides are chosen as the method of control.

IPM Evaluation and Implementation Process

1 Evaluate impact of pests before deciding to control them

- Identify pest
- Determine pest biology
- Determine size of pest problem
- Evaluate current level of natural control, such as types and number of natural enemies
- Determine whether this is a primary or secondary pest

2 Evaluate management options (non-pesticide first)

Preventive

Plant selection

- Choose pest-resistant strains
- Diversify plant varieties, inter-crop
- Provide habitat for natural enemies

Site preparation and planting

- Choose pest-free planting dates
- Enhance or provide shade for shade-grown crops
- Assign crop-free periods or rotation
- Install buffer zones of non-crop plants or physical barriers

Plant tending

- Improve soil health
- Use an appropriate planting density
- Fertilize and irrigate appropriately
- Weed

Responsive (curative) interventions

Physical/mechanical control

- Remove or destroy diseased plant or plant parts
- Weed
- Install traps

Biochemical control

- Pheromones (very effective; not currently easily accessible or economical, but they may become so)
- Homemade bio-pesticides

3 Evaluating and using synthetic pesticides

The use of synthetic pesticides should be avoided. If there is no feasible alternative, take measures to reduce their risk. Risk is a function of both toxicity and exposure. Reducing risk means (1) selecting less toxic pesticides and (2) selecting pesticides that will lead to the least exposure before, during and after use. Taking the following steps will reduce risk to the extent possible:

Use least toxic chemicals to minimize pesticide toxicity

- Use registered pesticides
- Don t use pesticides in WHO classes Ia and Ib
- Don t use non-OCDE registered pesticides
- Don t use pesticides on Prior Informed Consent (PIC) and Persistent Organic Pollutants (POPs) Convention lists
- Follow WHO guidelines

Reduce exposure time or degree of exposure

Before use

Transport

- Separate pesticides from other materials being transported
- Avoid private distribution it s dangerous

Packaging

- Follow international and national norms and guidelines
- Use packaging adapted to needs
- Eliminate re-use of packaging materials

Storage

- Follow FAO norms
- Develop strict guidelines for village level storage

Labeling

- Follow and respect national norms
- Follow and respect FAO norms
- Use appropriate language and approved pictograms
- Use and respect appropriate toxicology color bands

Formulating:

- Use appropriate type and concentration

During use

Training

- Should be continuous
- Identify level and audiences (distributors, farmers, transporters, etc.)

Use application equipment

- Adapted to user needs and possibilities
- Assure maintenance and availability of parts and service

Use protective equipment and clothing

- Adapted to local climatic conditions
- Adapted to user needs and possibilities (budget)
- Should not reduce but avoid exposure

Focus on buffer zones

- Housing
- Environment: water, sensitive areas

After Use

- Know, enforce, respect exclusion periods after application
- Assure proper cleaning and rinsing of applicators clothing and equipment

Develop an adequate monitoring and evaluation system for

- Adherence to national and international policies on pest management and pesticides
- Human toxicology: applicators, public health (epidemiology), domestic animal health
- Efficacy on target pests
- Impact on environment: water, soils, air.
- Elimination of pesticide leftovers and containers

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General Resources

Community IPM.

This is an excellent source of information on the FAO Asia Farmers Field School methodology, with many interesting and valuable downloadable documents. Online: www.communityipm.org.

Consortium for International Crop Protection.

The Consortium offers a very good portal to a host of IPM resources, including searchable databases, Radcliffe s IPM World Textbook, periodicals (including back issues of *IPMnet News*), reviews of recent publications, and more. Very well organized. Online: www.ipmnet.org.

Cornell University-Biological Control: *A Guide on Natural Enemies in North America.*

An excellent guide to natural enemies. Limited geographically, but great photos and summary of biology and ecology. Online: www.nysaes.cornell.edu/ent/biocontrol.

EXTOXNET (Extension Toxicology Network).

EXTOXNET is an excellent source for searching for information by substance. Online: http://ace.ace.orst.edu/info/extoxnet .

Radcliffe s IPM World Textbook.

This great resource text is constantly updated and improved. The *IPM World Textbook* is excellent for students, teachers, and extensionists who want a concise presentation of thematic areas, or the state of the art in IPM by crop. Online: http://ipmworld.umn.edu.

UNEP (U.N. Environment Program) and WHO (World Health Organization).

The joint UNEP and WHO Web site offers wealth of authoritative information on many international programs and agreements, such PIC and POPs. Online: http://irptc.unep.ch.

USEPA (U.S. Environmental Protection Agency).

The EPA s pesticide site is a goldmine of information. Thousands of technical documents are available, including the new edition of *Status of Chemicals in Special Review*. Online: www.epa.gov/pesticides.

The *Pesticide Management Resource Guide* lists resources at the EPA and elsewhere available to help national pesticide authorities in the decision-making process. Online: www.epa.gov/oppfead1/pmreg/.

WHO (World Health Organization).

The most authoritative resource on human health effects of pesticides, the WHO offers a very good Web site that includes the International Programme on Chemical Safety. Not all documents are online yet, but the WHO Recommended Classification 1998-99 is one of the most cited sources of acute toxicity information. Online: www.who.int/pcs.