# Environmentally Sound Small Scale Agricultural Projects: Guidelines for Planning

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# ENVIRONMENTALLY SOUND SMALL SCALE AGRICULTURAL PROJECTS

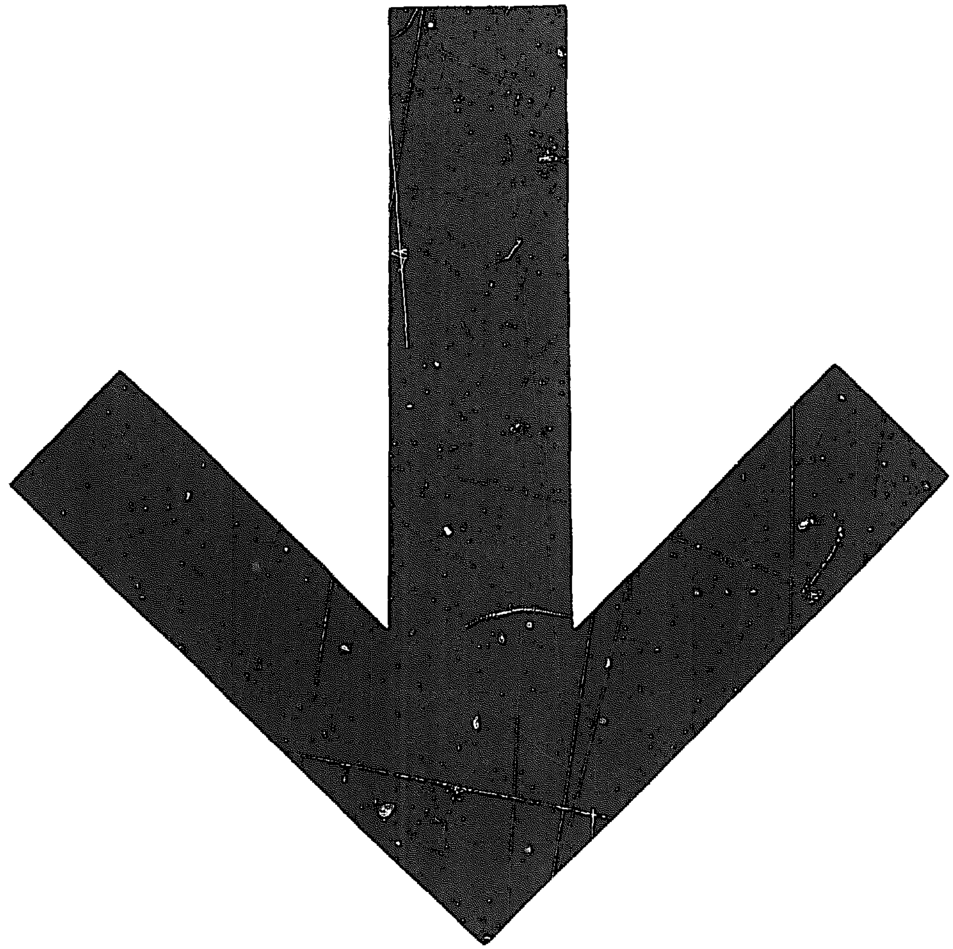
## GUIDELINES FOR PLANNING

Mohonk Trust
a VITA publication

# ENVIRONMENTALLY SOUND SMALL-SCALE AGRICULTURAL PROJECTS

## GUIDELINES FOR PLANNING

VOLUNTEERS IN TECHNICAL ASSISTANCE
THE MOHONK TRUST



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# PREFACE

This booklet is the result of a dialogue begun in October 1977 among 66 representatives of U.S. private voluntary development organizations operating in Third World countries and U.S. environmental organizations having global interests. The setting for the dialogue was the Environmental Concerns in Development Conference sponsored by the Mohonk Trust with partial funding from U.S. Agency for International Development and the participating organizations. (See Appendix I for list of organizations.)

Conference dialogue centered on the participants' approaches to development projects in Third World countries. As noted in the official conference report, "A need was acknowledged for close communication and understanding between development planners and environmentalists . . . the seeds of understanding and trust were established which deserve or rather demand continued attention if knowledge of environment and development in Third World countries is to be shared. The door has been opened for future interaction and mutual learning."

In this spirit, a recommendation was presented at the final conference plenary session by three participants--Peter Freeman, Anne LaBastille and Gus Tillman. Based on an idea from Anne LaBastille, they recommended drafting a set of environmental guidelines for use by development planners and field workers. This booklet is the outgrowth of a recommendation based on their suggestion. It presents environmental concerns as tools to be used for planning and implementing ecologically sustainable projects. It is the first of a series which will include manuals in the areas of agriculture, resources, livestock, human settlements, renewable resources, small-scale industry.

The Mohonk Trust gratefully acknowledges the contributions of all who worked to make this manual possible: Freeman, LaBastille and Tillman who not only developed the idea but took it from the drawing board to the point where it assumed form, shape and substance; Marilyn and Paul Chakroff who so well combined their expertise and outlooks to develop this final draft; Laurel Druben whose perception as an editor and development communications expert gave the book focus; Linda Jacobs who provided artwork for the text.

Mohonk especially appreciates the thoughtful responses from the many persons to whom the booklet was sent for technical review. Delmer Dooley, Oramel Green and Ping-sheng Chin commented on the material from the perspective of private voluntary development organizations. Peter Freeman, Frank Golley, Dale Jenkins, and Gus Tillman commented from an environmental perspective. In addition, the book was reviewed by numerous VITA staff and volunteers and AID personnel.

The Mohonk Trust offers special thanks to members of the planning committee of the 1977 Environmental Concerns in Development Conference who have worked so hard to oversee the evolution of the booklet from an idea to its present form:

Leon O. Marion, American Council of Voluntary Agencies for Foreign Service
Gus Tillman, The Cary Arboretum
Boyd Lowry, CODEL, Inc.
Beatrice Duggan and Jacob Scherr, Natural Resources Defense Council
Pat Scharlin-Rambach, Sierra Club Office of International Environmental Affairs
George Gerardi and Gary Kilmer, Technoserve, Inc.
Molly Kux and Stephen W. Bergen, U.S. Agency for International Development
Agnes Pall, YMCA

This booklet is published jointly by the Mohonk Trust and Volunteers in Technical Assistance. We welcome constructive reactions to this booklet; a questionnaire is enclosed for those who wish to use it.

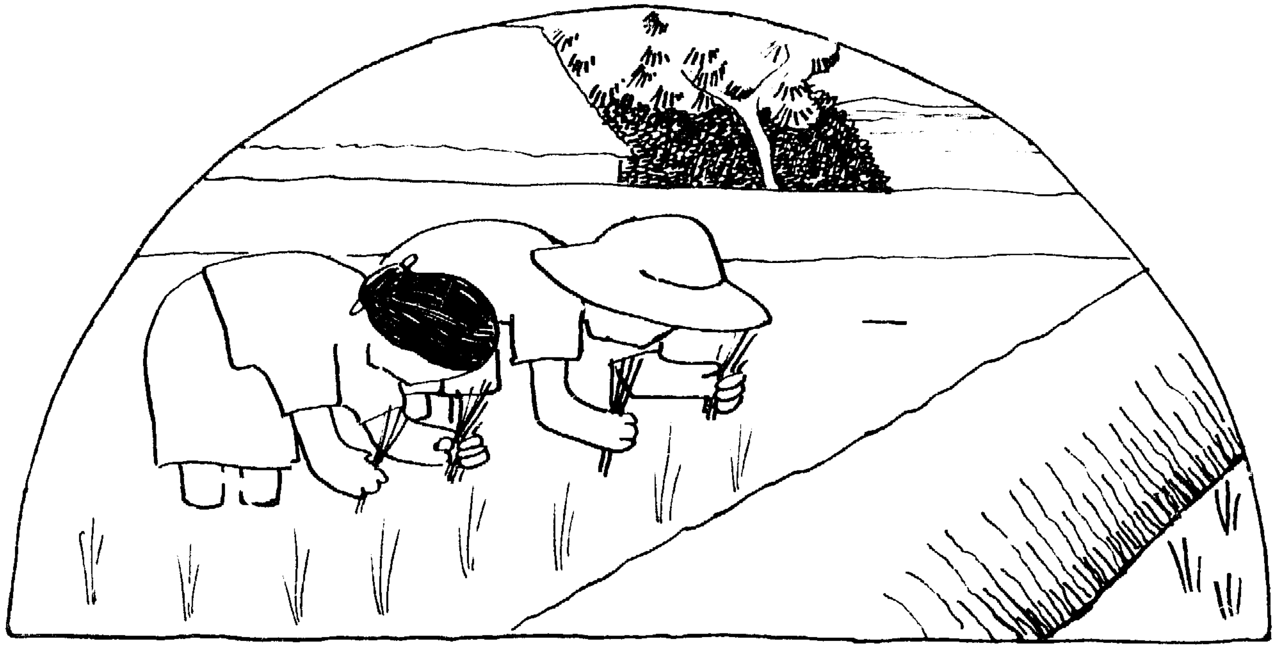
Carol Roever
Keith Smiley
Helen L. Vukasin
THE MOHONK TRUST

## ABOUT THE MOHONK TRUST

The Trust is a non-profit, charitable and educational organization founded in 1963. One of its purposes is to promote international understanding, world order and peace through conferences, seminars and the exchange of ideas in a setting of unique spirit and unusual beauty. The Environmental Concerns in Development Conference was sponsored by the International Concerns Committee of the Trust. Copies of the Conference Report are available upon request from the Mohonk Trust, Mohonk Lake, New Paltz, New York 12561, USA.

## ABOUT VITA

VITA is a private, not-for-profit organization which makes available to those working to assist low-income people in their own efforts a wide variety of information and technical resources and assistance. For example, VITA provides needs assessment and program development support, by-mail and on-site consulting services, training in information system design, product design assistance with a wide range of low-cost, small-scale technologies, and a variety of publishing and publications development services. For more information, and to order copies of this booklet, contact VITA, 3706 Rhode Island Avenue, Mt. Rainier, Maryland 20822, USA.



# I. USERS AND USES

## WHO SHOULD USE THIS MANUAL?

Anyone interested and involved in planning and/or implementing small-scale agricultural projects who wishes to:

- -- learn more about environmental considerations and their relationship to small-scale agricultural projects;
- -- approach agricultural projects, even though small, from an environmentally aware perspective;
- -- integrate environmental factors into planning activities.

## WHAT DOES THE MANUAL PROVIDE?

- -- Introduction to ecological concepts of which a development worker involved in agricultural projects should be aware.
- -- Introduction to planning for small-scale agricultural projects.
- -- Guidelines for using knowledge of environmental effects to determine positive (benefits) and negative (costs) factors in a given small-scale agricultural effort, as well as perspective on using these factors, once defined, to make well-informed decisions on alternative project designs.

-- Background information which can be used as the basis for planning environmentally sound projects in the areas of water supply and management, nutrient management, soil management, pest management.

## WHAT PURPOSES DOES THE MANUAL SERVE?

The overall purpose of this manual is to assist those who plan and implement small-scale agricultural projects. This manual helps by promoting awareness of environmental concerns and, more importantly, by supporting the development worker's ability to design projects which are both environmentally sound and potentially more successful because of that awareness.

More specifically, this manual has two purposes:

To promote well-planned and environmentally sound small-scale agricultural projects. Regardless of the size of the effort, sound planning requires more than finding the right technology and a source of funds: planning involves consideration of the social, cultural, economic and natural environments in which the project occurs.

To transfer environmental technology and techniques through awareness and training. Development workers are in a position to pass on awareness of environmental concerns to community groups, government planners, village residents, farmers and students. For example, a development worker may use this manual in class to increase students' awareness of erosion control methods and alternatives. Another development worker, as a project planner and/or implementor, may wish to use the book for on-the-job training of project workers or for technical training of farmers and local residents.

This manual can assist development workers to view projects as part of larger environmental systems. And it offers a perspective which can assist users to ask the right questions and to look for and find information about local resource availability and use, traditional methods, weather patterns, social and cultural traditions.

However, an entire range of small-scale agricultural project issues--land use patterns, inability of small landless farmers to take risks, lack of credit, lack of money, access to technical personnel and appropriate agricultural expertise--while beyond the scope of this manual are important and must also be considered along with issues mentioned here. Finally, this manual cannot address all of the environmental conditions found at individual project sites. However, the use of the general concepts and principles outlined here will enable development workers to recognize environmental issues and to consider them in the planning process.

## 2. INTRODUCTION TO AGRICULTURE AND ENVIRONMENT

A primary goal of agricultural projects is to provide food for growing populations. Emphasis is usually placed on increasing and improving production by developing new areas, new methods, improved equipment, and so on. Increased food production, however, is not the only benefit of agricultural projects: increased production requires more labor and thus increases employment; new varieties and types of nutritious crops can be grown to improve people's health; surplus crops can be stored to serve as security for times when crops fail; extra crops can be sold to provide income for other needs.

Agricultural projects may also have negative effects, such as altering social or cultural traditions or causing burdens in a segment of the population that is not benefitting from the project. Determining the possible positive and negative effects of a project is an important task faced by planners of small-scale agricultural activities. Planning environmentally sound agricultural projects requires understanding of important environmental concepts and awareness of the relationship between the environment and various types of agricultural activities.

### WHAT IS MEANT BY ECOLOGY AND ENVIRONMENT?

Many environmental concepts can be said to have their basis in the science of ecology, which may be defined as the study of living things, the places in which they live, and the interactions among and between the living and non-living components of the place being studied.

Ecology then includes aspects of the sciences of biology, physiology, geology, chemistry, and meteorology. Agricultural projects can change both the organisms of an area and their surroundings (or habitat); thus each project, no matter how small, has potential for causing change in the ecology of an area.

Environment on the other hand, is used to refer to the natural, social, cultural and economic surroundings of a project. Agricultural projects influence and are influenced by environmental factors. This book deals with that part of the project environment made up of physical, chemical and biological factors; social, cultural and economic factors also play a major role and should not be overlooked, but they will not be discussed in detail.

## How Are Agriculture And Environment Related?

Each agricultural project takes place within a complex system of social attitudes, cultural patterns, economic structures, and physical, chemical, and biological factors. This total system is the environment in which a project occurs, and every agricultural project, no matter its size or scope, affects and is affected by these factors, i.e., by its environment.

All agricultural projects, whether they involve irrigation, pest control, fertilization, or the introduction of new varieties of crops and cropping methods, have positive and negative effects upon the environment.

Some of the interactions between parts of the total environment are easy to forecast; for example, it is clear that the amount of rainfall, the money available for the project, and the acceptability of the project by local people are factors that can affect the success of an agricultural project. Other factors, however, such as the effect of using certain pesticides over a long period of time are much harder to predict.

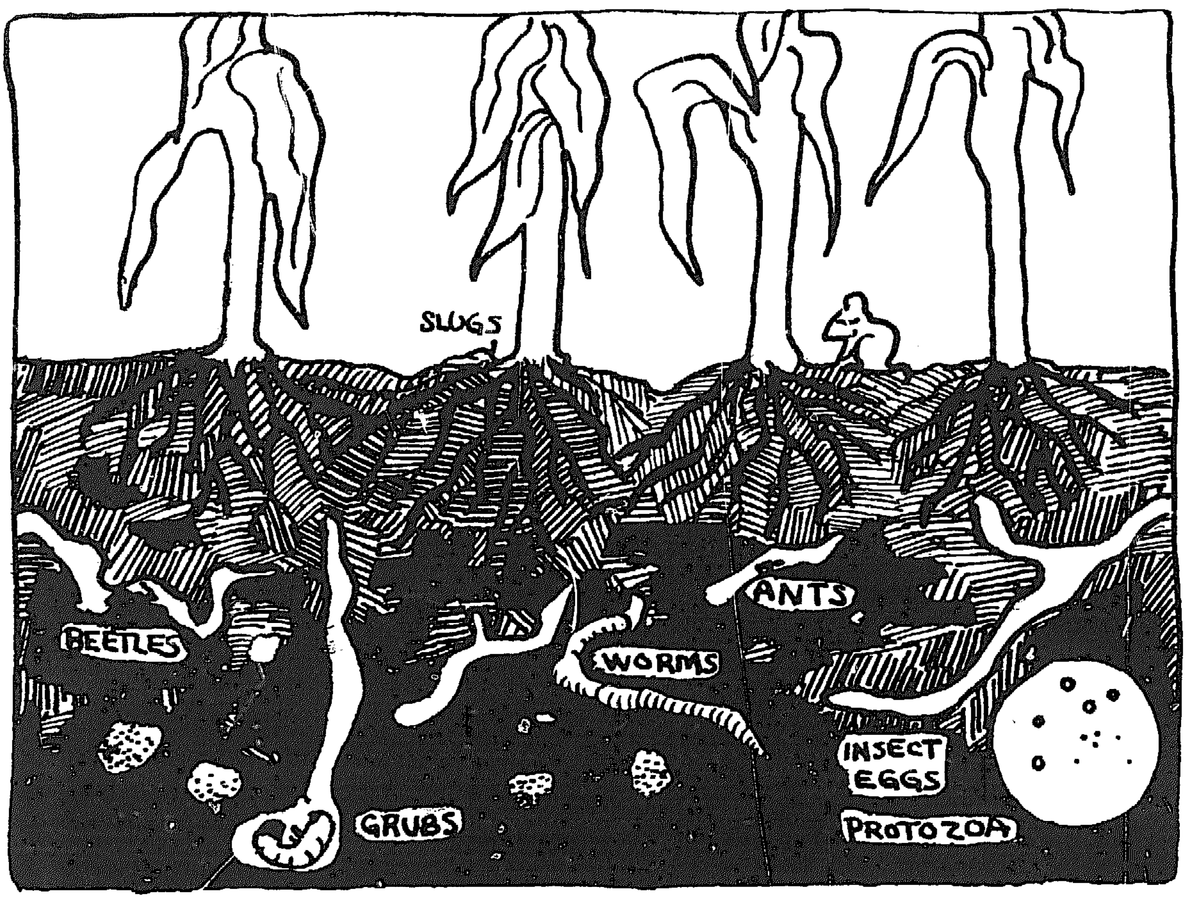
In the agricultural setting, therefore, environment includes the people of the region, the animals, the plants, soil, water, nutrients, the weather, ways of planting and cultivating, and so on. Those planning and implementing small-scale projects must consider all of these influences. Those who can see beyond the technical design of projects to view the interactions among environmental factors have developed an important ability because this familiarity can be used to help determine project feasibility.

## Why Are Ecological Concepts Important For Agricultural Development?

Agricultural development implies change for the better--a change from the present system or part of that system to a "better" or at least more productive one. Therefore, in order for development to occur as a result of an agricultural project, the alterations or changes made as a result of the project must have more positive effects than negative. Because they are guidelines, or principles, ecological concepts can provide a basis for judging how the natural environment is affected and will be affected by agricultural projects. Knowledge of ecological concepts and systems can be used to determine whether the effects of a given project are likely to be positive or negative. Concepts discussed here are Ecosystems, Stability in Diversity, Succession, and Limiting Factors.

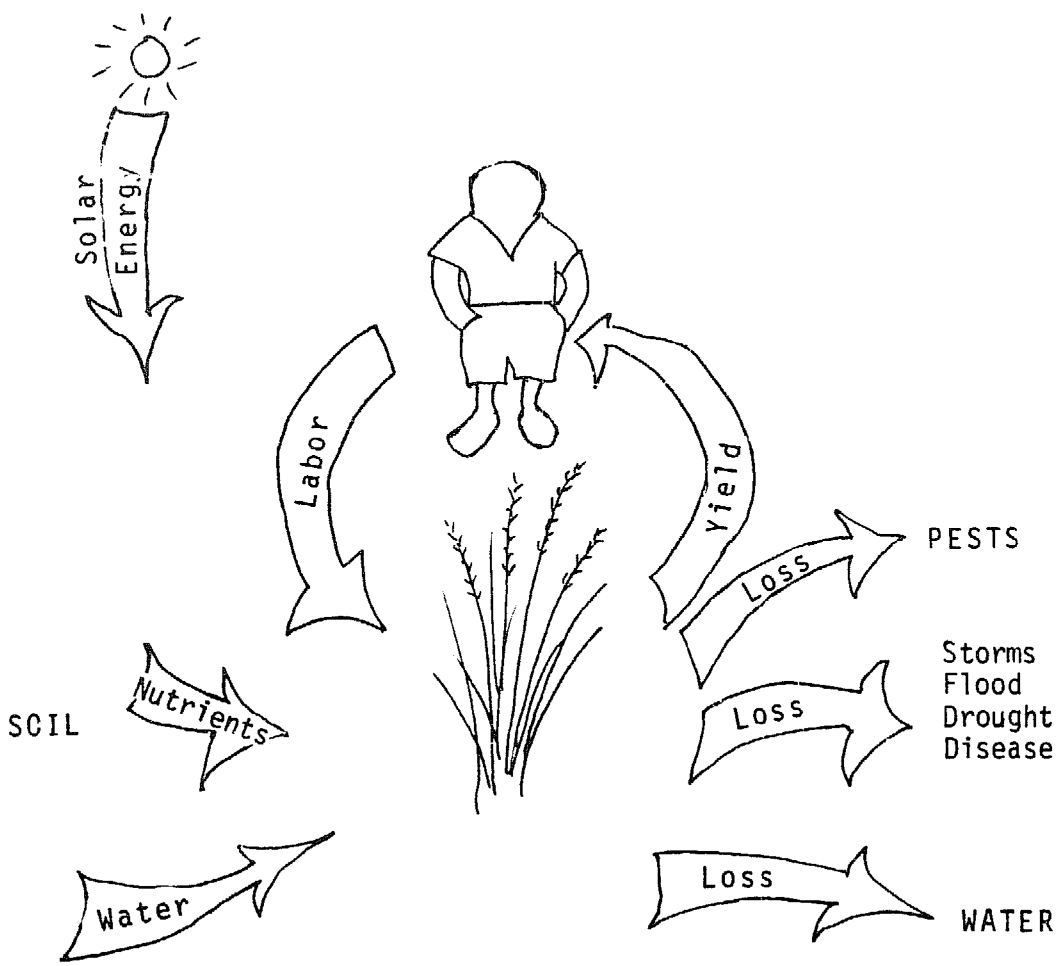
## What Are Ecosystems?

A planner viewing a potential project site for the first time is looking at an ecological system, or ecosystem, on the site--the complex of organisms interacting among themselves and with the non-living environment in processes such as competition, predation, decomposition, feeding and so on. When an agricultural project "interferes" with the existing system by adding fertilizers or eradicating pests, the balance is changed.




AN AGRICULTURAL ECOSYSTEM

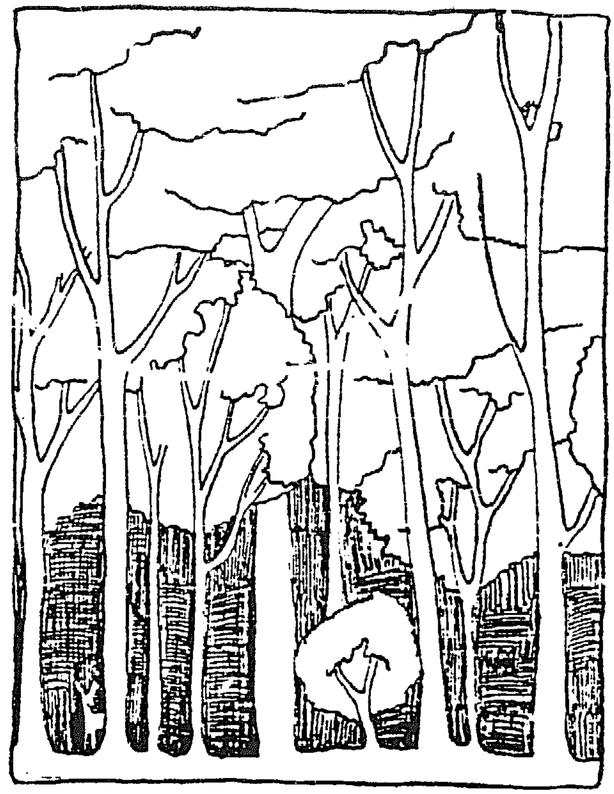
Whether an area consists of farmland that has grown rice for many years or is a virgin forest, there is a system functioning there. If there have been no major changes in the area in the recent past, the system is probably in a balance. Any decision made to change this system, for example, to replace the rice with a new crop or to cut down the forest for agriculture, should be made with an awareness of the characteristics of the existing ecosystem and of the effects such a decision would have.

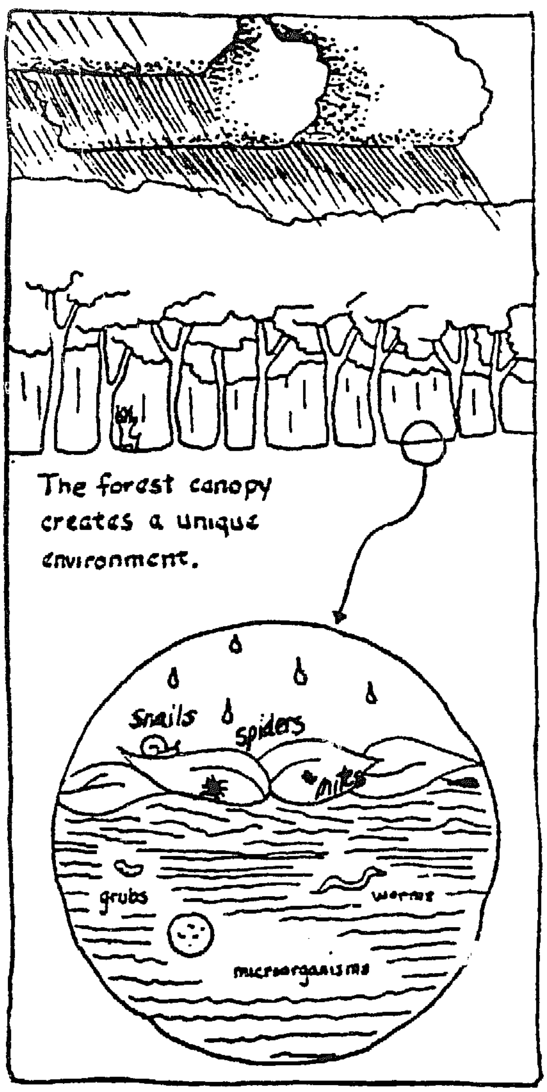



A BALANCED AGRICULTURAL ECOSYSTEM

On the farmland, the growth of rice is balanced with the availability of water, nutrients, soil, the sun's energy and energy supplied by man in the form of labor. The yield of the land is balanced with the weather and the control of local pest species by various means. The population of humans that is sustained by a rice crop is balanced with the yield of the rice that has been planted and cared for.

In forest ecosystems there are also dynamic relationships among the components. Trees protect forest soils from wind by serving as windbreaks, from water by intercepting hard rainfall so that it can be absorbed more slowly by the soil, and from the extreme heat of the sun by providing shade and cooler temperatures underneath the tree canopy. This protection of the soil allows dead organic matter to decompose, releasing important nutrients used for growth by the forest plants. The plants






are producers, able to convert nutrients and sunlight into plant tissues, or food. Soil micro-organisms decompose organic matter, while other soil organisms, such as worms and grubs, help to turn over and aerate the soil. Organic matter on top of the soil also retains moisture which prevents soil from drying out, provides water for plant growth, and adds porosity to the soil by enabling water to percolate (move down) into deeper soil layers. Plant roots also break up the soil, thus enhancing water penetration.

Humans, as one element in the ecosystem, interact with other organisms in the system. One of these interactions is the development of agricultural projects. When a development worker makes the decision to increase yield from the farm by substituting another crop for rice or cutting down all or part of the forest, he or she is deciding how to interact with the ecosystem.

## WHAT HAPPENS WHEN NATURAL SYSTEMS ARE ALTERED?

A look at the forest ecosystem will show what can happen when the protection of the trees is taken away and not replaced by other cover:

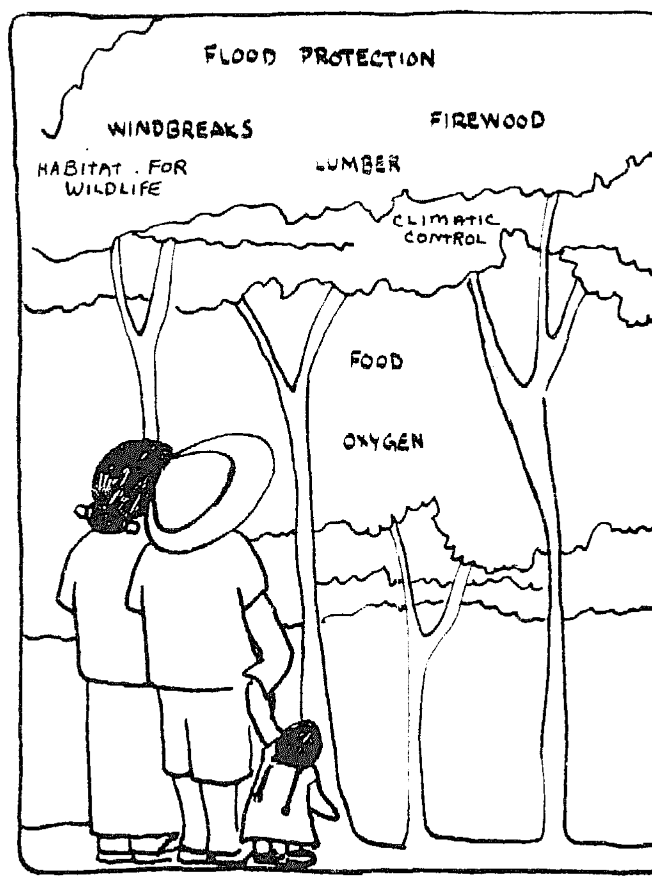
-- Wind can pick up the organic matter and dry out the soil so that it is not good for cultivation.

-- Nutrient-rich soil particles may be dislodged by hard rainfall and carried away.

-- Protection from flooding can disappear. Forests maintain soil porosity, absorb rain, and retard the surface movement of water, thereby protecting villages from floods.

-- Sources of firewood, lumber, and tree crops for domestic needs are no longer available.

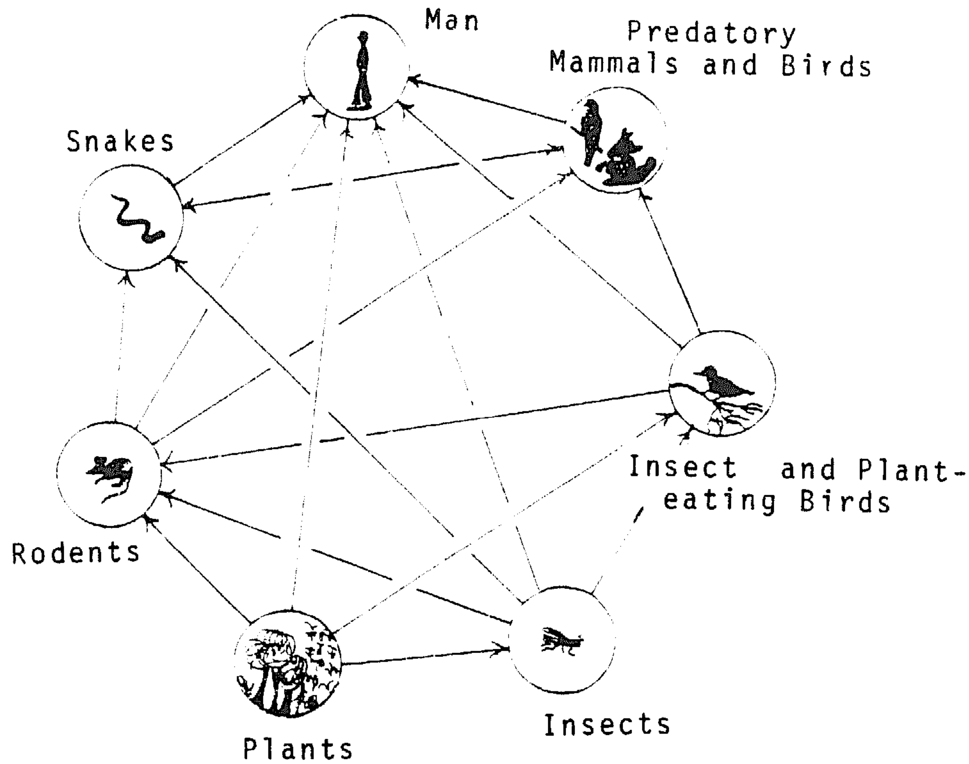
-- Diversity of plant and animal life is affected. Many birds, mammals, reptiles, amphibians, and insects that prey upon agricultural pests disappear with the loss of the forest habitat.



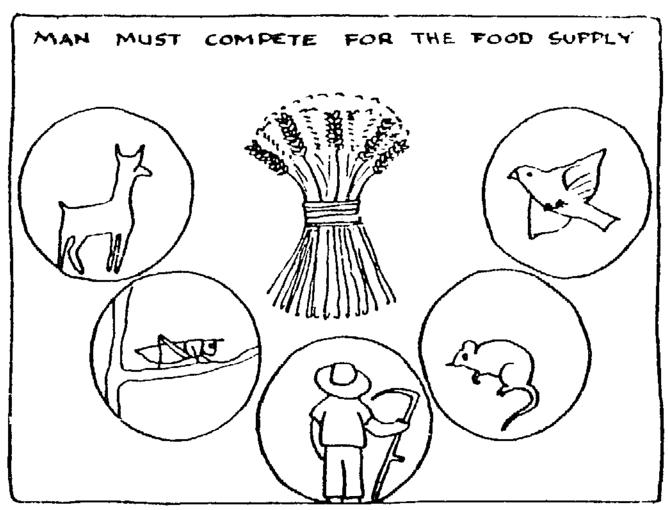
THE FOOD WEB

Plants, plant-eating animals, predators, scavengers and decomposers interact in what is commonly called a "food web."

A Generalized Food Web



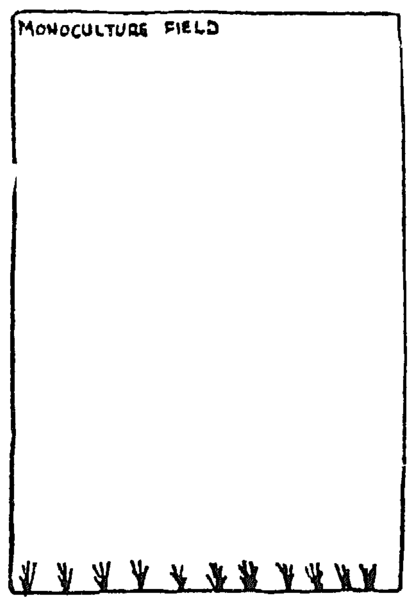

Humans are both predators and consumers in the food web and as such compete with other organisms in the ecosystem. As consumers, humans are in competition with other consumers of food crops, including insects, rodents, and other animals. In order to reduce the competition, farmers become predators and control these "pest" species by using physical and chemical control measures.



The scope and nature of small-scale agricultural projects often must be determined on the basis of economic factors and sheer necessity. Needs and money to meet them remain important and priority considerations. Knowledge of the concept of ecosystems can be used by planners working within such boundaries to insure that projects, once planned and implemented, will both accomplish what they must from the investment of resources and be carried out within an environmentally sound framework.

## How Does Stability Relate To Diversity?

When land is cleared for agricultural crops, usually the numbers and kinds of plants and animals living there are greatly reduced. In general, it is always best to design projects which will keep the plants and animals as diverse as possible. One ecological theory says "diversity contributes to stability," implying that ecosystems which contain many different kinds of species are more stable than those containing only one (as in monoculture).


For example, the forest ecosystem is very diverse and usually very stable; the ecosystem components change relatively little year to year--even when droughts or insect epidemics occur. Agricultural ecosystems, on the other hand, (particularly those which promote the use of monoculture cropping systems) are likely to be less stable when one species represents a high proportion of the total number of plants on the site. Monoculture systems may be easier to plant and less time-consuming to tend. On the other hand, some polyculture systems require less effort to tend; for example, corn, bean, cassava crop combinations in Costa Rica have been found to be less labor demanding because of reduced weed growth in the multicrop fields.

Over the long term, monoculture systems may be far more susceptible to major crop failure than a polyculture farm. For example, look at a multicrop farm containing equal numbers of pea, corn, and bean plants compared with a monoculture corn farm. If both farms were attacked by a disease or insect that destroyed 80% of the corn, the monoculture farmer would be left with a 20% yield, while the polyculture farmer would have a 73% yield.

These considerations must be weighed in terms of local situations. In any case, small-scale experimentation is recommended whenever farmers are considering changing present crops or cropping methods

**Planted Fields**

Maize Monoculture

| | | | | | |
|---|---|---|---|---|---|
| M | M | M | M | M | M |
| M | M | M | M | M | M |
| M | M | M | M | M | M |
| M | M | M | M | M | M |
| M | M | M | M | M | M |

Pea/Maize/Bean Polyculture

| | | | | | |
|---|---|---|---|---|---|
| P | M | B | P | M | B |
| P | M | B | P | M | B |
| P | M | B | P | M | B |
| P | M | B | P | M | B |
| P | M | B | P | M | B |

P = peas
M = maize
B = beans

**Harvest after 80% maize loss**

| | | | | | |
|---|---|---|---|---|---|
| | | M | | | |
| M | | | | | M |
| | | | M | | |
| | M | | | | |
| | | | | M | |

20% maize harvest

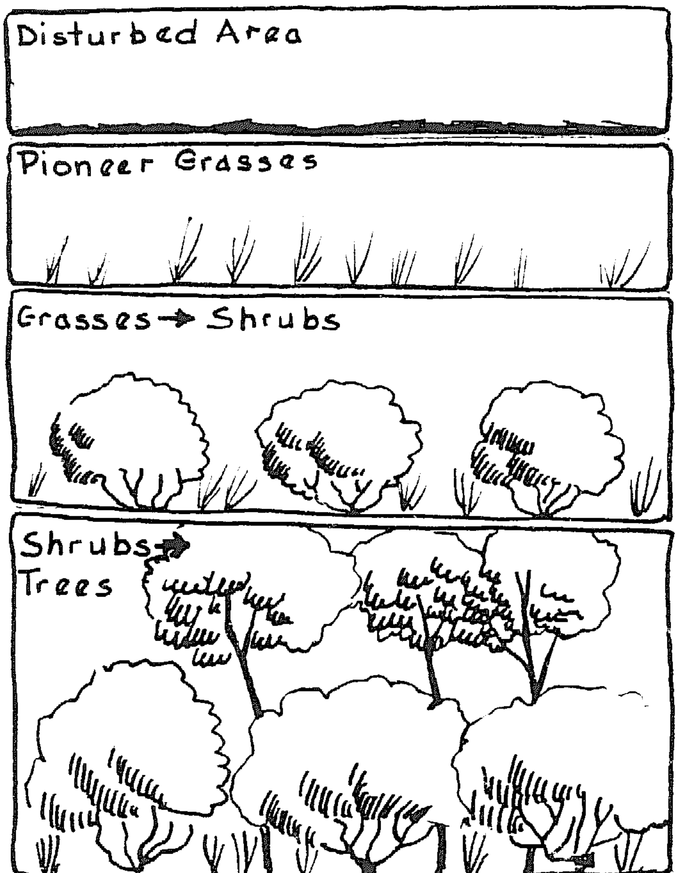
| | | | | | |
|---|---|---|---|---|---|
| P | | B | P | | B |
| P | M | B | P | | B |
| P | | B | P | | B |
| P | | B | P | M | B |
| P | | B | P | | B |

33% pea harvest
33% bean harvest
7% maize harvest (20% of 33%)
73% total harvest

## What Is Succession?

In natural ecosystems the tendency to develop and change from one state or type of ecosystem to another is called succession. Succession refers to the process in which plant and animal species enter sites, change the site, and are later replaced by other types of plants and animals. This repeated invasion and replacement continues until the site is dominated by types of plants and animals that replace themselves and are not forced out by other species. The final stage is known as the "climax community" for the site, and the represented species of plants and animals will remain relatively unchanged until the site is disturbed by fire, changes in climate or water table, or by man's activities, such as clearing land for logging or homesteads. This process can take hundreds of years, but the early stages of succession can be seen much more quickly. If a field is left fallow for one growing season, weeds, legumes, grasses, and wildflowers will invade the field, along with various insects, rodents, and birds. Left alone for many years, eventually the field would become a forest or some other climax community, probably similar to the community that previously existed on the site.

Natural Process of Succession




Succession tends to restore agricultural development sites to the original ecosystems--if not prevented from doing so by the farmer. In order to prevent natural succession, the farmer has to interfere continuously with the process by weeding manually, applying herbicides, or by mulching or flooding. In many cases, succession would return a site to shrub and forest conditions within several decades, or even years, thereby reversing negative effects of certain activities on the environment. However, if a project has had major impacts on the site, such as altering the water table or resulting in massive erosion of topsoil, natural succession can take centuries or may never return the site to its previous condition. For example, sites exist where humans cleared out forests centuries ago only to have the unprotected site remain as a barren desert. The development worker should consider seriously the magnitude of the project and whether its effects are reversible or irreversible by natural processes.

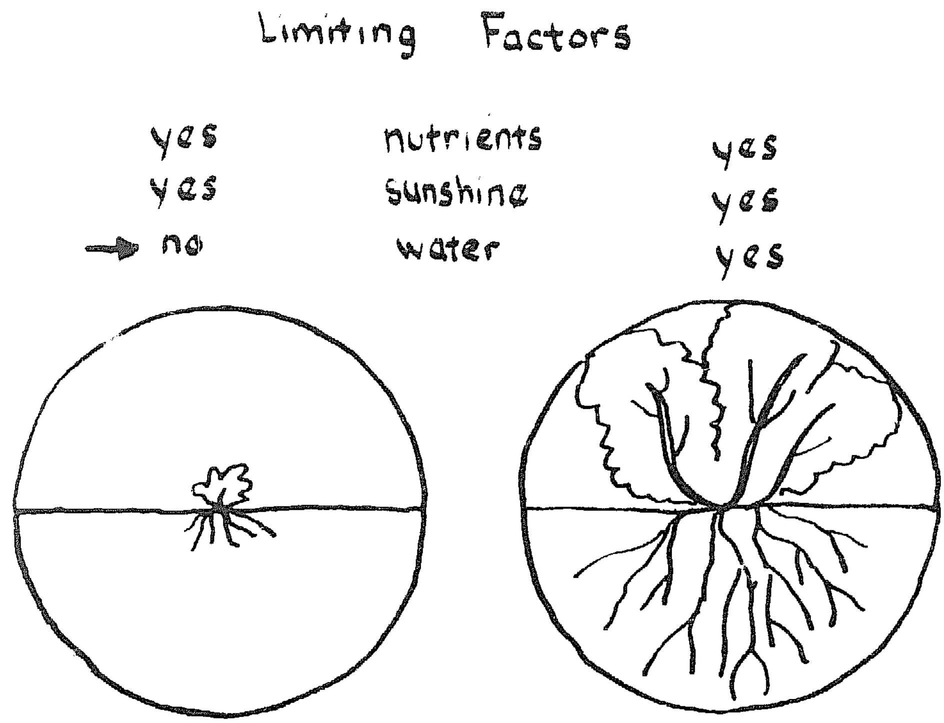
In the well-known traditional practice of slash and burn agriculture, farmers clear a patch of forest and burn it--thereby releasing nutrients--and plant their crops. Once the soil fertility that was built up over many years is exhausted by continuous cropping, the farmer moves to a new site and the cycle begins again. On the abandoned land, succession takes over. Eventually the land may again take on the characteristics of the original community.


Both agricultural crops and trees take nutrients out of the soil; however, unlike a forest ecosystem, most agroecosystems do not return nutrients to the soil. Harvesting of crops, erosion and runoff all take nutrients from the field. Unless these nutrients are replaced, the land probably will become less capable of producing crops.

Natural succession could add nutrients back to the soil. Since waiting years is usually not possible, use of fertilizer becomes necessary for this to happen. The decision to cultivate a certain area demands dealing with the fact that the supply of nutrients is not endless and that organic or inorganic fertilizers will have to be added to the site. Inorganic fertilizers do supply necessary chemical nutrients, but do not supply organic matter to the soil or contribute to the build-up of soil structure over the long term. Consideration of the use of non-polluting, organic fertilizer must be part of the planning process from the beginning.

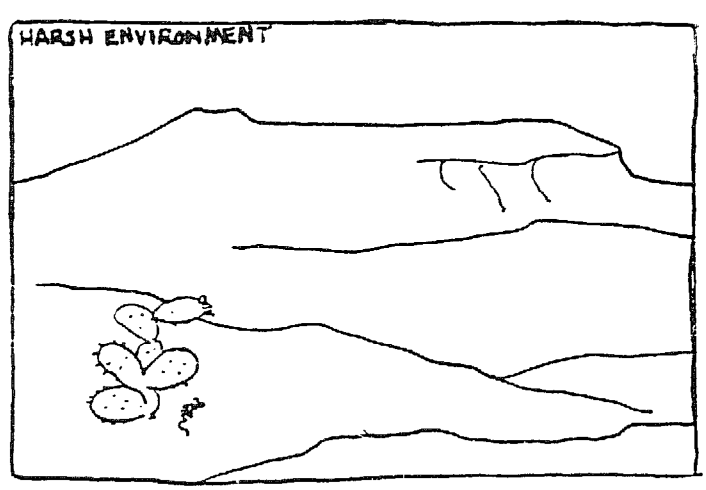
## What Are Limiting Factors?

Agricultural projects are undertaken in all kinds of areas--forest, flatland, mountainside, or coastal plain. In each there are interrelationships at work; success of a project is determined by the ability of all factors important to the project to work together well. In some agricultural projects, crop production can be improved by increasing or decreasing one factor. For example, in a given project area, climate, nutrient availability, and soil type are perfect for the growth of rice. However there is not enough water and rice plants simply will not grow. In another field there is too much water and corn will drown even though other conditions are perfect for its growth. In both cases, water availability is the limiting factor: it dictates both the type and the quantity of growth on the site.

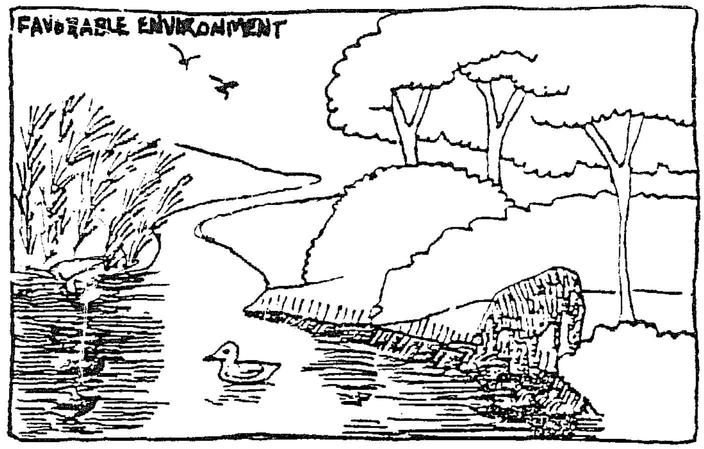



The environmental conditions of an area--temperature range, amount and intensity of rainfall, soil characteristics, and availability of nutrients--dictate the variety of species and numbers of individual plants and animals that can live in a given size of territory. For example:

-- In arid lands with sandy soil, relatively few species are adapted to withstand such harsh conditions, and those species which are present are generally not present in great numbers.



-- In a fertile flood plain adjacent to a large river, a much greater diversity and number of plants and animals are present because all the requirements for life are available--sunshine, water, nutrients, and good fertile soil.




Natural sites are able to support a number of plants and animals; the limits of this support are determined by the availability of the elements needed for life. This limit is known as the site's biological potential. Obviously the biological potential of a fertile flood plain is much greater than that of arid lands of the same size because more water, better soil, and more nutrients are available to organisms living there.

Biological potential can be increased by adjusting the limiting factors: in agricultural projects, crop production can be increased by adding whatever is missing or in limited supply to the area. This addition could be fertilizers, organic matter, water; or, in a case where pests are limiting growth, some kind of pest control.

When considering limiting factors, remember:

-- Satisfying the most obvious limiting factor may not solve the problem. In fact, satisfying one limiting factor may reveal yet another. For example, when nitrogen is lacking in a corn field, the farmer may add a nitrogenous fertilizer. He may then find that crop growth is now limited by a lack of phosphorus, or a micro-nutrient, or by too little water.

-- There are limits to the amounts of nutrients plants can use. Too much fertilizer can be just as detrimental to crop growth as not enough.

-- Changing present conditions by adding limiting factors may harm organisms that adapted to living under former conditions.

Understanding of the concept of limiting factors can be combined with knowledge of ecosystems and how they function to provide important guidelines for planning agricultural projects that are both successful and environmentally sound.

## What Are Environmental Effects?

Environmental effects are the specific changes or alterations of the environment caused by a project. Determining the potential effects of a particular project requires looking at economic, cultural and social factors, in addition to those factors which make up the natural environment and which are the focus of this manual.

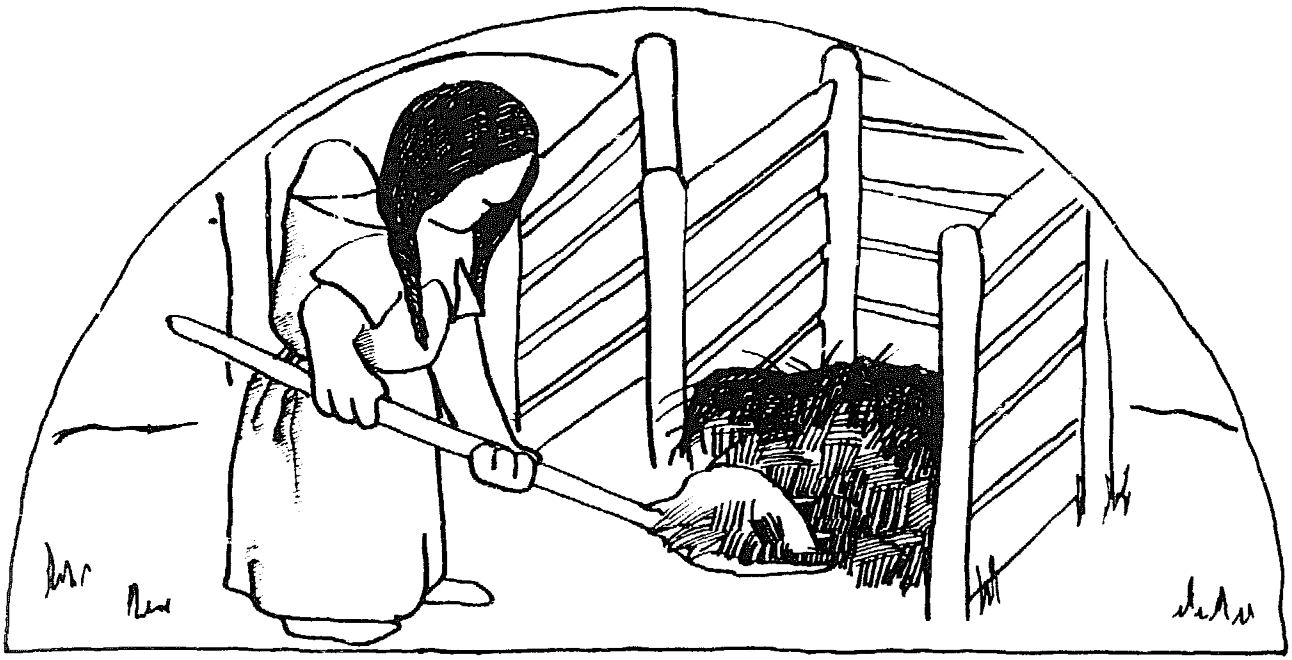
Small-scale agricultural projects can have both good and bad effects. Small projects, however, may not have small effects on the environment; the impact of any project may be smaller or much larger than the scope of the project itself. Also, changes caused by a project may not be easy to see right away. Sometimes it takes a few years of using a new practice for effects to become apparent; for example, long and extensive use of a pesticide may result, over a period of years, in the genetic development of an insect strain which is resistant to the chemical. A policy of "forewarned is forearmed" is wise. Know the characteristics of any pesticide being considered. While it certainly is not possible to predict the final outcome of all practices and pesticide use, there is certainly need to use wisely that information which is already available. Determining effects of projects upon the natural environment requires awareness of the interactions between component parts of the project being considered. For example, knowledge of how water moves through the soil of a project area and of how a particular pesticide being considered interacts with the soil and water can be coupled to provide an indication of possible environmental effects.

## How Can Knowledge Of Environmental Concepts And Effects Be Used To Insure More Successful Projects?

Development workers can determine overall feasibility by identifying potential ecological changes, and by placing these factors into perspective along with the economic, social, and cultural factors that may influence the project. If this process indicates a number of possible good and/or bad effects, the development worker then looks for acceptable alternatives or makes what seems an acceptable trade-off or compromise based on the situation. For example, if people are starving and increased crop production seems to require use of a pesticide which is somewhat questionable, the decision will have to be based on the urgency of the situation. But at least the conclusion is made upon the basis of awareness rather than ignorance so that use of the pesticide can be monitored carefully.

To date, many small-scale agricultural efforts have not benefitted from an environmentally sound approach. Because these agricultural efforts often have dealt with serious problems, there has been need to get underway quickly. Therefore, steps in planning have been skipped in order to get going.

Sound planning of small-scale efforts does not have to take a long time. It does require that the planner be aware of 1) environmental factors as they relate to the type of agricultural project being considered, and 2) of some very basic planning methodolcgy.



# 3. A WELL-PLANNED APPROACH

## WHAT IS PLANNING?

Planning as it is used here refers to the process of thinking through an agricultural project in terms of all its components and how they interrelate. It includes determining goals and objectives, figuring out finances, weighing benefits and costs. All these factors must be considered in order to determine whether or not the project can or should be done.

## WHY PLAN WHEN THERE ARE OFTEN NO ANSWERS?

This manual will not provide easy or quick answers. Indeed it is often the case that there are no simple answers. For the most part in small-scale agricultural activities, development workers make decisions in the field or on the site based on their best judgements at the time. This fact makes it more important to provide development workers who are planning and implementing small-scale agricultural projects with sufficient background upon which to base their decisions.

This manual seeks to assist development workers or other planners of small-scale agricultural activities to ask the right questions concerning their projects and the natural environment.

-- Is an agricultural project the best use of this land?

-- Will building terraces result in more room for growing crops, or will it result in heavy runoff and leached, less fertile soils?

-- Is the project planned for an area where no project should be undertaken at all, for example because the slopes are steep or the area is part of the margin lands of a desert?

-- Will improved seeds require fertilizer that is expensive and hard to get? It may be better to continue using animal manure instead.

## Why Are Goals And Objectives Important?

For the most part this manual assumes the project goal(s) and objectives already have been pretty well determined, but some explanation here can be useful as a context for further discussion.

A project must start with a firm goal: to introduce a polyculture cropping system, perhaps. In order to reach that goal the planner must devise a good plan for getting there. Objectives are quantifiable indicators of progress; they show how much progress has been made toward the goal within a given time period. Objectives set at various points in the plan are a means of telling the development worker if things are going well.

In many cases, failure to achieve meaningful project results has been due to failure to establish objectives--to work toward the goal in a step by step fashion. Objective-setting demands that the person doing the planning think carefully about the goal and how, given local conditions and realities, that goal can be reached. A development worker may decide that an objective of the polyculture system is to increase the yield from the land by 50% in the first year. In order to set that objective, the development worker must look at all the positive factors and the possible constraints--soil quality, water availability, financial resources, and so on may be constraints in one situation and positive factors in another. Realistic objectives can be set only after looking at all these factors and determining that probability is high that the polyculture system will indeed produce a 50% increase in yield. This process is a simple but effective form of benefits/costs analysis.

## What Are Benefits And Costs?

Benefits are positive effects; costs are negative effects. In any project, it is possible that one action will produce both positive and negative effects. Take the case of the polyculture cropping system and whether or not it can increase yield by 50%. That increase is obviously a potential benefit; other benefits seem to exist as well--increased resistance to disease, decreased time in the fields, improved soil structure and fertility. On the other hand, these benefits may have associated costs: in order to increase yield, new farming implements or techniques may be necessary, thus adding to time and expense; seeds may be more expensive; local storage facilities and food processing techniques are probably inadequate to take care of a 50% increase in yield.

Other benefits and costs are more difficult to calculate; they relate to social customs, cultural conditions and other intangible considerations. If women traditionally cultivate and the project involves more or less time from the women, this effect also must be estimated.

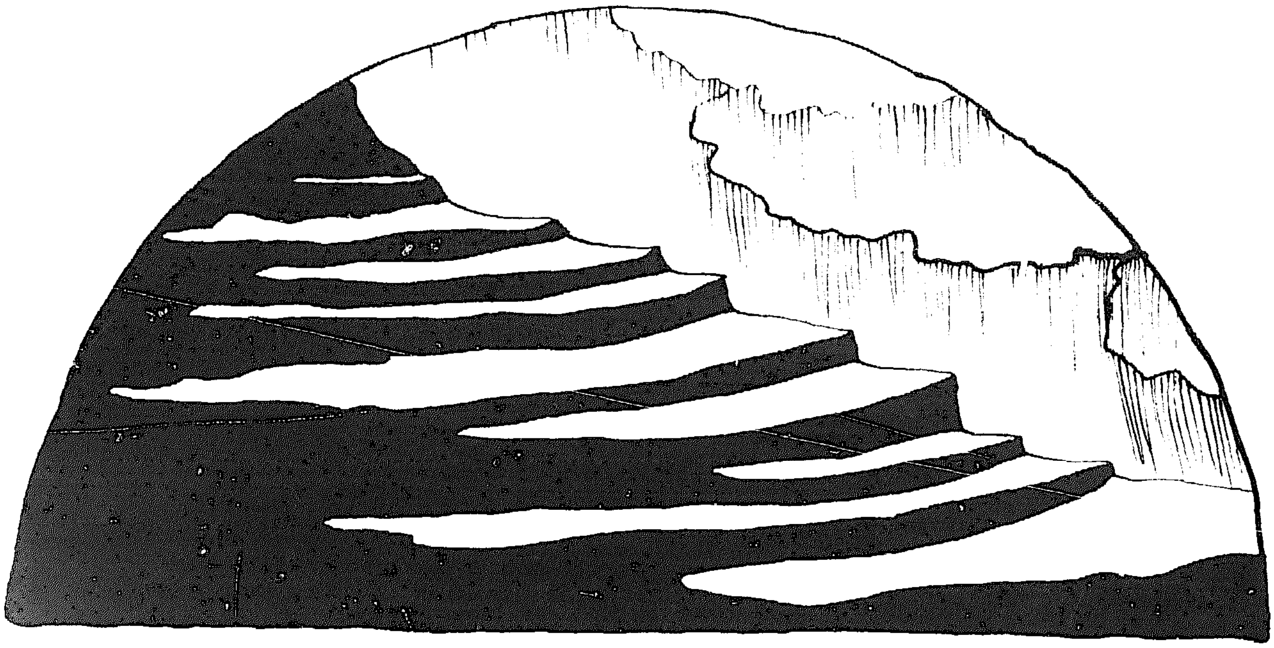
## How Does A Development Worker Find Alternatives And Make Trade-Offs In Small-Scale Agricultural Activities?

Again there are no easy answers. The key to the answers, however, is found in understanding agricultural efforts in terms of their interactions with the natural environment, using resources wisely, and listening to and learning from local experience.

Agricultural efforts may result in ecological changes. Predicting whether these changes can be costs or benefits in a given situation requires that the development worker have knowledge of technologies--irrigation, fertilizers and pesticides, improved mechanizations, and so on--being considered. It also requires familiarity with alternatives to the technologies proposed. And, finally, both technologies and possible alternatives to them must be weighed in terms of local priorities.

Determining <u>when</u> it is necessary to seek alternatives or to make trade-offs in a small-scale project is often more difficult than finding the alternatives themselves. However, a well-planned benefits and costs approach can be used to highlight potential imbalances in the project and point the development worker toward the specific areas where alternatives are needed.

The development worker should be able to use the information in this manual as the basis for planning small-scale agricultural projects quickly and in a field context. This book supports efficient project planning by assisting development workers (without easy access to human or information resources) to assess the potential for positive and negative effects of a given effort.



# 4. BACKGROUND FOR PLANNING: WATER SUPPLY AND MANAGEMENT PROJECTS

An understanding of the relationship between water and agriculture is key to planning environmentally sound projects. With knowledge of this relationship, it is possible for a development worker to judge a proposed water supply or control practice in terms of the results of its interaction with the environment of the agricultural project.

As the primary transport medium on agricultural lands, water can be both friend and enemy. Water carries or moves nutrients through the soil to plants and within the plants themselves. Water also moves pesticides and fertilizers from the fields and into the surrounding environment where they can cause serious problems. An understanding of how water moves and what its effects are on agricultural lands is the key to knowing how, when, and where a given project may interfere with these processes.

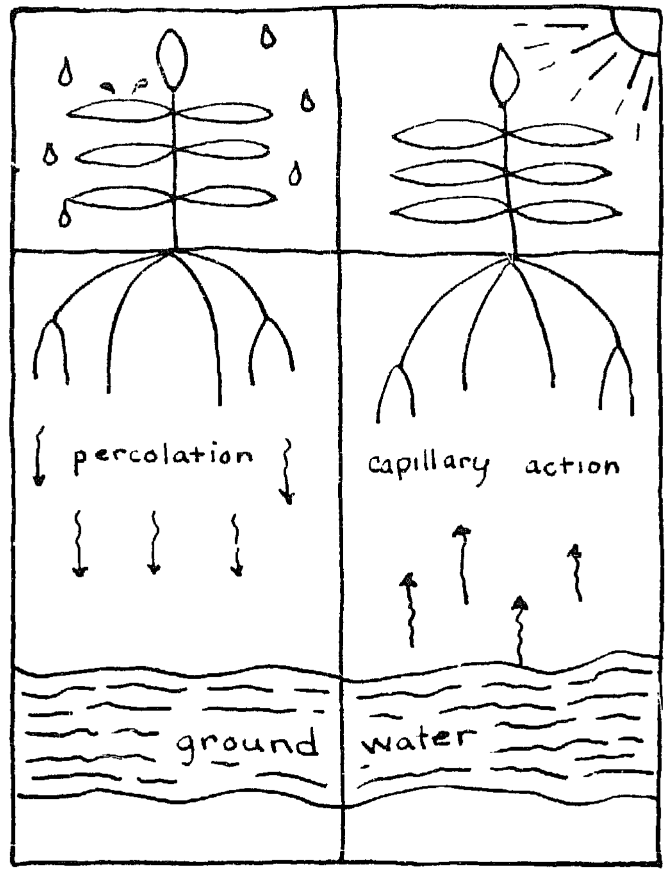
## WHAT ARE THE MAJOR SOURCES OF WATER?

- Surface water. Lakes, ponds, streams, and rivers provide water to plants either indirectly through evaporation and later condensation over agricultural lands (as rain), or directly, when tapped and channeled for irrigation purposes.

- Rain. Rain falls directly on plants and filters down, or percolates, through the soil to the roots and continues down to add to groundwater supplies.

The amount of rain varies greatly from season to season and from area to area. In many places, records kept of the amount of rainfall can be used to discover patterns in the amounts of water available and to identify both flooding and drought cycles or patterns.

Groundwater. Water accumulates underneath the soil at various depths depending upon soil and geologic structures. These groundwater supplies are relatively permanent. Groundwater moves up through the soil profile by capillary action to become available to plants at times when there is not enough rain. Water held in deep pockets can be made available by digging wells.




## How Does Water Move And What Are The Effects?

Water, regardless of the source, moves materials to and from the project site physically and chemically:

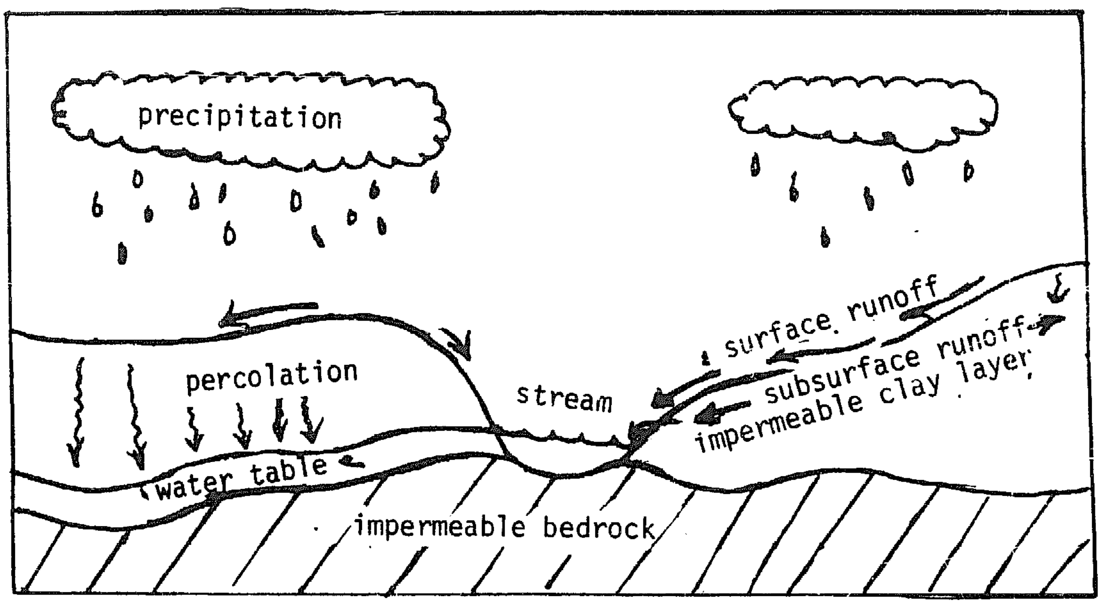
<u>Chemical Transport</u>. Many minerals, nutrients, and pesticides and other chemicals are dissolved and are carried in water (or leached) through surface runoff (water flowing over the ground surface to a stream), subsurface runoff (water moving below the surface soil, for example on top of an impermeable layer of clay, towards a stream), or percolation (water seeping down through the soil to the water table, or the groundwater supply).

As runoff, water moves towards surface waters picking up more chemicals, nutrients, and sediment, and depositing them in surface waters. Depending upon the amount of runoff, the kinds of materials carried and the amount of material dissolved in the surface water, a number of negative effects can result from chemical transport: chemicals can kill aquatic organisms and fertilizers promote algae growth which may pollute the water. Through percolation, water may carry soluble agricultural chemicals directly to wells or to surface streams as part of the groundwater.

Percolation may move nutrients down beyond the root zone of plants, where they are useless to plants. The amount and frequency of deep percolation depends upon the water storage capacity of the soil, the vegetative cover of an area, the amount of runoff and rainfall, and the type of soil and geologic conditions below the root zone.

Percolation has beneficial effects as well. One of these is moving dissolved salts deeper into the soil. When this does not occur, salts accumulate in the topsoil and can eventually become toxic to agricultural plants.

Physical Transport. Raindrops falling on unprotected soil dislodge soil particles and carry them from the site over the surface of the land. This surface water runoff can be a major cause of erosion. Erosion has three negative effects: 1) loss of valuable topsoil, making agriculture more difficult on the site, 2) pollution of streams and lakes downstream from the project site by soil particles which accumulate and form sediment, and 3) washing of fine particles into spaces between larger soil particles creating a physical block which reduces water percolation.




MAJOR SOURCES OF WATER

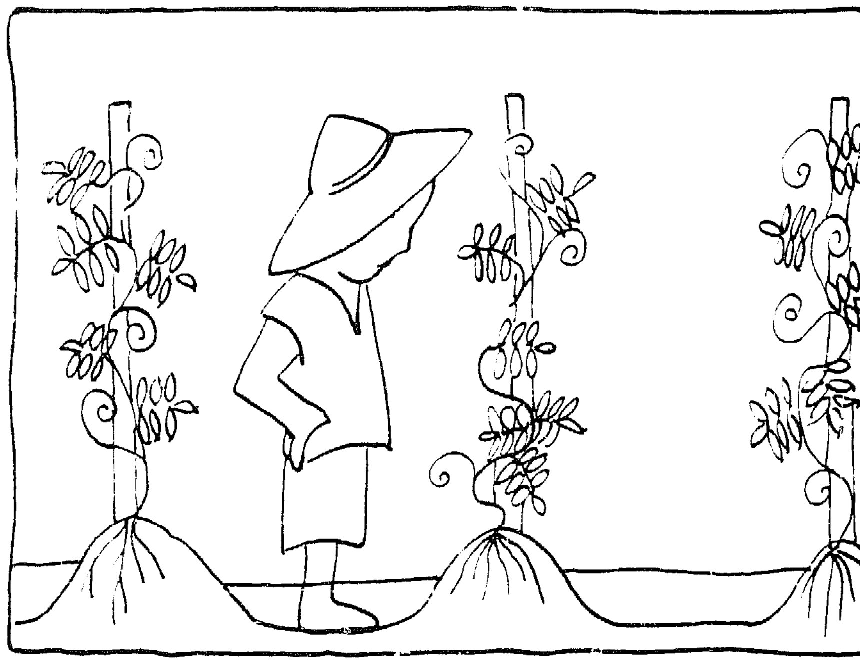
Sediment chokes streams, decreases the amount of light which can penetrate the water, and clogs the gills of fish and shellfish. Nutrients and pesticide chemicals adhering to the soil particles increase their polluting effects in the water. On the other hand, physical movement of the soil can have beneficial effects. For example, in flood plains many agricultural lands receive fertile top soil as a result of annual floods that transport soil from sites upstream.

## How Important Is Irrigated Agriculture?

The types of water management practices, such as those used to control percolation, runoff and sediment movement, will become clearer as other types of agricultural concerns--nutrient and soil management, pest control--are discussed. Water management seeks to insure the best use of available water. In many areas and in many small-scale agricultural projects, the major problem, at least initially, is inadequate water supply. A common answer, although not the only one possible, to this problem is irrigated agriculture.

Agricultural lands are irrigated in many ways; the best method to use in a given area depends upon:

-- supply and quality of water
-- slope of the site
-- infiltration and percolation rates of the soil
-- water-holding capacity of the soil
-- chemical characteristics of the soil (salinity, etc.)
-- moisture requirements of the crop
-- weather conditions of the area



## Why Is It Necessary To Plan Irrigation Projects Carefully?

Irrigation projects can have far-reaching effects on the environment of a vast area. For example, irrigation can affect water-table depth, water quality, soil characteristics, crop productivity, human health (the spread of diseases such as malaria and schistosomiasis), family structures and mobility patterns, economic status of farmers and land ownership patterns.

Irrigation projects also can be affected by other efforts underway. For example, check the watershed that will be providing water for the project. Determine if it is protected adequately to ensure water of the quality and quantity needed for proposed crops. Watershed development upstream from the project site could alter the water supply drastically, causing flooding, drought, fluctuations in seasonal flow, or water contamination.

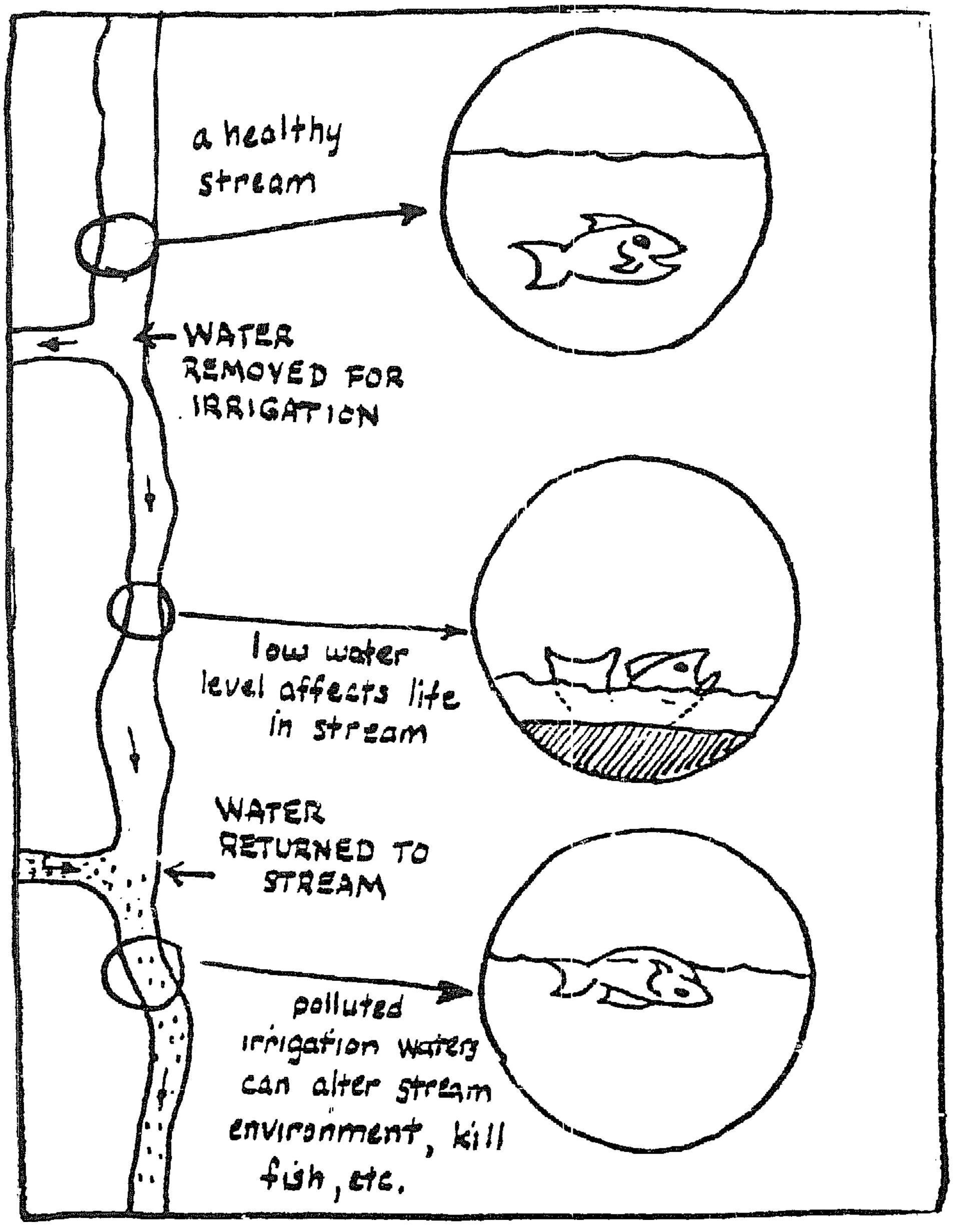
## What Are The Effects Of Using Surface Water For Irrigation?

Irrigation water usually is diverted via canals, ditches, and channels from surface waters nearby. Removal of water for irrigation can have far-reaching effects . . . .

ON THE AQUATIC ENVIRONMENT

-- Removal of water for irrigation can result in reduced flow downstream.

-- Reduced flow can cause the death of aquatic plants and animals.




-- Water returned to the stream after irrigation is of poorer quality than the original water, and may cause death of plants and animals.

-- Rivers drawn down on very large irrigation projects are also subject to encroachment of sea water at the river's mouth.

## ON FARMLAND

Water carried to irrigated fields is also subject to evaporation from open canals or seepage from canals in areas where the soils are permeable. When irrigation from surface waters spreads out over the land surface, the water percolates downward and can accumulate underground. Over a period of time:

-- accumulated subsurface water can raise the water table until it is within a meter or even a few centimeters of the soil surface;

-- the raised water table inhibits the growth of plant roots by waterlogging the soil;

-- waterlogged soils serve as breeding grounds for hosts of crop diseases;

-- the soil on the surface becomes very salty as water evaporates from it leaving a concentration of deposited salts in the upper few centimeters of the soil (salinization).

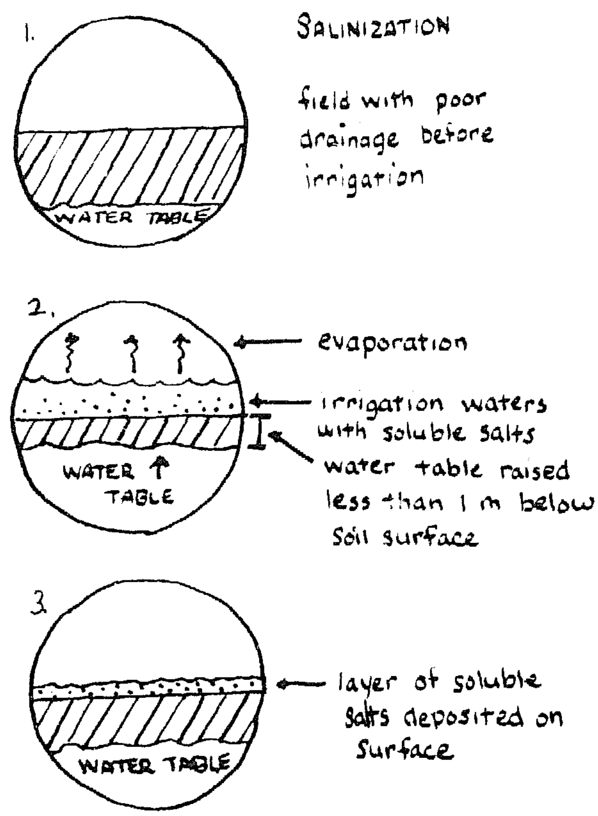
Irrigation also changes the wet-dry cycle to the benefit of insect pests. Many insect populations die back to low levels during the dry season. With irrigation, pests can continue to breed throughout the year.

## SALINIZATION

Salinization, a major hindrance to plant growth, is the concentration of mineral salts--sodium, calcium, magnesium, and potassium--in the upper soil layers or on the surface in the form of a white crust or powder.

When drainage is adequate, salts need present no problems; they can be washed out of the soil by applying water in excess of the rate of evaporation and water use by plants. Where drainage is not good, salinization can occur when surplus water accumulates and raises the water table to within one meter or less of the surface so that increased evaporation leads to salinization.

Inadequate drainage and elevated water tables are the underlying cause of salinization problems in irrigation projects. Awareness of the nature of this problem and its causes is another planning tool: development workers must check drainage and water table characteristics before developing an agricultural project using surface waters for irrigation.



## ALKALINIZATION

Of particular concern in arid and semi-arid regions, alkalinization is similar to salinization.

Alkalinization is more serious than salinization because it is harder to remedy (salinization can be remedied by applying water; leaching alkaline soils may worsen their condition).

Sodic soils have a high sodium content. Sodium, unlike other soluble salts, does not leach away because it is adsorbed on the surface of clay and organic matter. When other salts are leached away by runoff or irrigation water, the sodium remains in the form of sodium hydroxide or carbonate of soda. The presence of the sodium hydroxide causes dissolving of the organic matter in the soil and destroys the soil structure, making it difficult to till and almost impermeable by water. Expert assistance is needed to correct this soil condition.

## LATERIZATION

Clearing forests for cultivation can result in soil weathering and laterization in humid tropical regions. Because of adequate water supply and warm temperatures, bacteria break down organic matter rapidly causing the soil to contain little or no humus. Insoluble oxides of iron and aluminum accumulate in the subsoil creating yellow and red clays, or, where drainage is restricted, rock-like layers called "laterite." Care should be taken during the project design phase to ensure adequate drainage and maximum soil protection to avoid erosion and oxidation of subsoil layers. Otherwise the formation of laterite could prevent agricultural production indefinitely (see Appendix II for map detailing the extent of laterite soils).

# WHAT ARE THE EFFECTS OF USING GROUNDWATER FOR IRRIGATION?

When water for irrigation is drawn from groundwater supplies by sinking wells and pumping, the water table is lowered. This has several possible effects which must be considered by the project planner:

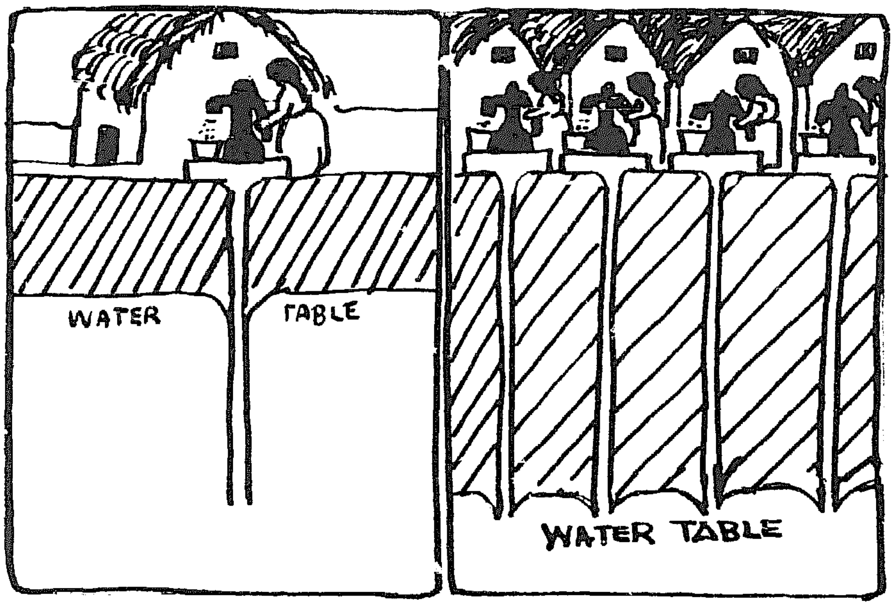
- local vegetation may no longer be able to reach the water table

- marshes, springs, and wet places may dry up

- river and stream flow may be reduced

- the land may even sink, or subside if water has been pumped out too quickly from underground storage areas, or <u>aquifers</u>

- if too much water is applied, waterlogging may occur in the soils

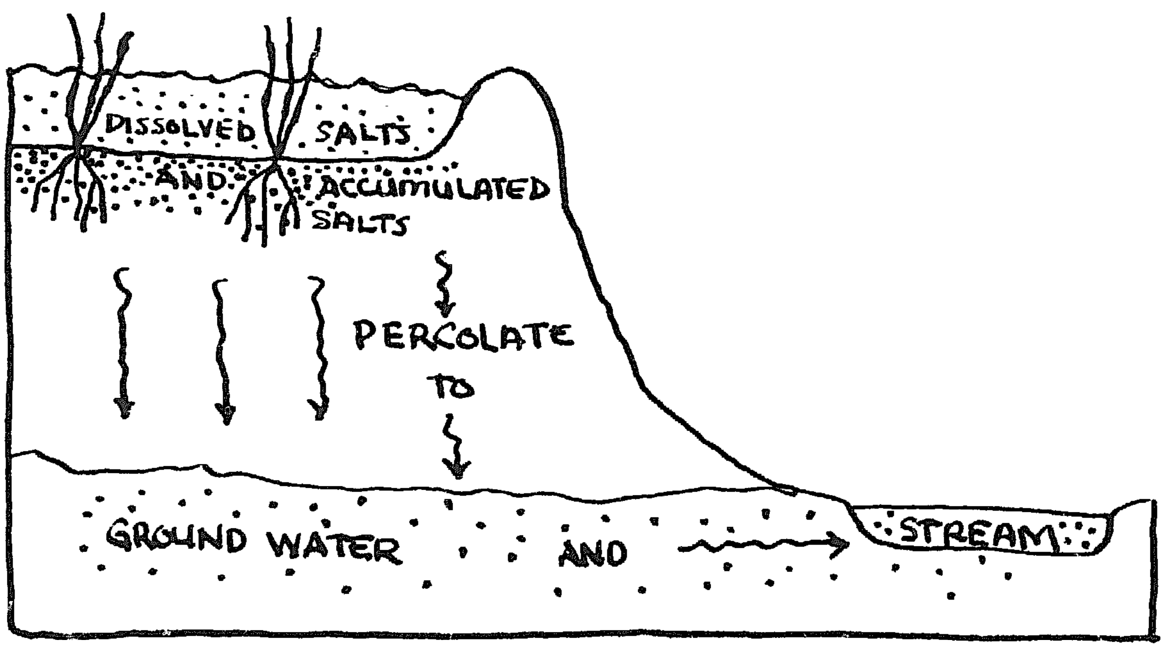



Lowered Water Table

-- water table or aquifer water may be polluted causing contamination of agricultural crops.

## WHAT ARE IRRIGATION RETURN FLOWS AND THEIR EFFECTS?

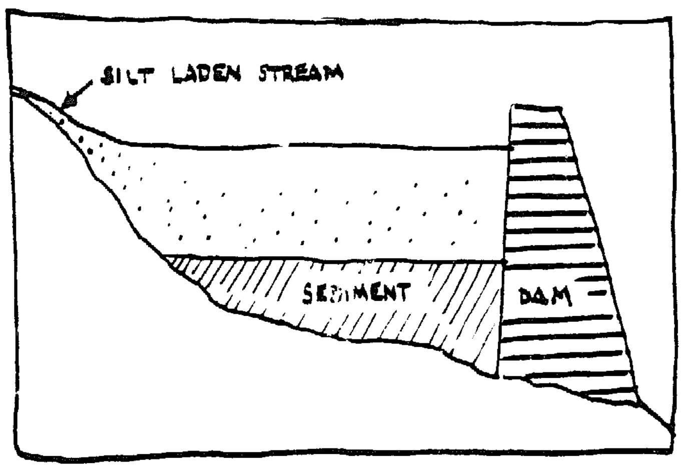
Water used for irrigation flows back to water sources through transport processes. This return flow from irrigation can be a significant polluter of surface waters, groundwater, and soil. Dissolved salts, for example, can be carried to the subsoil or groundwater. Water percolating through the ground carries with it the salts accumulated in the root zone and moves them up or down in the soil profile. Some salts also wash into drainage systems and are returned to mainstreams. When irrigation water returns to main streams it may have adverse effects:



-- because of leaching and evaporation in the fields and canals, the salt content of the irrigation return flow may be two to five times as great as that of the initial water used. Too much salt can kill fish and other aquatic organisms downstream from the point of return.

-- return flows carry pesticides which can be lethal to beneficial aquatic organisms that provide food for higher organisms in the food web, including man.

-- irrigation return flows can carry sedim[illegible] silt which raises the beds of irrigation canals, ch[illegible]s the direction of canals (causing them to meande[illegible] [illegible]ills the streambeds of reservoirs and lakes down[illegible].




## WHAT ARE THE POTENTIAL EFFECTS OF IRRIGATION ON HUMAN HEALTH?

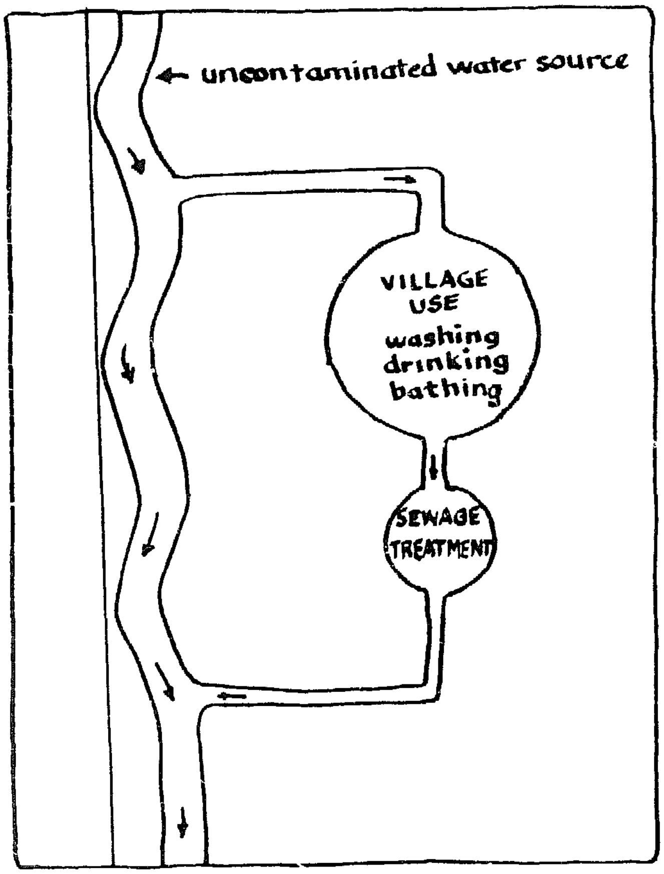
The importance of considering the possible answers to this question fully cannot be overemphasized: the human health implications of developing an irrigation system can be extremely serious and can include the following:

-- Irrigation canals and ditches provide new places for the growth and reproduction of various disease organisms and can be instrumental in spreading these diseases.

-- Canals carry chemical pollution from one place to another.

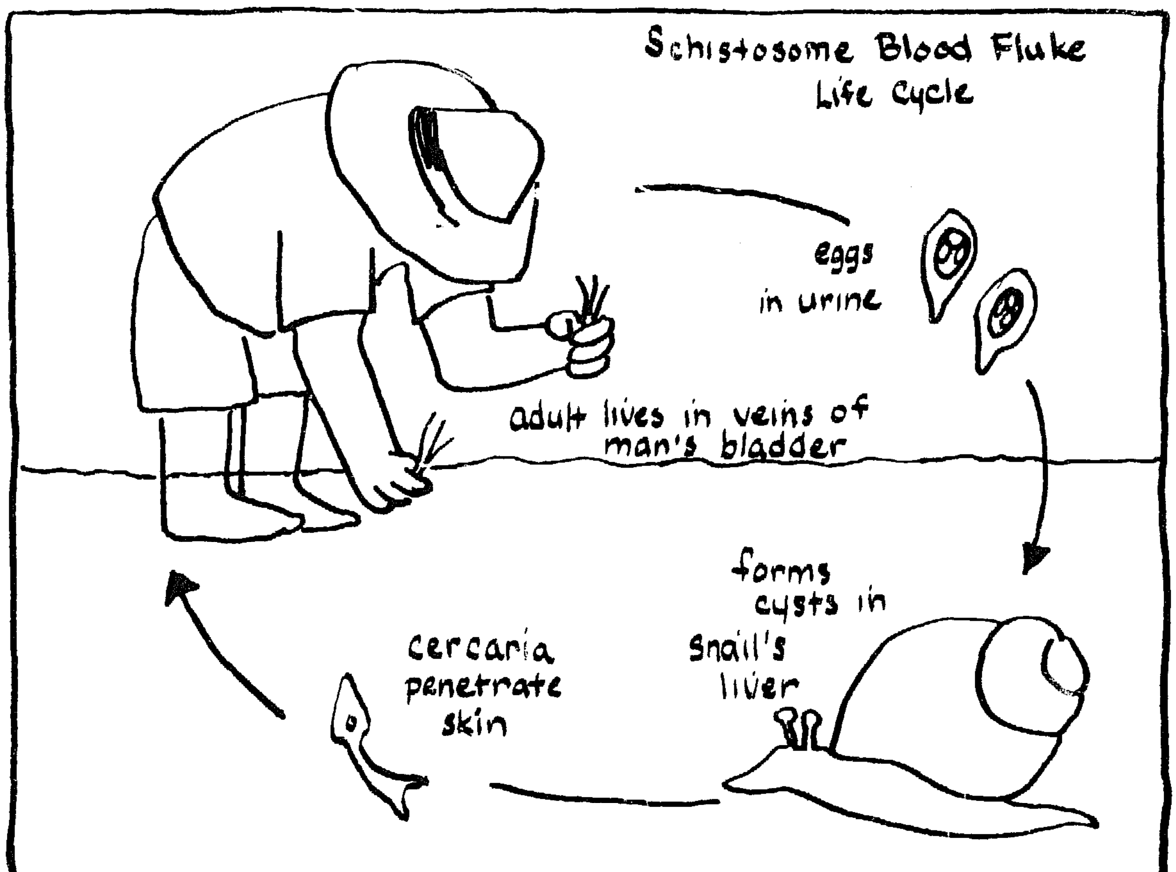
-- If people draw water from the canal and use it for both bathing and waste disposal, there is a risk of bacterial and viral infection.

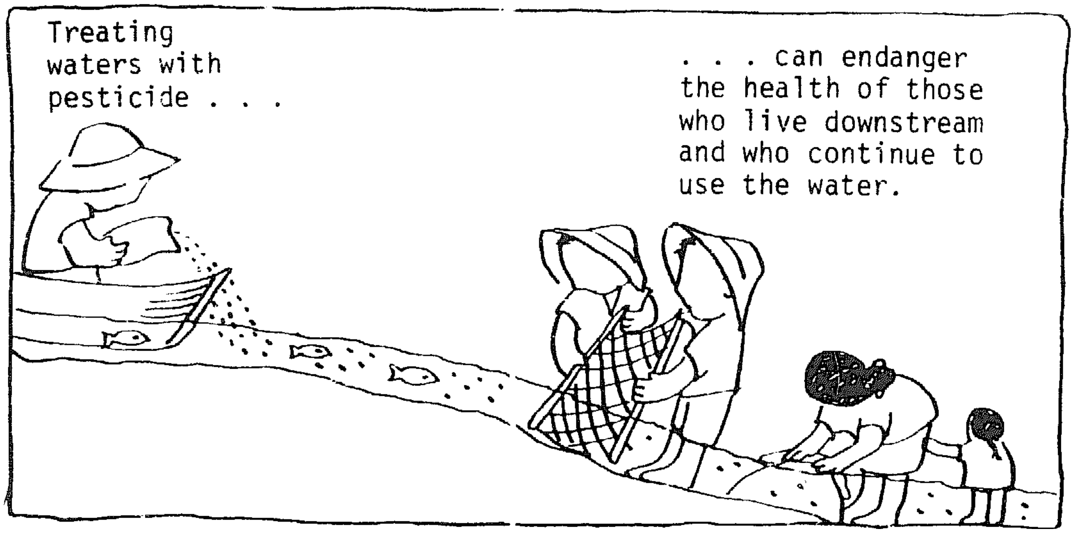
-- Slow-flowing or stagnant storage ponds, supply canals or deeper drainage ditches are ideal habitats for disease organisms, especially when canals become choked with aquatic weeds which slow the flow of water and offer a feeding substrate for mosquitoes and other




aquatic organisms that transmit disease. Many of the world's most serious human diseases, such as malaria, yellow fever, and schistosomiasis, are carried by organisms such as snails and mosquitoes.

-- Although snails and mosquitoes that spread disease can be controlled by pesticides, these pesticides also kill the eggs, larvae, and adults of many species of aquatic animals. Pesticides also accumulate in the food web and can cause harm to humans who use the water or eat fish grown in contaminated water. (See Chapter 6 on pesticides for more complete information.)






-- Control of disease organisms by chemicals can also harm fish-raising efforts in irrigation canals and reservoirs.

-- Mosquitoes that transmit malaria can develop resistance to specific insecticides over time.

Alternatives to pesticides include promoting insect-eating fish (Gambusia, the mosquito fish), birds and other predators (see Chapter 6 for information on biological control methods).

## How Does One Determine The Effects Of Water Supply And Management Projects?

One approach is to take information provided in this chapter and use it to form questions which will help determine effects on a local level. By forming and answering such questions for each project and site, development workers will be able to build a good picture of the potential effects of projects.

-- Is there adequate water for the project, either from precipitation, surface water, groundwater, or aquifers?

-- Are 20, 50 and 100 year floods and droughts accounted for in the project design? What would be their impacts on the project when they occur?

-- Could the project design minimize surface runoff that might carry away valuable nutrients and topsoil and pollute receiving waters?

-- Could upstream resource uses affect the quality of the water to be used by the project? For example, will construction or forestry activities pollute the water to be used by the project?

-- Could the project involve irrigation? If so, the planner should be particularly careful to assess the impacts of the project downstream, the possibility for increasing habitat for aquatic insects including vectors of water-borne diseases, and the abundance and quality of the project water source.

-- Could the project affect water flow patterns of the area? Would these alterations affect the water supply needed by other users?

-- Are malaria, yellow fever, schistosomiasis, or other water-borne diseases carried by organisms associated with water prevalent in the region? And could the project in any way result in increased incidence of the diseases?

-- Could the project reduce downstream water flows and thus affect fisheries, impact aquaculture projects, allow the growth of aquatic weeds, provide habitat for mosquitoes, other disease vectors or insect pests?

-- If habitat is increased for disease vectors, could this result in increased use of insecticides or molluscicides with the possible result of chemical poisoning of fish and water supplies?

-- Could irrigation cause waterlogging of the soil?

-- Could evaporation cause salinization of the site's soil?

-- Does the soil have a characteristically high pH and could irrigation result in soil alkalinization?

-- Does the site have lateritic soil and is laterization a potential problem?

-- Will groundwater be taken for the project by sinking new wells? If so, could this affect the level of the water table?

-- If the water table level is affected, what could be the impacts on stream levels, wetlands, and other water uses in the region?

-- Is the project site near the sea? If so, could lowering the water table allow salt water to intrude, contaminating freshwater supplies?

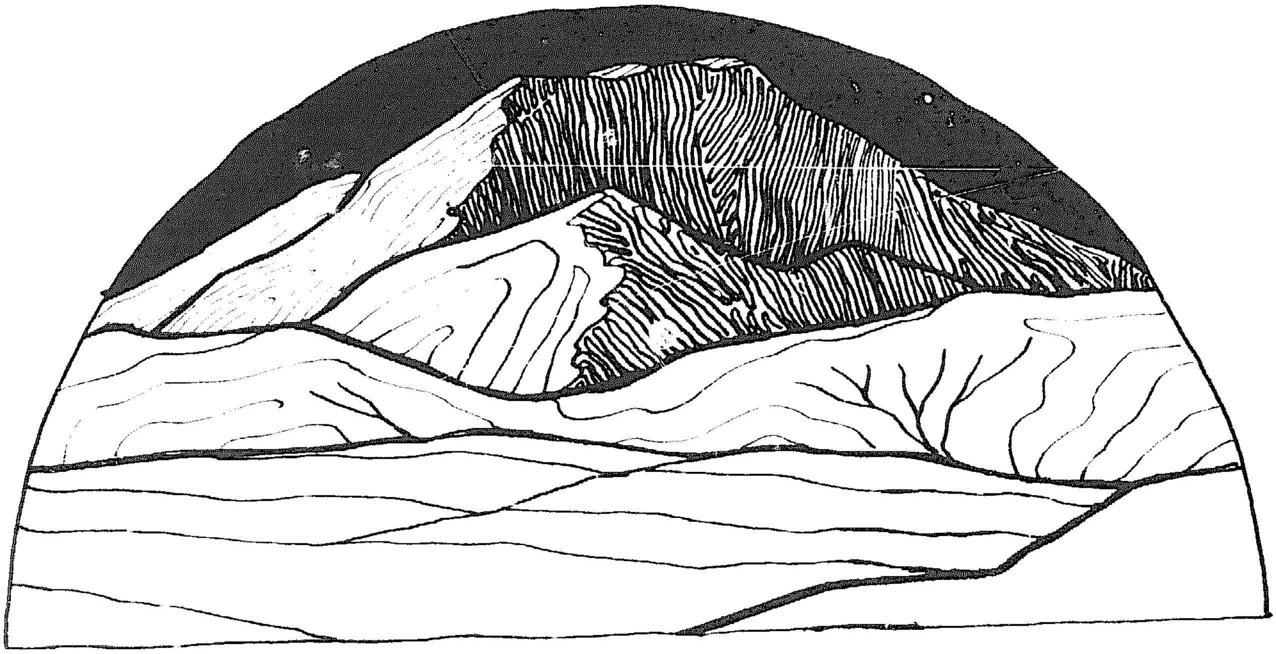
-- Could downstream water or groundwater quality be affected by high salinity in the return flows from the project site?

-- Other water supply and management considerations.

-- What alternative designs could minimize the above water supply impacts?

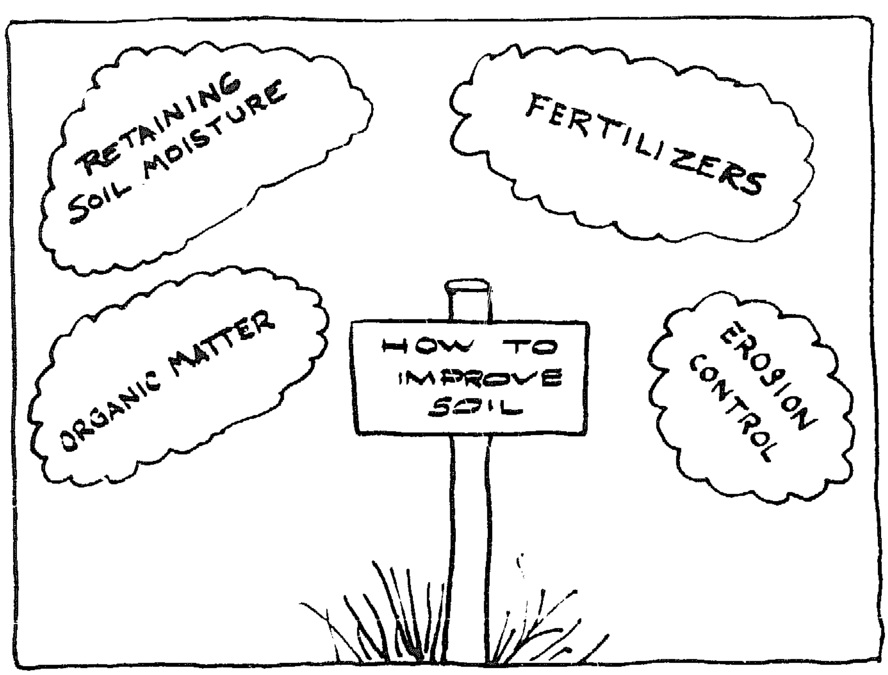
## WHAT ALTERNATIVES MAY EXIST?

There are several ways to avoid, or mitigate, negative effects of irrigation on human health. When canals are used, people can take extra care to draw water from uncontaminated stretches of the canal, or from safer sources such as deep wells. If alternative waste disposal methods are adopted, disease organism life cycles can be interrupted, preventing the spread of disease. More research on the natural enemies of snails and mosquitoes may identify ducks, geese and fish that serve as predators. There may also be local plants that serve as molluscicides, such as the soapberry, (berry of the dodecandra plant in Ethiopia). The best method may be to deprive disease vectors of a suitable habitat by conveying water in pipes or tile aqueducts and by using buried tiles to drain excess water from fields. On a small scale, the use of enclosed systems for irrigation would not only protect man from disease but would also prevent seepage and evaporation of water used for irrigation.

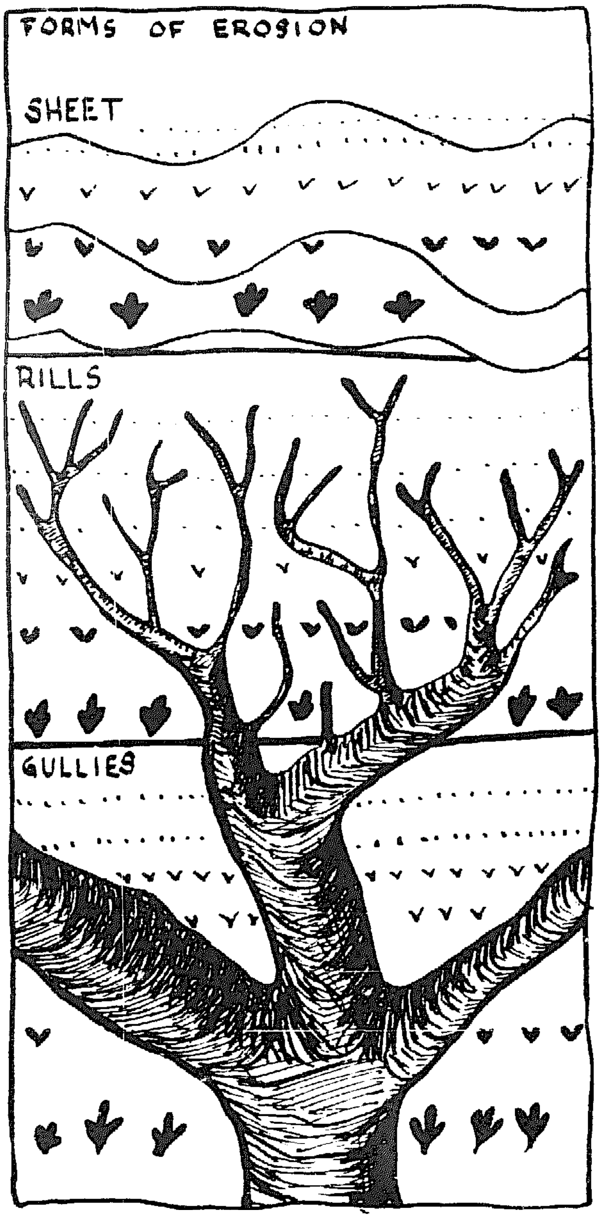


## 5. BACKGROUND FOR PLANNING: SOIL MANAGEMENT THROUGH EROSION CONTROL

Soil contains the nutrients and water that plants need for growth and serves as a substrate in which they grow. Many agricultural projects involve the need for some type of soil management effort, such as using fertilizers to provide nutrients, introducing irrigation to provide water, or adding organic matter to add soil nutrients and improve soil structure.



The primary purpose of soil management practices is to provide a continuously supportive soil for plant growth. Plants in turn contribute to soil stability by shielding the soil from sun and rain, by holding onto soil with their root systems, by retaining soil moisture, and by returning nutrients to the soil when they die and decompose.




When plants do not cover the soil, erosion can result. Since erosion is the most serious environmental problem facing many farmers around the world, this chapter provides background for planning agricultural projects in areas which are subject to erosion. In order to do this, it is necessary to understand the process of erosion and its effects both upon the project and the environment.

## WHAT IS EROSION?

Erosion is the wearing away of the land surface by water, wind, ice, or other geological processes. Erosion occurs as a function of climate, topography, soils, vegetation, and factors associated with human activity, such as cropping methods, irrigation practices, and equipment use. Erosion control becomes more necessary as the slope of the land increases.

There are three main stages of water-caused erosion:

SHEET EROSION. Soil moves over the bare earth surface, usually during high intensity rainfalls. Topsoil is dislodged by the impact of the raindrops. As water moves down the slope, it follows the path of least resistance. Therefore, it flows in already developed channels--in tillage marks and depressions in the natural land surface. Sheet erosion is the first stage of damage and as such may be harder to identify; those seeking to develop the land should check carefully for signs of it.

RILL EROSION. Concentrated runoff may remove enough soil to form small channels, or rills, in a field. While rills are often the first visible sign of erosion, they can be covered up by tillage practices. Learn to recognize the signs of rill erosion and watch for them. Under continued rainfall, rill erosion increases rapidly; steeper or longer slopes increase the depth of the rill. The erosion potential of flowing water increases as depth, velocity and turbulence increase. Sheet and rill erosion together cause most soil losses on agricultural lands.

GULLY EROSION. As water accumulates in narrow channels, it continues to remove soil; this is the most severe case of erosion and can remove soil to depths of 1 to 2 feet, or up to several hundred feet in extreme cases.

## WHAT IS WIND EROSION?

Soil can also be eroded by wind. In arid regions, wind erosion can be extremely serious. Topsoil blown away from the land can leave the land unproductive for crops, as well as increase the number of particles in the atmosphere, thus affecting the local (and perhaps the earth's) climate. Wind erosion can also:

-- cover and kill plants
-- irritate organisms living in the area
-- increase labor and cost of cleaning those areas which are covered by soil
-- reduce amount of solar energy (sunlight) reaching plants in the region

In extreme cases, wind erosion, coupled with climatic changes and man's activities, can contribute to the formation of deserts. For example, people increase wind erosion and make the problem of desertification worse by overgrazing lands, cutting woody species for firewood, overcultivation, and so on. In many cases, such practices are the result of increased population pressures and other social, political and economic factors.

## HOW CAN EROSION BE CONTROLLED?

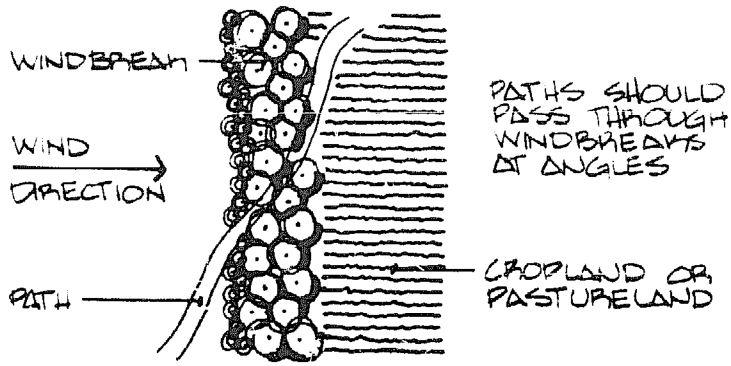
Erosion can be controlled by reducing the mechanical forces of water or wind, by increasing the soil's resistance to erosion, or by doing both.

Wind erosion can be reduced a certain extent by:

-- planting trees as a windbreak

-- strip cropping with furrows and sprinkler irrigation

-- using trickle irrigation




*This windbreak is protecting the cropland from high winds which would carry away topsoil and make the land useless for farming.*

Since water can be a key factor in control of wind erosion, most development workers planning agricultural projects will be concerned with controlling or preventing erosion by water.

There are five ways to control erosion from water; implementation of each of these control measures may be a project in itself, or the measures may be part of other agricultural projects. The methods are:

-- improved vegetation cover

-- wise use of plant residues (mulching)

-- improved tillage methods

-- crop rotation

-- sound mechanical support practices

## Why Is A Good Soil Cover Important?

A good soil cover is the most important control for both wind and water erosion. The soil cover:

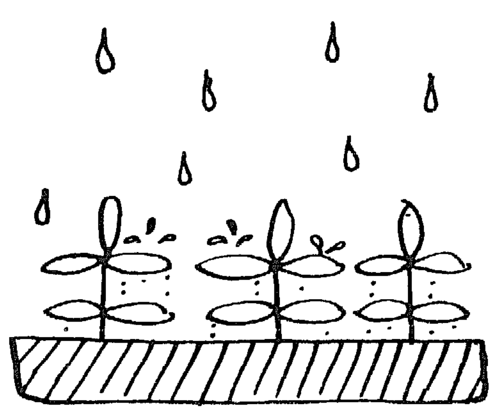
-- interrupts rainfall so that its velocity is slowed down before it hits soil particles

-- decreases runoff velocity by physically restraining soil movement

-- increases the soil's water storage ability

-- improves soil porosity

-- increases biological activity in the soil



The leaves and branches of a crop can provide a canopy or cover over the soil at a certain height, thus protecting the soil from heavy rainfall and wind. Corn, for example, forms a canopy several feet above the ground. Lower crops, such as grasses or legumes, provide cover closer to the ground surface and offer a very good method of erosion reduction: soil loss from a grass and legume meadow is practically zero.

Projects should be designed so that some kind of vegetative cover remains in place at all times. If an area is cleared, make plans for the cleared area to be covered by vegetation as soon as possible, or at least take time to check and see that weeds will grow naturally in the fallow field. This is necessary for three reasons: 1) the cover reduces the possibility of soil erosion; 2) the weeds can be plowed under to provide nutrients for later crops; 3) once humans make a decision to disturb the balance of an ecosystem, they have an obligation to make provision for ensuring that the disturbance will not have lasting, negative effects.

## How Do Plant Residues Combat Erosion?

Plant residues are corn stalks, wheat chaff, weeds, etc., left in the field after crops have been harvested for food. They provide effective erosion control by eliminating raindrop impact on the soil and reducing runoff, thus increasing the potential for water to move down into the soil.

The practice of leaving plant residues on the field is called mulching. Mulching helps prevent erosion; it is also particularly useful for protecting young plants from high temperatures and for contributing to soil fertility as the residues decompose.

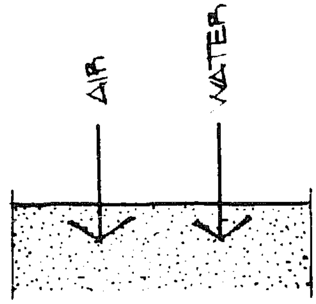
Mulch can be left on the surface, or it can be worked into the topsoil by plowing, discing or harrowing. When this practice is followed, the amount of organic matter in the soil increases and soil structure and water infiltration improve; on the other hand, working mulch into the soil reduces the percentage of surface cover and loosens soil so that it is somewhat more susceptible to erosion. Also, insect pests and fungal and bacteria diseases often thrive in the mulch and can be difficult to control.

The decision to plow plant residues into the soil or to leave them on the surface depends upon the quality of soil in the area, the amount of runoff normally seen, and the tillage practices.

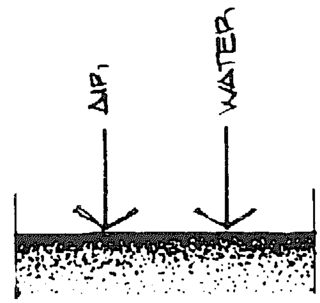
Obviously fullest protection from erosion is provided by not plowing mulch into the soil. Yet, even when mulch is worked into the soil, more soil can be saved than would be possible if mulch were not used at all. As a general rule, therefore, the most important factor is to design projects that keep plant residues in the field as mulch.

## What Are Improved Tillage Methods?

As agriculturalists are well aware, conventional tillage methods, because they result in a smooth seedbed, can leave soil open to erosion until the crops come up.

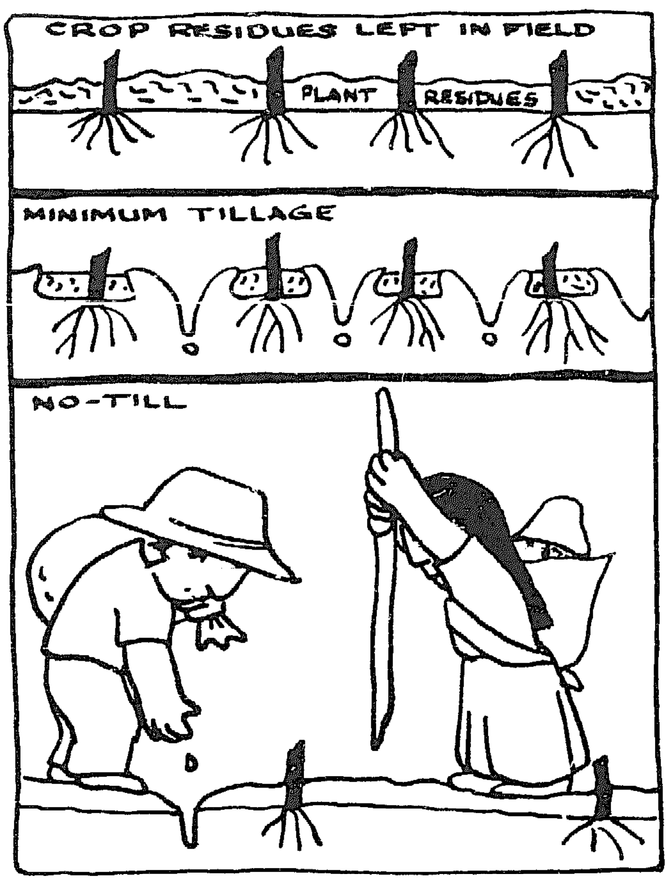


Air and water can penetrate the surface of the soil.



This soil is packed or compacted. Air and water cannot penetrate the surface.

Tillage methods can affect the runoff velocity of water, the amount and rate of infiltration of water into soil, and the degree of soil compaction. Compaction, which occurs naturally in soils with a high clay content and hampers root and plant development, can be made worse by use of heavy field machinery, thus further increasing the chances of erosion.




MINIMUM TILLAGE. Soil is worked as little as possible to produce crops under existing soil and climatic conditions. Fields are plowed, but other practices are omitted.

CONSERVATION TILLAGE. Plant residues are usually left in the fields to control weeds and to create as good an environment as possible for the growing crop while simultaneously conserving soil and water.

NO-TILL. Crops are planted directly into seedbeds left untilled after the last harvest. No-till is done by planting in narrow rows between previous crop residues. When plant residues are adequate to provide nearly complete surface cover, no-till planting can be the most effective year-round erosion control practice. While development workers who are also agriculturalists will be more familiar with these options, most who work with farmers in rural situations and plan projects should become familiar with using these practices or combinations of them. It is also necessary to keep up with advances which may be important to include in agricultural projects. For example, in many areas, these improved tillage practices have been hampered by lack of low-cost but efficient tools for planting through the plant residue. Now, however, new implements have been designed and tested; some of the best work in the area has been done at the International Institute of Tropical Agriculture in Ibadan, Nigeria.

## Does Crop Rotation Help With Erosion Control?

Crop rotation is one way to prevent or control soil erosion. Since the use of different crops in rotation reduces the amount of time a field is left without an adequate vegetative cover, erosion is reduced. In addition, if the rotation is planned wisely, certain crops can be chosen for their ability to assist the soil's resistance to erosion under succeeding crops. The greatest of these residual effects is derived from grass and legume meadows; because they are sod-forming crops, they provide cover and help build up the soil even when they are later plowed during conventional tillage. There may also be residual effects in rotations using non-sod-forming crops; for example, corn leaves soil less erodible than soybeans, but more erodible than small grains.. In addition to planting crops with different harvest times, crops can be planted between rows of permanent plant barriers such as broomstraw, elephant grass, or tree crops such as leucena.

## What Are Mechanical Support Practices?

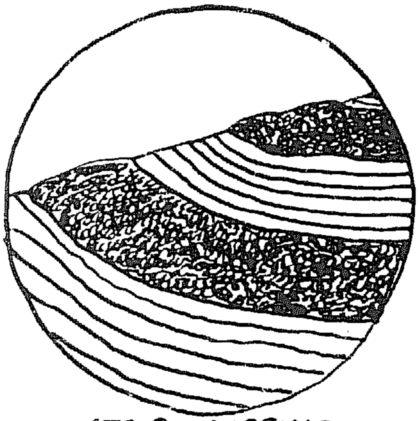
Mechanical support practices are those which require moving the soil, often by use of machinery. The most common practices--contouring, graded rows, contour strip cropping and terracing--are practiced when the slope of a field is long or steep. These practices reduce erosion by slowing down the velocity of water and, therefore, decreasing the scouring action. In semi-arid regions, these practices or variations of them can be used for conserving water.

CONTOURING. Crops are planted across, rather than up and down, the slope; this practice has the effect of creating ridges across the land which break up the flow of water thereby decreasing the velocity of the water moving down the slope. Because the water moves less quickly, erosion is reduced and the soil is able to absorb more water. However, plan and undertake contour planting carefully: used alone on a very steep slope or in areas of heavy rainfall and easily eroded soils, water can build up in each contour, spill over, and break across contour lines.

The volume of water builds up with each broken row, and the result can be more erosion, not less.

GRADED ROWS. Contoured rows are built up at the outer edges; this improves surface drainage and decreases the likelihood of rows breaking from water flow.

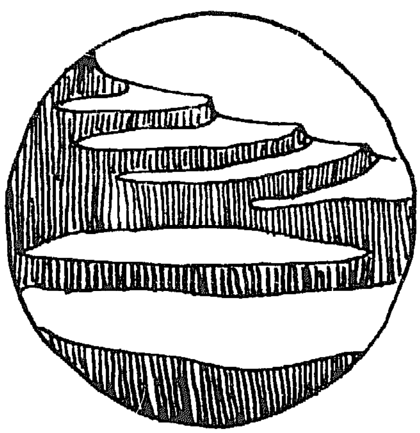
CONTOUR STRIP CROPPING. Contoured strips of crops are alternated to reduce the effect of row breakage. For example, sod and crops are planted in alternating strips: sod serves as a filter to control runoff and to catch much of the soil washed from a strip crop row. Strips structured close to land contours give good erosion control.



STRIP CROPPING AND CONTOUR PLOWING

TERRACING. Terracing is a very old practice used especially in mountain areas where there is little flat land for farming. Terraces, however, are costly to build and require constant maintenance. Used with contour farming practices, terraces are more effective for erosion control than strip cropping alone. Terraces can be very effective erosion control devices; they retain a great deal of the soil moved between terrace rows. Terraces are also used in semi-arid regions for conserving water.

## How Can Direct Runoff Be Controlled?



TERRACING

Erosion control practices usually will reduce runoff: control of runoff and the peak rate of flow reduce erosion-causing runoff.

Peak runoff rates can be decreased by lengthening the flow path and decreasing the slope of the land. Runoff volume can be reduced by measures, such as mechanical support practices, which increase the ability of soil to absorb water, improve surface retention (allowing more time for water to infiltrate the soil), and enable growing plants or plant residues to receive and hold the necessary amount of rainfall.

The decision on the best method for reducing surface runoff should be made carefully and in consultation with experts if possible: reducing runoff may result in some increase of sub-surface runoff and deep percolation. In areas where leaching is a problem, it may be better not to reduce surface runoff at all.

## What Are The Effects Of Soil Management/Erosion Control?

A heightened awareness of the relationship among soil, water, and methods for erosion prevention and control can be used to weigh effects in a given situation and as a basis for determining alternatives should they be necessary. The following questions are provided as a starting point for considering projects in which soil is a limiting factor due to erosion.

-- Would improved tillage practices provide better erosion control? If so, would there be obstacles--money, customs--or constraints to changing practices?

-- Are there signs that the site would be subject to wind or water erosion? For example, does the site have a steep slope? Is it a windy area without protective windbreaks? Is the soil light-colored due to loss of organic matter?

-- Are there periods during the year when the soil of the project site is unprotected by vegetative cover and subject to sheet, rill, or gully erosion?

-- Will the project cause silt to form in downstream water bodies such as streams, lakes, and reservoirs?

-- Will heavy equipment be used on the project site? It could damage the soil structure and leave the soil susceptible to erosion.

-- What is the major factor limiting agricultural production in the area? Is erosion a major roadblock to increased agricultural production? Or is poor soil the problem? Are these two problems related?

-- What are the social, cultural, physical and economic costs of erosion?

-- Can the project be set up to include a training course for local project participants?

-- What other soil management considerations might be part of this particular effort?

-- Are there alternative project designs which might minimize soil erosion at the project site?

## What Are The Alternatives?

Other specific, mechanical or improved tillage methods can be undertaken to protect soil from erosion. They include:

-- improving soil fertility

-- timing of field operations

-- plow-plant systems

-- grassed outlets

-- ridge planting

-- construction of ponds for runoff collection

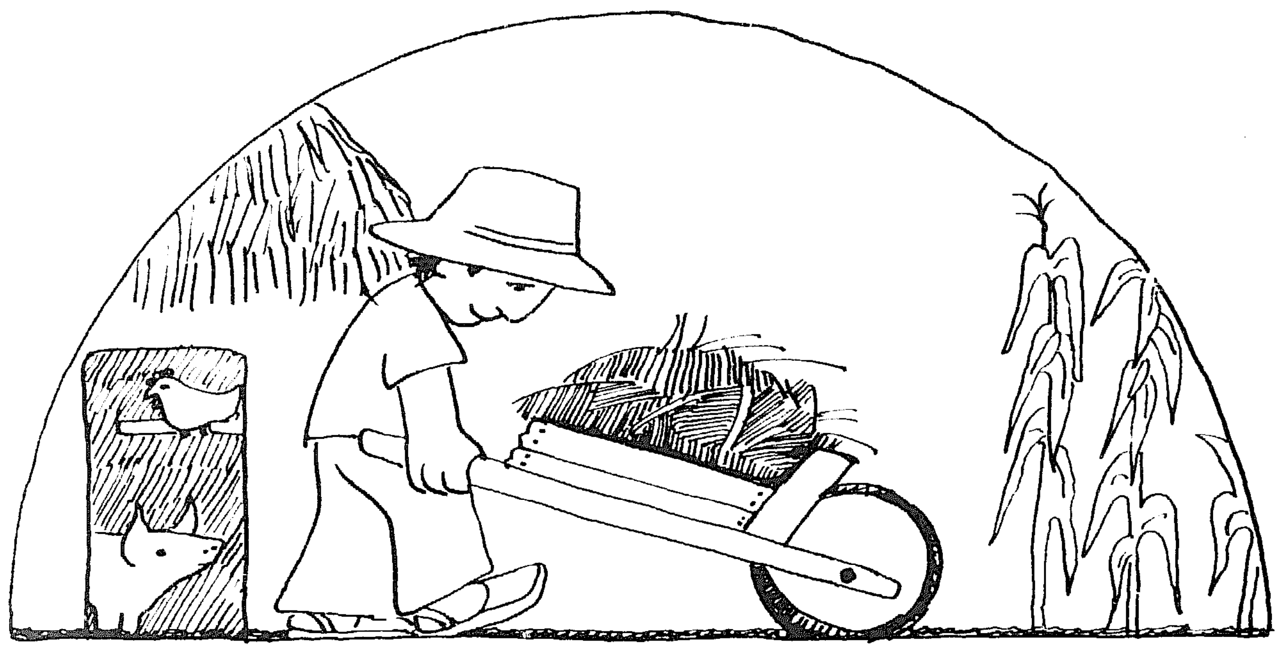
-- changes in land use

These practices are described in the following table which has been drawn up based on material from the US Department of Agriculture and the US Environmental Protection Agency. The left-hand column gives the name of the practice; the right-hand column describes the advantages and disadvantages of each as an erosion control method and describes the potential effects of such a practice. This presentation makes it possible to view all of these measures as a set of alternatives to be considered during the project planning process.

## EROSION CONTROL PRACTICES

| PRACTICES | HIGHLIGHTS OF PRACTICES |
|---|---|
| No-till | Most effective in grass, small grain, and in crop residues; reduces labor and time required for agriculture; provides year-round control. Not effective when soil is too hard to allow root development. |
| Conservation tillage | Includes a variety of no-plow systems to retain some residues on surface; more adaptable than no-till but less effective. |
| Sod-based rotations | Good meadows lose almost no soil and reduce erosion from next crop; total soil loss is greatly reduced but is unequally distributed over rotation cycle; aid in disease and pest control. |
| Meadowless rotation | Much less effective than above; provides more continuous soil protection than one-crop systems; aids in disease and pest control. |
| Improved soil fertility | Can reduce soil loss as well as increase production of crops. |
| Plow-plant systems | Rough, cloddy surface increases the infiltration rate and reduces erosion; seedlings may be poor unless moisture is sufficient; mulch effect is lost by plowing. |

| PRACTICES | HIGHLIGHTS OF PRACTICES |
|---|---|
| Contouring | Can reduce soil loss up to 50% on moderate slopes, less on steep slopes; not effective if rows break; cannot use large farming equipment on steep slopes; must be supported with terraces on long slopes. |
| Graded rows | Similar to contouring but less likely to have breaks in rows. |
| Contour strip cropping | Rowcrops and hay in rotation in alternate 50 to 100 foot strips reduce soil loss to about 50% of that with the same rotation that is only contoured; area used must be suitable for across-slope farming. |
| Terraces | Reduce erosion and conserve moisture; allow more intensive cropping; some terraces have high initial costs and maintenance costs; cannot use large machines; support contouring and agronomic practices by reducing effective slope length and runoff concentration. |
| Grassed outlets | Facilitate drainage of graded rows and terrace channels with little erosion; are costly to build and maintain. |
| Ridge planting | Reduces erosion by concentrating runoff in mulch-covered rows; most effective when rows are across slope; earlier drying and warming of root zones. |
| Contour listing | Minimizes row breakover; can reduce yearly soil loss by 50%; disadvantages same as contouring. |
| Change in land use | May be the only solution in some cases. Where other control practices fail, may be better to change to permanent grass or forest; lost acreage can be supplanted by intensive use of less erodible land. |
| Other practices | May use contour furrows, diversions, sub-surface drainage, closer row spacing, intercropping and so on. |



# 6. BACKGROUND FOR PLANNING: NUTRIENT MANAGEMENT

Nitrogen, phosphorus, potassium (NPK) and other nutrients are essential to plant growth. Planners of agricultural projects should have an understanding of how nutrients occur in the natural environment in order to understand at what point they can begin, or need to begin, to control the amount of available nutrients, while simultaneously protecting the environment from harmful effects of excessive nutrients.

## WHERE DO PLANT NUTRIENTS COME FROM?

There are six main sources of nutrients on crop lands:

### NATURAL SOIL FERTILITY

All cropland has a degree of natural fertility. Some soils, such as the flood plains of rivers, are usually very fertile and capable of holding moisture well. On the other hand, loose sandy soils, which contain little or no organic material, have almost no nutrients and are, therefore, not fertile. Project planners should seek those areas and sites having a good amount of organic matter in the soil.

### PLANT RESIDUES

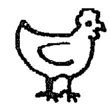
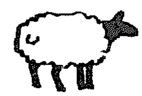
Leaves, roots, and other plant debris build up the soil structure by providing organic matter. As these materials decompose, stored up nutrients are released for the use of growing plants. The amounts of nutrients vary greatly depending upon the type of plant, temperature, rainfall, and whether the material is plowed into the topsoil or not. For example, if plant residues are being used for erosion control, it is best not to plow them under. If, however, they are being used primarily as nutrients, plowing under is recommended.

## ANIMAL WASTES

Animal wastes--primarily manure--are also organic matter which may be broken down by decomposers to provide nutrients to the soil. Manure has been used as fertilizer for centuries and has proven both useful and environmentally sound.

The nutrient content of manure depends upon the animal, the type of feed given, and the amount of water consumed by the animal. Project plans should include use of the type of manure that is most readily available. Only manure from healthy animals should be used: disease organisms which may affect humans may be carried in the animal's excrement. Extra precaution is necessary when using animal manures if these diseases are a problem in the area. Local authorities usually are aware of these problems and can be good planning resources. (Composting, as discussed on page 52, will kill the pathogenic bacteria, eggs and spores found in animal manures.) Other animal by-products which may be used for fertilizer are bone meal, blood meal, and fish meal.

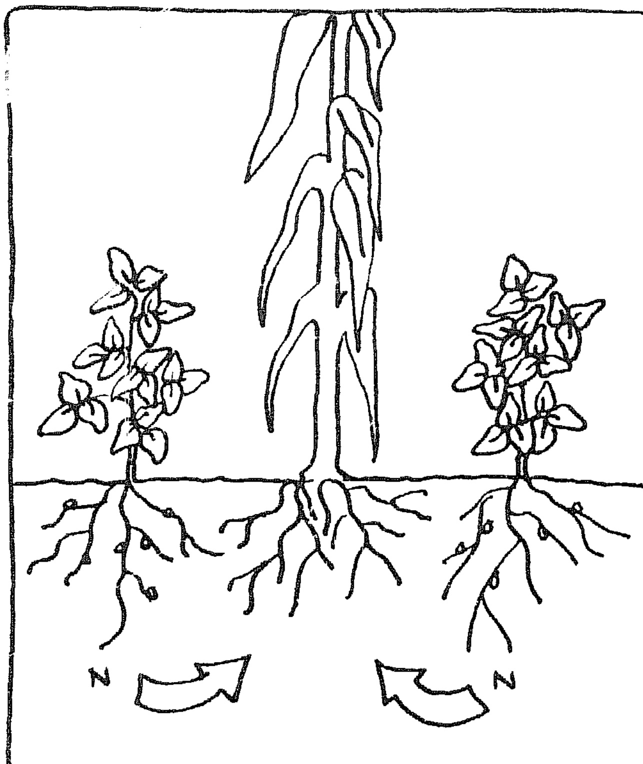
**NUTRIENT CONTENT OF MANURE**

| | % NITROGEN | % PHOSPHATE |
|---|---|---|
|  | 2.4 | 1.4 |
|  | 1.1 | 0.8 |
|  | 0.7 | 0.3 |
|  | 0.7 | 0.3 |
|  | 0.6 | 1.4 |
|  | 0.6 | 0.2 |
|  | 0.5 | 0.3 |

## LEGUMES

Legumes, plants such as peas, beans, and alfalfa, contain nitrogen-fixing bacteria in their root systems. This means that these plants incorporate (fix) nitrogen from the air in proteins which become available to plants when the bacteria die. The bacteria can fix enough nitrogen to support a grass and legume meadow if no other nitrogen source is available. The nitrogen usually is produced as the plant needs it; plants with poor growth, then, will not fix much nitrogen. If there is a high level of nitrogen available in the soil, the plant fixes less because it is not needed. (In this case, nitrogen is not a limiting factor.)

Legumes are often grown in a two-crop, intercrop, or crop rotation system to help aerate the soil as well as provide nitrogen for other plants. For example, peas and beans are often grown with maize in a mutually-beneficial system; such multi-cropping, or polyculture, practices can reduce or eliminate the need for chemical fertilizers and keep nutrients in the soil where they belong. This is an important point to consider when planning. It is always best to use natural fertilizers rather than chemical ones.



INTERCROPPING BENEFITS CROPS WITH HIGH NITROGEN DEMAND

In addition to their compatibility in the field, maize and legume combinations complement each other nutritionally; by eating both, human beings can receive nearly their complete protein requirements--without adding meat or dairy products. Other plants have similar relationships, both symbiotic and nutritional. Very often traditional crop patterns and choices turn out to be the best use of the land as well as the best combination for providing essential proteins for human diets. Development workers planning projects to introduce new species should consider the plant's ability to obtain nutrients from existing conditions and to provide, in combination with other crops grown locally, adequate nutrition in the diet.

## PRECIPITATION

Rainfall can also provide nitrogen and phosphorus to cropland, but in very low amounts compared to other sources. The nutrient content of precipitation is influenced by the weather, presence of industry, cities, disposal sites, power plants, feedlots, etc. For example, phosphates which may be present in dust, ash or smoke, are made available to plants when dissolved in rain.

## INORGANIC FERTILIZERS

Inorganic fertilizers consist of chemicals with little or no organic matter. Chemical fertilizers supply nutrients that are readily available right after application, in amounts and ratios that are more readily controlled.

However, inorganic fertilizers are expensive and do little to improve the structure of the soil. Many farmers have difficulty calculating how much chemical fertilizer to apply. This can lead to over-fertilization and even greater costs. Since plants can only use so much fertilizer, too much may actually reduce the growth of crops by harming the microorganisms in the soil, or the plants themselves.

## WHICH SOURCE OF NUTRIENTS IS BEST?

The "best" choice depends on the situation. Even soils which are naturally very fertile can have their nutrients depleted by continuous plantings of crops.

The need for the addition of fertilizer--anything added to the field to increase the natural fertility of the soil--depends on:

-- ability of the soil itself to provide essential nutrients to crops (soil fertility);

-- nutrient demands of the crops;

The choice of fertilizers depends on their availability and costs.

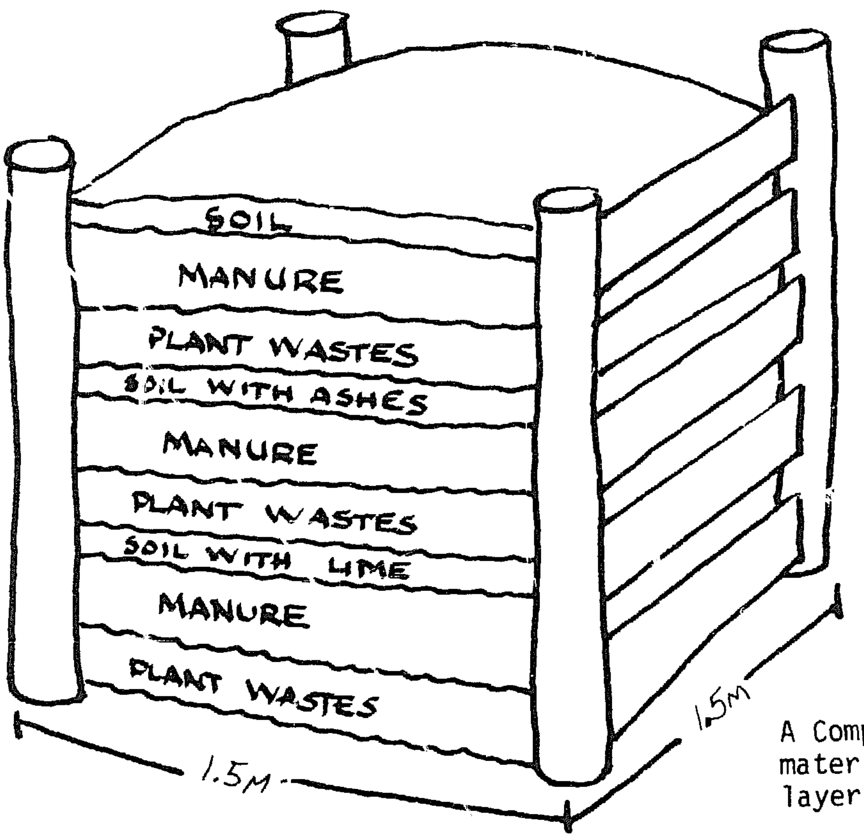

Whether nutrients are organic or inorganic does not matter to the plant; it can use them no matter how they are derived. But because the effects of inorganic fertilizers often are unknown for some time, and because they are hard to get and/or expensive, planners should try to incorporate the use of organic fertilizer in projects wherever possible. Potential organic fertilizers exist wherever there are animal and plant wastes. They do not cost anything and they build up the organic content of the soil. In the warm, moist soils of the humid tropics, organic matter decomposes rapidly so that its nutrients are available quite quickly. One of the best practices for fertilizing with organic materials is composting.

COMPOSTING

-- uses waste materials and costs little or nothing

-- can yield organic matter for fertilizer within several weeks, depending upon the ingredients used, the climate, etc.

-- generates heat sufficient to kill eggs, larvae, bacteria, and other pathogens which may cause disease in humans if wastes are used directly.




A Compost Pile. Organic materials are added in layers and kept moist.

In many countries, composting of some form or another is practiced traditionally. Examination of local methods can provide good guidelines for project planning in terms of available ingredients, length of preparation time, receptivity of residents to the practice, and so on.

## How Does The Environment Affect Fertilizers?

Both fertilizers and naturally occurring nutrients are subject to all the natural processes that tend to reduce nutrient levels--leaching, runoff, and erosion.

If these processes can be halted or slowed, the chances are greater that the nutrients present in the soil and those placed in the soil in the form of fertilizers will remain available for plant growth. And, to state the reverse, ensuring that nutrients, particularly inorganic fertilizers, remain in the soil for crop use lessens the likelihood of a damaging effect on the larger environment.

### LEACHING

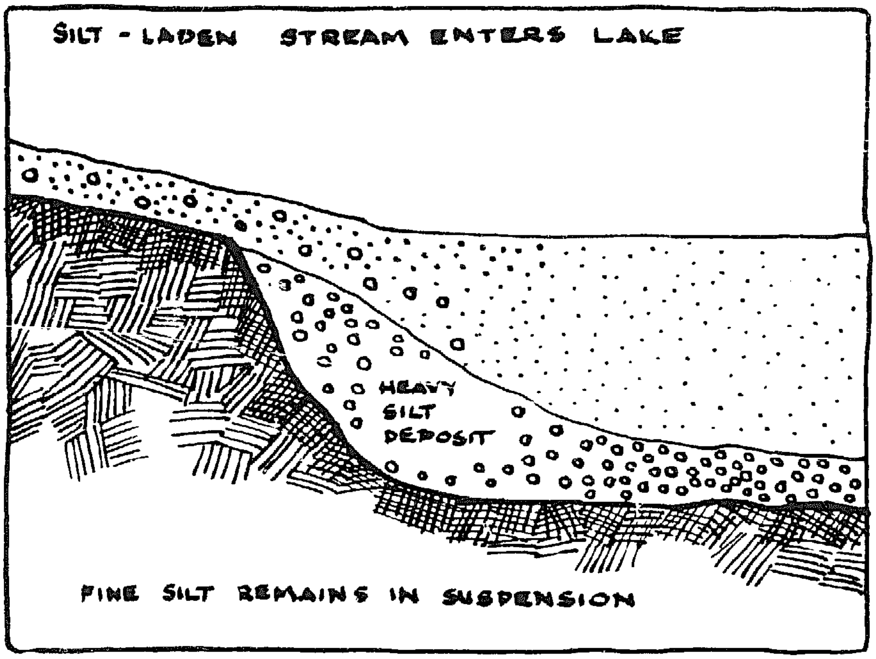
Leaching is the process in which soluble chemicals are dissolved and removed from the soil by water that is percolating through or running off the soil. Nitrates are the principal nutrient form found in drainage waters from leached areas. Leaching from cropland depends upon the type of crop grown, as well as the soil type and soil characteristics.

### RUNOFF

Runoff usually occurs when it rains so hard and fast that the ground cannot absorb the moisture fast enough. When fertilizers are left on the soil surface, the first rainfall can carry away a substantial portion of the nutrients in the fertilizer. But if fertilizer can be applied before a time of heavy rains and potential runoff, there is much greater chance that light rains will be able to move the fertilizer into the soil and for water in the soil to dissolve the fertilizer. The loss of fertilizer is much less if the fertilizer has been incorporated into the top few inches of the soil before rains begin. Nitrates, being very soluble, are leached into the soil with the first part of a rainfall. The concentrations of nutrients in runoff will vary greatly from field to field, depending upon soil characteristics and crops grown, and will vary from storm to storm depending upon how soon after fertilization rainfall occurs and how heavy the rain is. Organic fertilizers mixed with the soil increase the soil's capacity to absorb water.

### EROSION

Erosion is the major transport process for phosphorus and organic nitrogen adsorbed on sediment particles. Sediment transport depends upon the volume and velocity of water flow in a field. When the velocity of water is reduced, the large particles of sediment fall out of solution. The remaining sediment is usually finer and has a higher capacity (more surface area for adsorption) to adsorb phosphorus, so that transported sediment is richer in phosphorus and nitrogen than the original soil.




Organic matter is often transported along with sediment, causing further nutrient losses from the fields. Nutrient losses from cropland can be controlled by proper management practices such as those described in Chapter 5.

Environmentally sound erosion control will generally result in sounder control of nutrient losses. For example, leaving plant residues on a field can reduce erosion and at the same time provide nutrients to the field and thereby reduce the need for inorganic fertilizer. Other soil management/erosion control methods, such as crop rotations with sod, contouring and terracing, can reduce nutrient losses as well. It is necessary for the planner to investigate control measures from all points of view. Nitrate leaching, for example, may be increased in no-till systems because runoff is sometimes decreased (water is able to infiltrate the soil).

## What Are The Effects Of The Movement Or Loss Of Soil Nutrients?

Nutrients, including fertilizers, when transported into groundwater or surface water bodies, may result in two problems:

- -- nutrients may reach toxic levels and become a health hazard to humans and animals
- -- when added to water, nutrients may accelerate the eutrophication rate to the extent that it becomes harmful to the environment (eutrophication is the enrichment of water by nutrients and the resulting increases in growth of aquatic plants).

### HEALTH EFFECTS

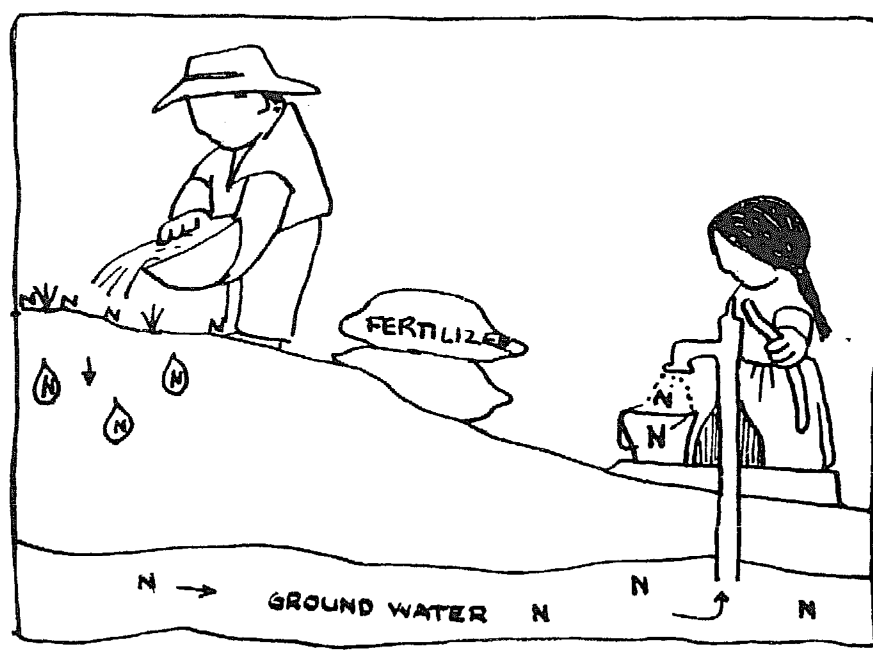
Fertilizers usually contain nitrogen, phosphorus, and potassium. Of these, nitrogen in particular has been associated with health problems when used incorrectly. Nitrogen, which occurs as nitrites, nitrates, and/or ammonia, may be converted to another form by chemical reactions occurring naturally in the environment.

Nitrites. The nitrite form of nitrogen is very toxic; if taken by humans in drinking water or in food, it enters the bloodstream where it interferes with the blood's ability to carry oxygen. Nitrites can also combine in compounds that may cause cancer in humans.

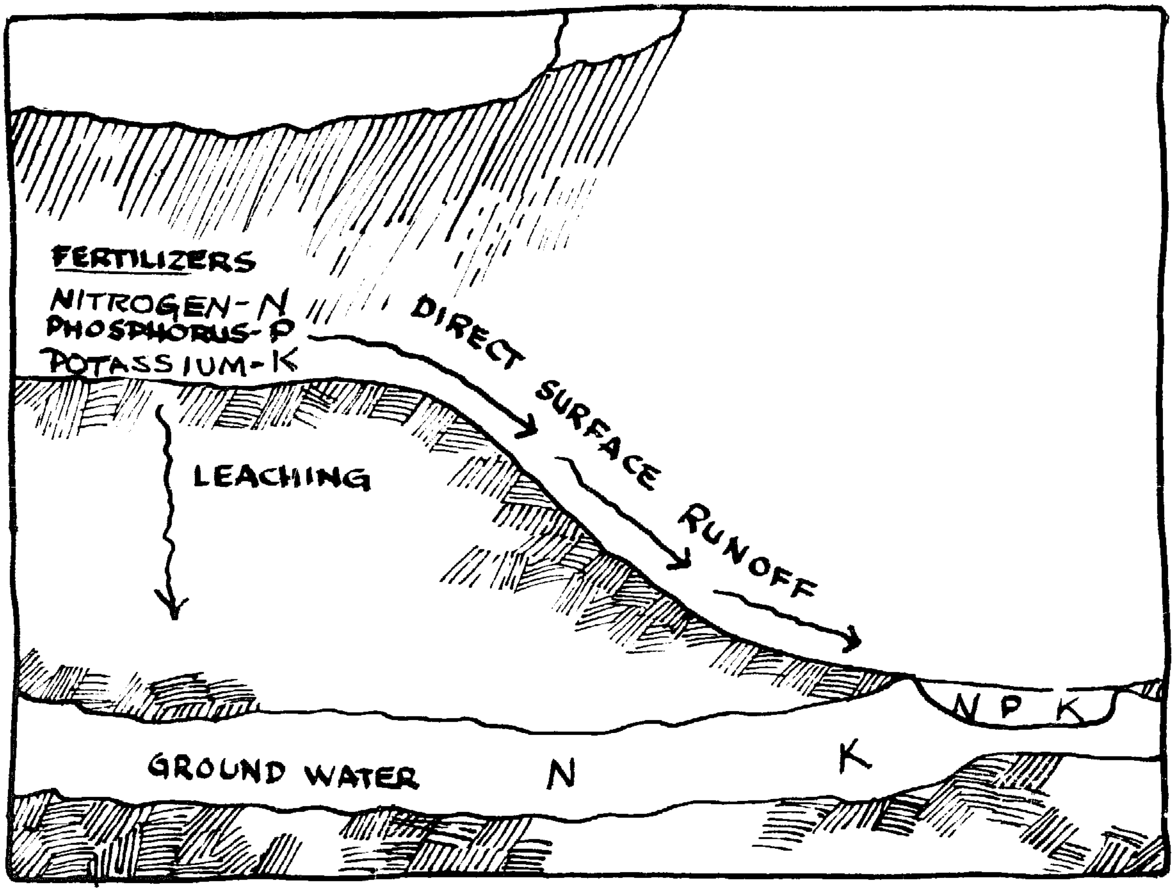
Nitrates. Nitrates are five to ten times less toxic than nitrites; healthy, mature animals with single stomachs are able to expell nitrates in their urine. However, cattle, young animals, and children can convert some nitrates to nitrites in their stomachs, a condition which can be harmful.

Both nitrites and nitrates occur naturally in foods and water, but only in small amounts. And only small amounts can be tolerated by humans. The World Health Organization has fixed the Drinking Water Standard for nitrates at 0 to 50 parts per million (ppm) as recommended dosages, and 50 to 100 ppm as acceptable. In many developing countries, however, these levels are exceeded, especially where drinking water supplies are contaminated by nearby concentrations of nitrogen, such as manure piles in farm barnyards.

Obviously project plans must include consideration of fertilizing practices in terms of the location of compost piles, manure accumulations, and slope of fertilized fields in relation to housing and water supply.




Ammonia. Ammonia, like nitrate, can be converted by specialized bacteria to toxic nitrite. Ammonia occurs naturally; it is generated by microorganisms as they break down organic matter on the bottom of stagnant lakes. Dissolved ammonia can occur at levels that are toxic to fish. Another problem with nitrogenous fertilizers is that the addition of a common fertilizer, sulfate of ammonia, may acidify an already acid soil; however, this may benefit a basic soil.

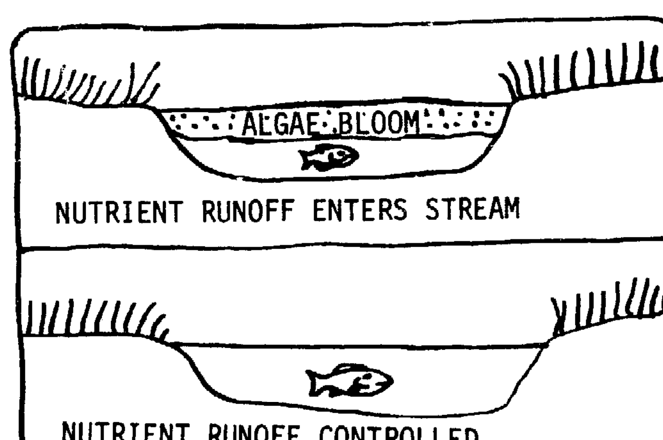



Phosphorus. Phosphorus usually enters water as a soluble phosphate compound which is completely available for algae growth. Phosphate may also enter the water adsorbed on sediment or on particles of organic matter; phosphates are then slowly released. These phosphates then contribute to problems associated with eutrophication.

Eutrophication. Eutrophication is enrichment of water by nutrients, and the resulting increases in growth of aquatic plants. When nitrogen and phosphorus enter the water in high levels as a result of runoff or other transport methods from agricultural lands, the limits to algae growth are removed and algae populations can explode.

Algae can:

- -- clog the screens of water treatment systems
- -- cause taste and odor problems
- -- create obnoxious conditions in impounded water such as small ponds.



This rapid growth of algae is the most widespread and the greatest eutrophication problem. When these massive populations suddenly die off, their decomposition releases substances and depletes oxygen levels in the water, both of which can be harmful to fish.

## HOW CAN ALL THESE NUTRIENT-RELATED FACTORS BE MANAGED?

Erosion control practices may be all that is needed to control the sediment-associated loss of phosphorus and nitrogen. However, if the area is losing nutrients dissolved in runoff, other practices may be necessary. For example, some combination of nutrient management practices--fertilizer management, crop rotation, legume cropping--should be looked into.

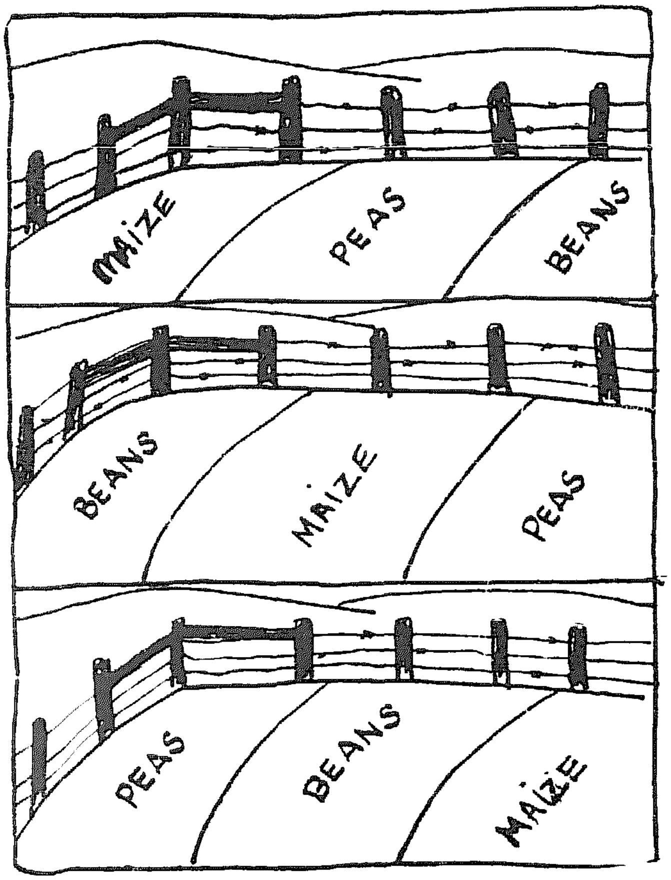
Planners must be careful that solving one problem does not creat another. As an example, in certain areas of the state of Texas, USA, terraces were built to retain moisture. While the terraces did hold water, this moisture control caused nitrate leaching, which contaminated the groundwater supplies of the area.

### MANAGING FERTILIZATION

To prevent the buildup of nutrients in soil and their subsequent loss through leaching, farmers should apply only the needed amount of fertilizer to croplands. Because it is hard to determine the amounts of nutrients needed on a field, many people tend to over-fertilize to make sure that the plants have enough nutrients. The best way to prevent over-fertilization and the leaching that results is to estimate the need for fertilizers and apply only that which will be used by the crop.

Another way to manage the use of fertilizer is by waiting several weeks after the plant emerges until the seedlings are a few inches tall, and applying the fertilizer in between the rows. The effects of fertilizers are greatest when fertilizer is applied near the time of fastest vegetative growth, that is, several weeks after the plant emerges from the soil. In this kind of application, less fertilizer is used and that applied is used more efficiently. Another way is to put half the fertilizer on the field at one time early in the growing season and the rest later.

Project planners who are not agricultural experts will probably want to consult others for advice on actually choosing fertilizers and using them in crop production: local farmers, extensionists and agricultural experts all have years of experience in determining what kind and how much fertilizer is needed.

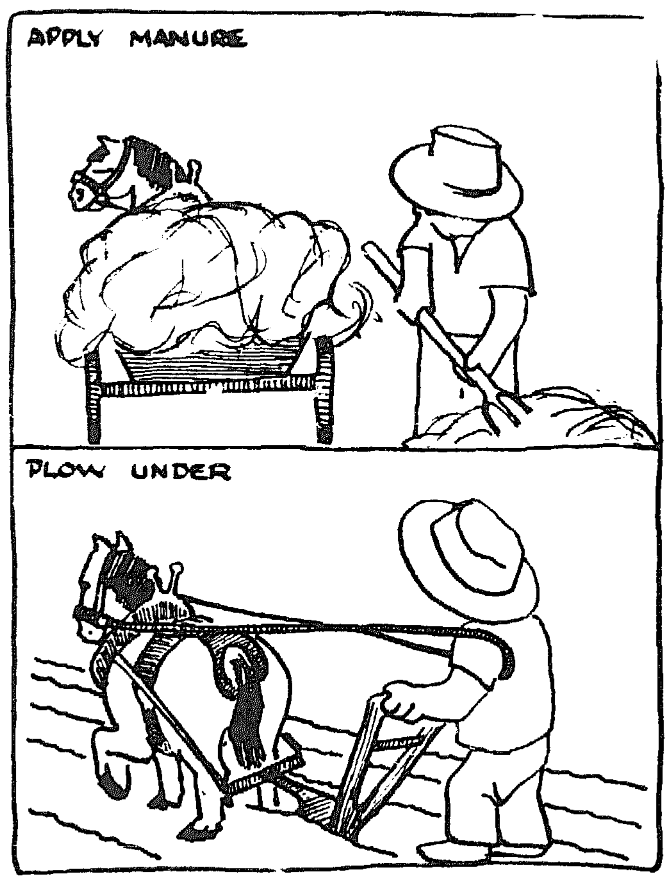



## USING CROP ROTATIONS

The average amount of nitrogen fertilizer needed on fields can be reduced by rotating crops. Crops that require high nitrogen levels, such as maize, sorghum, and cotton, can be rotated with legumes such as soybeans or alfalfa, or with crops that require only small amounts of nitrogen such as small grains. Crops can be alternated by growing season to reduce the need for other fertilizers.

## USING ANIMAL WASTES

Animal manures are very good fertilizers, but there are problems associated with them. It is best to use the manure when it is fresh, but this cannot always be done; storing manure is difficult and costly. It is also difficult to determine how much nitrogen is being applied when animal wastes are used, especially since the nitrogen amount varies with the animal and its diet. The best way to use animal manures is to prevent the nitrogen from leaching out by plowing it into the soil directly or adding it as a slurry so it soaks into the soil. One of the advantages of animal wastes as fertilizers is that they release nitrogen slowly and leave little available for leaching.



## PLOWING UNDER GREEN LEGUMES

Before chemical fertilizers were developed many farmers would grow a legume on a field and then plow it into the soil to serve as a nitrogen source for later crops. The main disadvantage is an economic one--no crops can be harvested from the field that season. However, compared with the cost of using chemical fertilizers and their potential impacts upon the environment, this practice is useful when a farmer has enough land to leave fields fallow. In areas where chemical fertilizers or animal wastes are not available, this might be a good way to increase soil nutrients and something which project planners should consider.

## CONTROLLING SURFACE APPLICATIONS

The type of fertilizer must be chosen carefully, and it must be applied at the right time. For example, nitrogen, which moves quickly through the soil, should be applied just before or during the growing season. Phosphorus and potassium fertilizers can be applied after the growing season or sometime before the next one. It is usually best to incorporate fertilizers into the soil right after application to prevent loss of nutrients from wind and water.

# WHAT ARE THE EFFECTS OF NUTRIENT MANAGEMENT?

By asking and answering questions such as these for each project and site, the development worker will have a good idea of the potential effects of projects. If the answers are not readily apparent, go back and think about the project site again. Be sure to consult local experts in the field if the answers point out major problems. Use the questions as guidelines to help plan projects that will be both environmentally sound and successful.

-- Is manure available for use as a fertilizer in the project? If used, could this practice result in the spread of disease through human contact with the manure?

-- Will plant residues be used for fertilizers and soil structure enhancement? Is care being taken to avoid the spread of plant diseases?

-- Will the project involve the introduction of new plant species or varieties? If so, this could have very great long-term environmental repercussions and the potential effects should be carefully reviewed.

- Could the new species outcompete traditional crops in the region?
- Do the new varieties need more fertilizer than traditional crops?
- Will the new varieties require more pesticide use, and/or the use of heavy farm machinery which could lead to other problems?
- Could new pest species be introduced into the region along with the new crop?

-- Will the project involve the use of inorganic fertilizers?

- Could this practice lead to nitrite or ammonia toxicity to man or animals?
- Are precautions being taken to avoid over-fertilization which can burn plants, kill soil organisms, and cause soil acidity?

-- Could the project result in the transport of nutrients off the site via runoff, erosion, or leaching?

-- Could nutrient transport cause algal blooms, growth of aquatic vascular plants, and ultimately oxygen depletion in water bodies?

-- Are there other nutrient management considerations?

-- Is the success of the project highly dependent on inorganic fertilizers? If so, do farmers have a reliable source? What are projected costs of fertilizers over length of project?

-- Are appropriate management techniques incorporated into the project design to minimize nutrient losses? See below, Control of Nutrient Losses.

-- What alternative project designs could be used at the site to minimize nutrient loss?

## WHAT ARE THE NUTRIENT CONTROL ALTERNATIVES

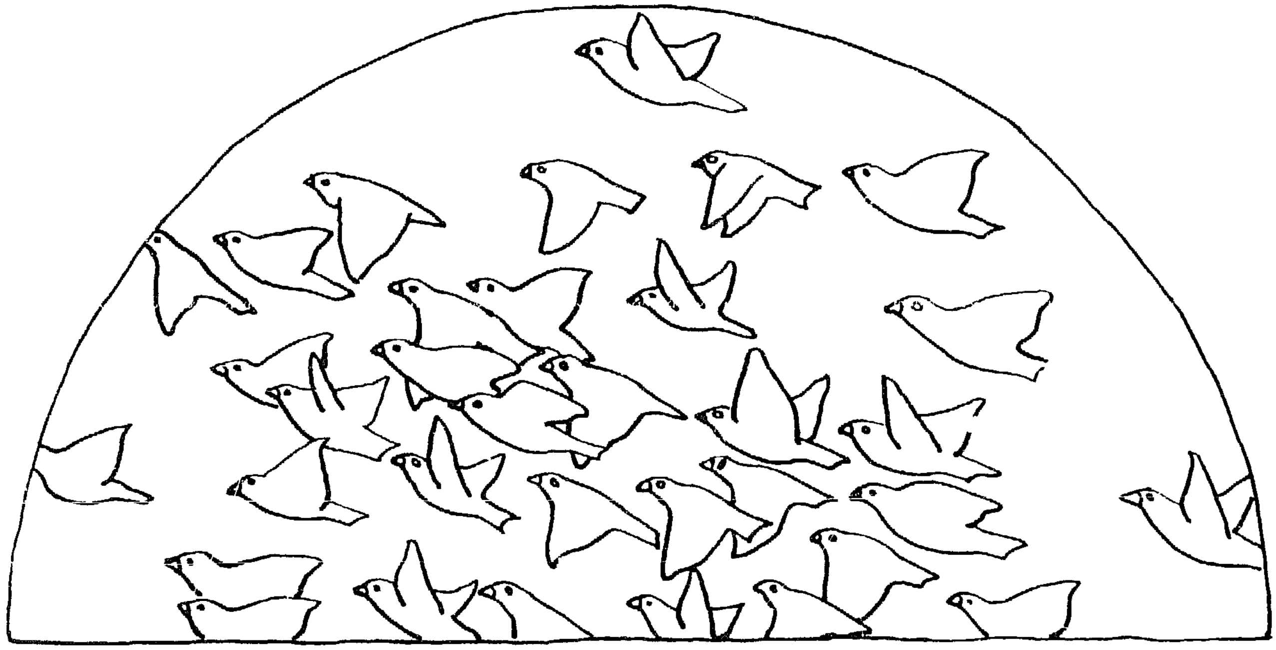
The following table lists ways to manage nutrients in agricultural projects. The left-hand column names the practice; the right-hand column describes the advantages, disadvantages, and potential effects of each as a nutrient control method.

CONTROL OF NUTRIENT LOSSES

| Practice | Advantage/Disadvantages |
|---|---|
| Timing nitrogen application | Reduces nitrate leaching; increases efficiency of nitrogen use. |
| Rotating crops | Reduces nutrient input; reduces erosion and use of pesticides. |
| Eliminating excessive fertilization | Reduces cost of fertilizers; can cut nitrate leaching; |
| Using animal wastes | Enables slow release of nutrients; economic gain for small farms; improves soil structure; spreading problems. |
| Plowing under green legume crops | Reduces use of nitrogen fertilizer; not always possible; amounts of nitrogen difficult to determine; ties up available land. |

| Practice | Advantage/Disadvantages |
| --- | --- |
| Controlling fertilizer release time | May decrease nitrate leaching; not yet economically feasible. |
| Incorporating surface applications | Decreases nutrients in runoff; may add costs; not always possible; no effect on yields. |
| Timing fertilizer plow-down | Reduces erosion and nutrient loss; may not be convenient. |

Adapted from: Control of Water Pollution from Cropland, Volume I - A manual for guideline development. November 1975. US Department of Agriculture Agricultural Research Service and the Environmental Protection Agency, Office of Research and Development



## 7. BACKGROUND FOR PLANNING: PEST MANAGEMENT

Changes in the types of crops grown or the methods used can lead to changes in the numbers or kinds of pests and predator organisms in the agricultural ecosystem. Planning environmentally sound agricultural projects requires looking beyond the types of pests and predators and considering how measures used to control pests will affect the ecosystem. Too often failure to take this broad approach has resulted in damage to the environment--and in less than successful projects.

In many agricultural projects, pests are controlled only by use of chemical pesticides; however, some chemical pesticides can create environmental problems as a result of their long life--both in the soil and in living organisms. In a small-scale project, it may be possible to control pests by using less damaging alternatives such as promoting natural predators, planting different crops, using less persistent and less toxic pesticides, or finding more species-specific pesticides.

Larger pest species, such as birds and rodents, cause great damage in agricultural systems by competing directly with man for food crops. Various methods can be used to control these pests--from scarecrows and netting to trapping and killing them individually. However, it is more common to poison these animals, even though poisoning is potentially a far more dangerous practice. Whenever possible, trapping and other mechanical control practices should be used to control larger pests. The decision not to use pesticides protects human beings and other non-target species from the poison, which could affect them as well.

## What Is Pesticide Persistence?

Pesticide persistence is the length of time a pesticide remains biologically active, or toxic, to target pests. Most pesticides are rated according to their persistence, as shown below:

### PERSISTENCE OF PESTICIDE CHEMICALS

| | Duration of activity | Chemical Group | Examples |
|---|---|---|---|
| Non-persistent | 1 - 12 weeks | Organo-phosphorous compounds<br>Carbamates | malathion, methyl parathion, parathion<br>carbaryl |
| Moderately persistent | 1 - 18 months | -- | 2, 4-D, atrazine |
| Persistent | 2 - 5 years | Organochlorine[1] compounds | DDT, BHC, lindane, aldrin, dieldrin, endrin, chlordane, heptachlor, campheclor |
| Permanent (residues) | Degraded to permanent residue | Compounds containing mercury, arsenic or lead | phenyl mercury acetate, arsenate of lead |

[1] A number of organochlorine compounds are in the "non-persistent" or "moderately persistent" classifications, e.g. methoxychlor, dicofol, chlorobenzilate.

In general, persistent pesticides (those which rema n biologically active for longer periods) are less soluble and volatile but have a strong tendency to become adsorbed. For example, if DDT, which is an extremely persistent pesticide, were being carried by water through an organic or clay soil, the soil would extract DDT from the water.

## What Other Factors Should Be Considered Before Applying Pesticides?

Local Experience. Pesticides vary in persistence and potency, and even these may vary for the same pesticide depending upon local conditions. Check with local farmers or extension agency personnel to see what previous experience has been with given pesticides.

Alternative Pest Control Measures. Before going ahead with chemical pesticides, become familiar with possible effects of their use (page 67) and check the variety of alternative control measures which may meet project needs without harmful effects. Some of these alternatives are described in this chapter beginning on page 70.

Synergism. When two or more pesticides are applied at the same time, their combined toxicity may actually be greater than the sum of their individual toxicities. Consider the possibility of such synergistic relationships before applying two or more chemicals to a field.

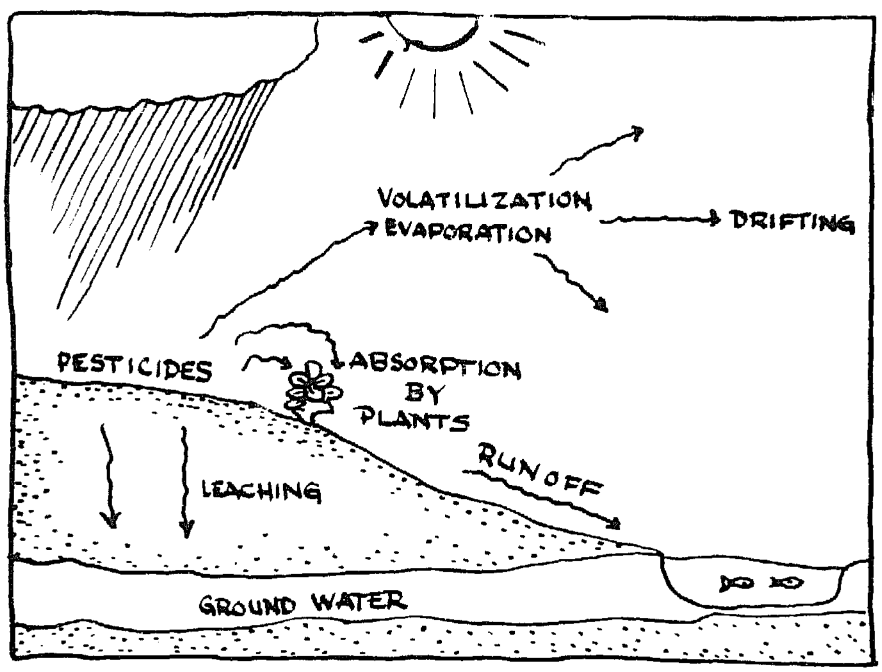
Timing of Application. If possible, apply pesticides well before heavy rains if they are to do most good toward controlling target organisms. The rate at which pesticides are washed off the land is usually high at first; much is lost with the first rain. This loss rate then decreases and finally steadies until changed suddenly by weather, soil, temperature, soil moisture level, acidity, and cultural practices. Some pesticides have greater losses if they are applied to wet soil rather than dry, especially if runoff occurs soon after application. When pesticides are incorporated into the soil, the loss to runoff is not as great as when they are just left on the soil surface.

Pesticide Movement. Cropland often is at some distance from open water; however, runoff travelling from cropland to the open water carries pesticides. As the water crosses other lands, some pesticide is left behind. While the total amount entering the water is decreased, nearby land may also be contaminated by pesticides. This pollution can have damaging impacts on animals and humans. Knowledge of the ways in which pesticides move through the environment can be used to design projects in which there is no room for unexpected pollution.

## How Do Pesticides Move About The Environment?

PESTICIDE PATHWAYS

Pesticides are applied to agricultural lands either in liquid or powder form. Both forms can be sprayed on the soil. During application, some of the pesticide is lost to the air through drifting or volatilization; after application, pesticides may be carried into the environment through a number of pathways.



-- biological or chemical degradation on the soil surface or foliage as a result of sunlight

-- evaporation

-- absorption by plants (which may be eaten by animals and/or humans)

-- adsorption onto soil particles which move off the land in erosion

-- dissolution in water (rain or irrigation); moves away in surface runoff or infiltrates the soil, later appearing in surface water or groundwater supplies.

Pesticides take one pathway rather than another depending upon the characteristics of the pesticide itself, the type of soil, the strength and amount of rainfall, the type of erosion control measures being used and the temperature. In general, pesticide compounds which are more water-soluble and less persistent will move primarily in runoff water; those that are more strongly adsorbed to soil particles will move mostly in sediment.

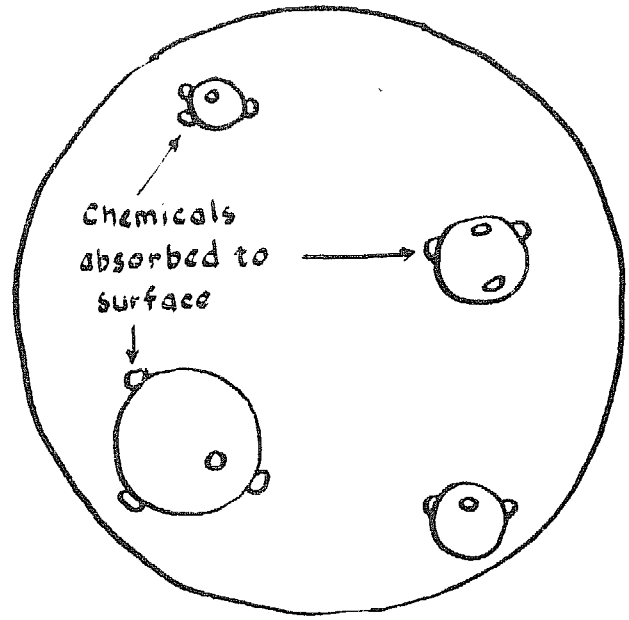
## DISTRIBUTION IN SOIL

Organic content is the most important soil characteristic influencing the way pesticides diffuse or separate into soil and water. Other properties--acidity, moisture content, temperature, mineral content--may also influence pesticide movement. Water and pesticides compete for adsorption sites on soil particles; therefore, as moisture in the soil decreases, the amount of pesticide adsorbed may increase. Pesticides in the soil are subject to leaching. Leaching of pesticides is influenced by the amount and rate of water flow, and the formulation, concentration, and rate of degradation of the pesticide. Pesticides may move laterally through soil as well, appearing in surface or subsurface runoff.

## DISTRIBUTION IN WATER

The quantity of a pesticide that moves into a water course from treated areas depends upon topography, intensity and duration of rainfall, soil erodibility, and land management practices. Improved erosion control practices can be very important to efforts to keep pesticides from entering the larger environment. Sound project planning requires consideration of the methods for erosion control in light of their applicability for pesticide control.

If a pesticide does enter a water body dissolved in water, it will move as the water moves. The pesticide may remain in the water, precipitate out of the water, be taken up by aquatic organisms or be biologically or chemically degraded. Pesticides adsorbed on sediment will distribute with the sediment. The finest particles (those carrying the greatest concentration of pesticide) will be transported the farthest and will typically be the last to settle out of the water in lakes or quiet water.




SOIL PARTICLES IN WATER

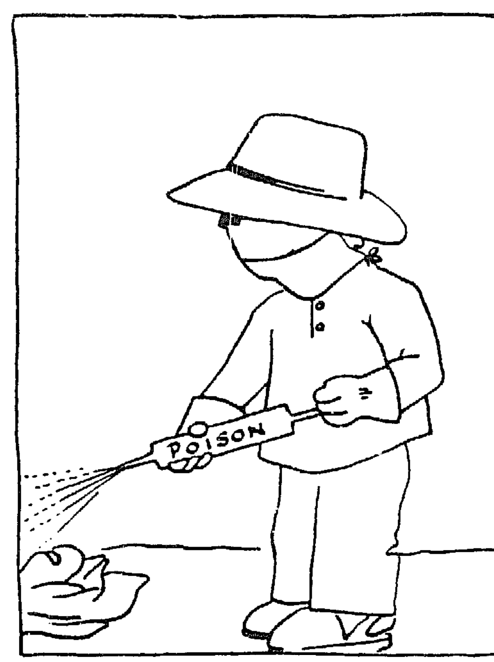
Until they chemically degrade, pesticides will not disappear. Because the system is dynamic, even those deposited in bottom muds may be later churned up and carried downstream. Also, pesticides continually desorb from muds back to the water. Once in the water, the pesticides may reach the surface and volatilize or be degraded by sunlight. On the bottom of a water body there is often a lot of microbial activity in the organic matter; biological decomposition consumes oxygen, creating anaerobic conditions which favor the degradation of many pesticides.

If pesticides must be used, try to use those which will degrade as soon after they have done their job as possible. Use pesticides that degrade rapidly in water in order to protect nearby aquatic environments. Also, keep in mind that the products of pesticide degradation may be toxic: consult an organic chemist to discuss the full range of products that may result from the application of a given pesticide chemical.

## What Are The Major Effects Of Pesticide Use?

### EFFECTS ON THE HUMAN ENVIRONMENT

Pesticides can be inhaled by humans or taken into the body through the skin. Body contact is a particular problem during the application of pesticides. Failure to take safety precautions and to handle certain pesticides carefully may even result in death. Other effects on the human environment occur because of contamination of water and food.




### EFFECTS IN THE SOIL

Each square meter of agricultural soil, if it is fertile, can contain millions of life forms--insects, earthworms, oligochaete worms, nematodes, protozoa, algae, fungi, bacteria, and yeast cells. These plants and animals are absolutely necessary for soil fertility--to convert nutrients into forms available to the plants and to break up and aerate the soil. Continuous use of pesticides which do not decompose rapidly can alter this soil microorganism community and, ultimately, may reduce soil fertility.

There can be other effects of altering the soil microorganism community. Many insect pests are killed routinely and thus kept under control by soil microorganisms. Overuse or misuse of pesticides can interfere with this natural control system. When this happens, pest problems can actually be worsened: the pest may develop resistance to the pesticide, and since natural controls have been eliminated, the pest populations can be virtually uncontrolled, at least for a time.

Remember that many pesticides kill not only target species but other harmless or beneficial organisms such as honeybees, insect parasites or predatory insects. In addition, excessive application of pesticides may prevent beneficial organisms from reproducing and, in the long run, from continuing to exist.

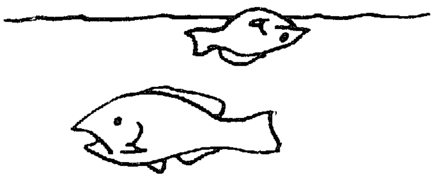
## EFFECTS ON THE AQUATIC ENVIRONMENT

Pesticides transported from treated fields into the aquatic environment by runoff and erosion are distributed throughout the water, the muds, and the organisms living in both. The concentration or buildup of pesticides in a given body of water depends upon:

- -- how much pesticide is entering the aquatic system;
- -- the persistence, or length of life (or toxicity) of the pesticide;
- -- the tendency of the pesticide to bioaccumulate, or build up within an organism;
- -- the sites or organisms in which the pesticide concentration is being measured.

Responses of Aquatic Organisms to Pesticides. The responses of organisms to pesticides may be difficult to predict. Very high concentrations can kill organisms outright--that is the hoped-for result of applying pesticides in the fields. In the aquatic environment, however, the responses of organisms can vary greatly according to the amount and depth of water, dissolved salt content, acidity, temperature, and type of organisms living there.

Contamination may cause outright mortality in eggs, juveniles or adult organisms; often it causes other less easily seen



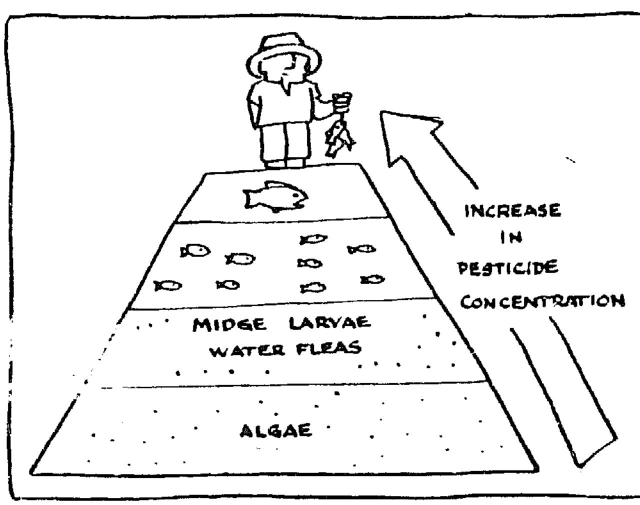
problems. The effects of pesticide use on the aquatic environment can go unnoticed for some time. The aquatic environment is another area of expertise entirely and it is hard to remember to take the time to look at the effects use of pesticides in a project would have on fish in local waters.

The toxicity of a pesticide to fish depends upon 1) the size, age, and species of the fish; 2) water temperature and acidity; and 3) physical differences in sites.

Survival times for fish in polluted waters are usually correlated with body weight, although some fish can and do develop resistance to pesticides. Fish deaths do occur in nature after long-term exposure to low levels of pesticides; more importantly, such low levels can actually cause disease in fish that live--such as lesions, eye abnormalities, and injury to organs. Some pesticides also have bad effects on the hatching process, on fry and fingerling growth, and on behavior; for example, some fish have shown unusual sensitivity to low water temperatures as a result of pesticide exposure.

Bioaccumulation. In a given aquatic environment there may be low pesticide concentrations found in the water and mud and high levels of pesticides in the organisms. In many organisms, pesticides entering the body concentrate, or bioaccumulate, in body tissues (particularly fatty tissues), and, as a result, pesticides may not be excreted.

As organisms prey on great numbers of contaminated organisms (such as fish eating plankton or large fish eating smaller fish), they bioaccumulate pesticide chemicals from their food into their own body tissues. Eventually the concentrations in the predators' bodies may reach toxic levels; this has happened in the case of predator birds which eat prey contaminated by DDT. Unfortunately, in many food chains the final consumer of the pesticide may be man.




Herbicides. Herbicides are more toxic to plants in the water than are insecticides, although they do not always cause adverse effects. However, herbicides do disrupt photosynthesis in phytoplankton, and some plants concentrate herbicides, releasing them when they die and decompose. Plants killed by herbicides in the aquatic environment cause terrible odors and impart a bad taste to the water as well as contribute to eutrophication of the water body.

## What Should Be Done If Pesticides Get Into The Aquatic Environment?

Remedial action may be necessary. If water and fish are polluted with toxic levels of pesticide, consider limiting or prohibiting use of the water or eating of the fish until natural dilution and biological and chemical degradation lower the concentration of pesticide present. Depending upon the persistence of the pesticide and the rate it moves through the lake (the flushing rate), the lowering of contamination levels could take from a few days to several years. Also, since this concentration of pesticide will move downstream, people there should be warned of the condition.

When pesticide pollution results in a fish kill, remove the dead fish from the water and destroy them. Destruction of the fish removes pesticide from the aquatic system, reduces the odor of decaying fish, and prevents the spread of disease. Another reason for destroying the fish is that if dead fish are left in the water to decompose, oxygen levels could lower and lead to more fish deaths.

If a pesticide pollution incident has occured, stop using the water body, at least temporarily, and try to assess the effects. If possible, call in an expert to assess the severity of the problem and prescribe proper water treatment or other remedial measures. Some chemicals have been linked to the incidence of illnesses such as cancer in humans because people are able to bioaccumulate pesticides in body tissues. They may either become ill, or even die when accumulations reach critical levels. Given these circumstances the less chemical pesticide used, the safer animals, humans and their environment will be.

## What Are Environmentally Sound Pest Management Practices?

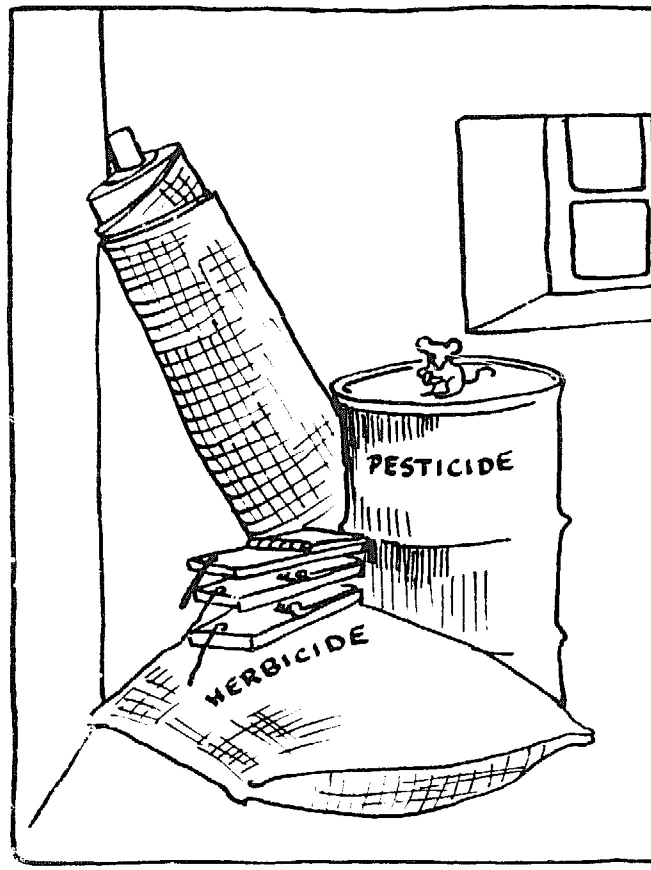
The best way to lessen or avoid unwanted environmental effects from pesticide use is to minimize the use of chemicals. Some alternatives to pesticides exist in most areas; the development worker should consult with local people to find out what these are in each project site. For example, there may be local plants which, when planted together, control pests for each other--tomatoes and marigolds do this. It is important for the development worker to understand how to use the controls that may be more appropriate for each particular situation; in the long run, it may be better to protect the natural predators of pest species than to use chemical pesticides. Insect pests in particular can rapidly develop resistances to certain pesticides and may do so after only a few applications. Predator species, on the other hand, may have longer life-cycles and may be more sensitive to repeated applications. Find out what kinds of pests are a problem before using a pesticide and try to use pesticides that are both species-specific and short-lived. General pesticides kill beneficial as well as pest organisms and are not recommended. Also find out what other pesticides are being used locally to control disease vectors or other pests. If pesticides are already in use some resistance may exist among pest species.

If possible consult local specialists and authorities before determining and obtaining any pesticide for use on agricultural lands. Some countries have very specific laws governing the use of pesticides, and these should be taken into account before any time or money is spent obtaining or using chemical pesticides. Contact local universities and government agencies for information on local pest species and their control practices when planning pest management measures to be sure that all the alternatives to chemical pesticides have been examined.

Because the potential effects of chemical pesticides are so bad, development workers should view it as especially important to understand alternative measures and try to implement them.

## USING ALTERNATIVE PESTICIDES

Whenever possible, decide upon and use pesticides that degrade quickly and are not toxic to non-target organisms. The pesticide that is chosen for a job should be one that is as selective as possible for the particular pest species being controlled. The use of persistent, non-selective pesticides causes the greatest and longest-lasting environmental problems. The loss of these organisms that are vital to crop growth through use of a non-selective pesticide may be far more devastating to crop production than to let the pest go uncontrolled. However, non-persistent pesticides may be more toxic to humans than persistent ones. And particular care should be taken in handling them.




## LOCAL PLANTS

Farmers know which plant species in their area have insecticidal properties. Try to find those plants and use them rather than chemical pesticides. Two such plants with insecticidal properties are tobacco and pyrethum (derived from chrysanthemums), both now widely distributed throughout the tropics. Another plant used is the derris root. It produces a chemical called rotenone which is used as a poison especially for ridding fish ponds of trash fish. When a local plant which has insecticidal properties is pointed out, try making a solution from crushed leaves or stems and spray it on a small test area. If this seems successful, it may be cheaper to use than commercial pesticides, easier to get, and environmentally safer.

## USING CROP MANAGEMENT PRACTICES

Rotation. Crops usually are rotated for economic and nutrient management reasons; crop rotation also can be used as a method to control insects, weeds, and plant diseases. Many traditional agricultural practices rely upon crop rotations to provide weed and insect control. Many crop-rotation combinations could work well enough to eliminate the need for chemical pesticides.

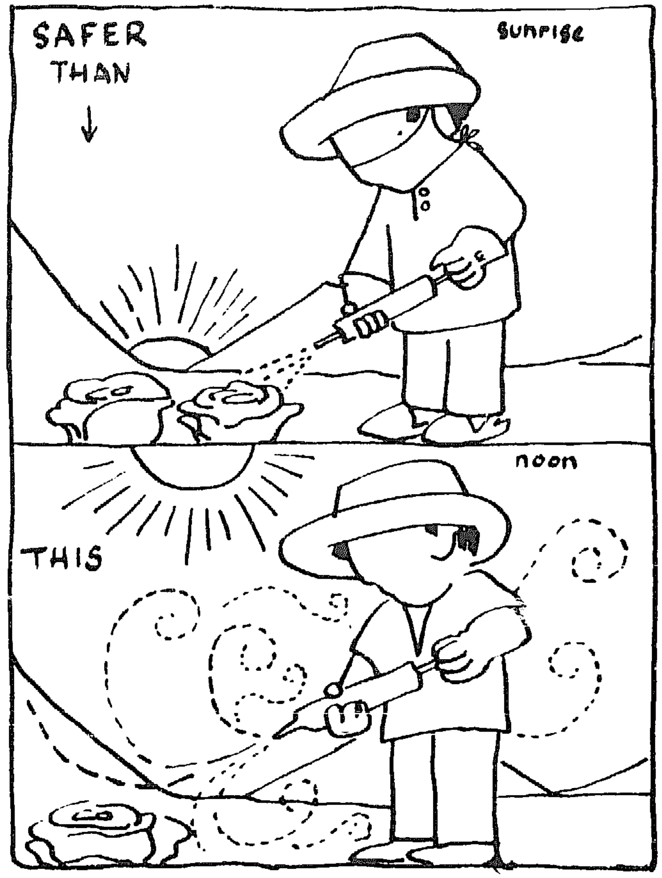
This possibility should be explored with local experts and talked over with those local farmers who seem to have fewer pest problems than others who grow similar crops. There are also crop varieties that develop (or are developed with) a resistance to attack by disease or insects; these varieties sometimes need the help of pesticides, but in greatly reduced quantities. Intercropping and polyculture can also reduce the spread of pests and disease organisms by interspersing unaffected plants with host plants in the same field.

Planting Time. Another crop management practice is to change planting times to prevent attack by insects and disease. Insect reproduction cycles are often attuned to the growth of plants; if crops can be planted a few weeks before or after the normal time, farmers may be able to by-pass the stage of the insect that causes the most damage to the crop.

Try planting a crop variety that matures very early, before the normal pest outbreak; this has been done successfully with varieties of cotton. This is very effective, but because it requires knowledge of insect species and their life cycles it may require the advice of entomologists or other scientists. Again, local universities and government agencies may have more information on the local insect species that damage crops, so consult them when planning this kind of management practice.

Intercropping. Modifying the spacing of plants or planting combinations of different crops in the same field (inter-cropping), may provide a measure of pest control. Also it may be found that the crop pests are breeding or spending some part of their life cycle on another species of plant in the area. If the alternate host is another crop, it may be best not to grow both in the same area. If the alternate host is a weed, it may be possible to control it and thereby control the pest population. On the other hand, if a certain type of crop is preferred by a pest, one way to control it is to plant that crop along with the desired crop and sacrifice the extra crop to the pest. One problem with this approach, however, is that this ensures continued populations of the pest species.

Placement and Timing of Pesticides. The way pesticides are placed on and in the soil can significantly affect the potential for contamination. The best way to avoid this is to place the pesticide in a narrow band well below the soil surface; the least desirable way is to broadcast the pesticide on the soil surface. Pesticides also are applied directly to emerging plants to control some types of pests. When and how pesticides are applied can vary greatly depending upon the susceptibility of target species.




The best times to apply pesticides, especially if they will be sprayed, are in the early morning or early evening hours when air is still. Spraying of pesticides should not be done in wind, during temperature inversions, or when heavy rains are expected. Most often pesticides are applied early in the growing season; but since this usually corresponds with a rainy season, the runoff merely carries the pesticides away. If possible, apply pesticides after plants have emerged, later in the season or even after the season to prepare fields for the next season. Also, for above-ground pests, pesticides should not be used until there is definitely a need to do so.

TYPE OF PESTICIDE. The kind and form of pesticide being used can be changed every few years. This practice will reduce the rate of accumulation of pesticide residues in the environment. It may also be found that by switching pesticides, a lower concentration of the new pesticide will be needed than of the one used for several years, because target species build up a resistance to any pesticide that is continually used.

MECHANICAL CONTROL PRACTICES. Sometimes the easiest, least costly, and most environmentally sound means of controlling pests on agricultural lands is by using mechanical control methods. Mechanical weed control, for example, consists of:

-- pulling weeds by hand or cutting them down

-- covering weeds with mulch to prevent growth

-- burning a field prior to planting

-- flooding the field

-- normal tillage practices such as plowing and harrowing.

The advantage of this is that no pesticides are used; therefore, they cannot enter the ecosystem. This can be very effective in those countries where labor is plentiful and money and/or pesticides are not. For example, insects can be killed by trapping or by letting chickens graze in the fields, rats can be smoked out, trapped or clubbed; and birds can be shot or trapped in nets and removed from the field.

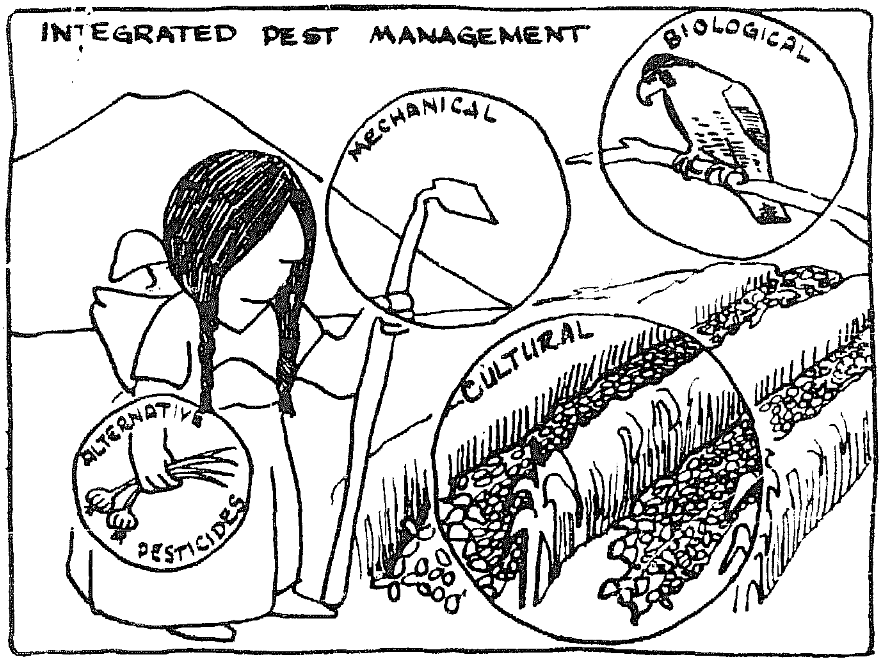
BIOLOGICAL CONTROL METHODS. Pests can be controlled as well by supporting the natural predators of pests or other biological means. Many of these methods are "new" as far as research is concerned; however, in agricultural areas that retain a diversified environment, biological control is an everyday occurence. Birds eat insects, cats eat birds, and so on; each predator has its prey and helps control the population of that prey. If the prey is at the same time a pest to crops, the way to control the pest is to foster the growth of the natural predator so that it will do the job.

For this to happen, however, it is necessary to let the insect pest population build up sufficiently to stimulate the corresponding build-up of the beneficial predator or parasite population. This will not happen if pesticides are used on the pest as soon as it appears. Thus, a certain amount of injury to the crop must be allowed; observation will have to determine the maximum pest population that can be tolerated at a particular time without crop damage becoming too serious before other controls are sought. Natural controls may take over before this happens; or if pesticides must be used, less will be needed and will be more effective.

Research into the use of biological controls has developed other methods, including the use of sex attractants, insect growth regulators, sterilized male insects, insect pathogens, parasite or predatory insects, and warning or aggregating chemicals that influence the behavior of insect colonies. These methods have worked well in some small-scale applications but may or may not work in other situations. They should be considered as alternatives that may be used alone or in combination with other pest control practices.

## WHAT IS INTEGRATED PEST MANAGEMENT?

The best way to control pests on agricultural lands may be a combination of the chemical, biological, cultural, and mechanical control techniques described here. Using a combination of these pest control practices has the advantage of preventing adverse impacts upon the environment from the continuous use of pesticides; preventing the development of resistance to particular pesticides in pest species; and, providing a backup pest control system in the event that any one method fails. The goals of integrated pest management are to decrease pest




populations to acceptable damage levels and to maintain them at that level. If integrated pest management is done correctly it can be the most successful pest control method available because it uses a combination of the best kinds of biological, chemical, cultural, and mechanical control practices developed, and can be done in a manner that is compatible with the environment. The most important objectives in any pest control program are to learn as much as possible about the life cycle and environmental requirements of the pest; find out where or when it is most susceptible; and determine the least environmentally harmful way or combination of ways to control the pest.

## How Does One Determine The Positive And Negative Effects Of Chemical Pesticide Use And The Potential For Alternatives In An Agricultural Project?

Asking and answering questions such as those which follow will provide the project planner with excellent background upon which to make informed judgements concerning the type of pest management practices which would both meet the need and be environmentally sound for a given effort.

- -- Will chemical pesticides be used as part of the project?
- -- If so, are the pesticides to be used in the project recommended for use on these particular crops by the manufacturers? By the government?
- -- Have adequate precautions been taken to protect workers from pesticide poisoning during transport, storage, and application of pesticides? Are instructions available in local languages?
- -- Is the pesticide persistent in soil? Will it tend to accumulate in the soil?

-- Could the pesticide suggested for use kill beneficial soil microorganisms?

-- Is it likely that erosion will carry pesticides into downstream water bodies? If so, could such pesticides affect fisheries, aquaculture projects, and domestic water use?

-- Is there a body of water nearby? If so, are people downstream highly dependent upon aquatic resources such as fisheries, aquaculture, and drinking water which might be contaminated by an accidental discharge of pesticides because of the project? What effect would contamination have--on health, finances, etc?

-- Does the pesticide tend to bioaccumulate in organisms? If so, which organisms would it affect in the immediate area, if any?

-- Can a species-specific pesticide be used?

-- Are alternative pesticides available which might not have effects as far-reaching? Are there plants with pesticidal properties which could be used?

-- Does the project design recognize the possibility that target species will develop resistance to the pesticide and larger quantities may be required each year to control the pest?

-- Is it possible to switch pesticides to reduce the likelihood of target species developing resistance to an important pesticide? If so, can a schedule for implementation be developed?

-- Can pesticide applications be timed to avoid rapid loss to wind or rain?

-- Are similar pesticides being used locally for health purposes, such as malaria control?

-- Have all pest management options been considered?

-- Is it possible to develop plans which can be put into effect--easily and simply--in case of an emergency, such as accidental pesticide pollution?

-- What alternative project designs could be used at the site to minimize environmental impacts from pesticide use?

## What Alternatives May Exist?

There are many pest control practices that may be used in an integrated pest management program. The combination chosen will vary according to the crops grown, type of pest, and kind of control measure already in use. As the development worker considers the proposed project and the site by thinking through questions such as those just listed, the following table can be a useful guide toward finding methods which provide viable alternatives given the circumstances of the specific project.

The left-hand column names the control practice, the right-hand column describes possible advantages and disadvantages of each practice.

| Practice | Advantages/Disadvantages |
|---|---|
| Using alternative pesticides | Applicable to all field crops; can lower aquatic residue levels and hinder development of target species resistance. |
| Using crop rotation | Can be used anywhere; can reduce use of pesticides and loss; good practice in many areas. |
| Using resistant crop varieties | Can eliminate need for pesticides; is applicable to a wide range of crops. |
| Optimizing crop planting time | Can reduce need for pesticides; applicable to many crops. |
| Optimizing pesticide formulation | Can reduce necessary rates of pesticide application. |
| Using mechanical control methods | Will reduce need for chemicals; best used for weed control. |
| Reducing excessive pesticide use | Best used in insect control, but requires understanding of insect life cycles. |
| Optimizing time of day of application | Can reduce necessary rates of pesticide application. |
| Optimizing date of application | Applicable only when pest control is not adversely affected. |
| Using integrated control programs | Effective pest control with reduction in amount of pesticide used; difficult to develop as a program. |
| Using biological control methods | Very successful in a few cases; can reduce herbicide and insecticide use significantly. |
| Using lower pesticide application rates | Can be used only where pests can be controlled in conjunction with other methods. |
| Planting between rows in minimum tillage | May reduce need for pesticide in row crops in no-till fields. |

Adapted from: Control of Water Pollution from Cropland, Volume I - A manual for guideline development. Agricultural Research Service, U.S. Dept. of Agriculture and Office of Research and Development, U.S. Environmental Protection Agency, Now. 1975.

## 8. THE PLANNING FRAMEWORK*

It should be stated clearly here at the beginning that the information which follows is meant to provide a direction or a guide for planning activities. It is necessary for the user to adapt this approach by expanding, subtracting and otherwise selectively applying this information to a given situation.

VITA has prepared this chapter as the beginning of a dialogue because of an increasing need within the community of private, voluntary and/or non-profit development organizations for improved tools for planning and estimating the economic and social feasibility of small-scale projects. Further, there exists the necessity for development workers to refine the capability to judge the full impact of projects upon communities from a benefits/costs point of view.

This chapter therefore suggests an easy-to-use-in-the-field methodology for planning and benefits/costs analysis of small-scale projects. The full power of this approach as a planning tool for smaller-scale activities has not yet been investigated. In fact it has been VITA's experience that many involved in small-scale development view benefits/costs analysis as an "alien" concept; it is seen as a cold, purely economic approach rather than as a tool for use in a more human-centered development process.

In reality this view is not only in error, it can be dangerous for at least two reasons: 1) it can cause planners to overlook the importance of economic effects; 2) it can lead to a failure to recognize that cultural, social and natural factors also can (and should) be considered in benefits and costs terms. Planners must be able to bring a benefits/costs approach to all facets of the planning process if they are to be able to judge project feasibility in terms of impact on the community.

The need for such an approach--which can be readily used--seems clear. The framework is presented to provide a starting point for further dialogue and for additional development of the approach.

* Laurel Druben, VITA, 1979.

## WHAT IS FLEXIBLE PLANNING?

Flexible planning is the ability to use a framework and the information and perspective provided by it creatively in the project design process.

A planning framework/methodology, such as the one described in this chapter, presents a logical, step-by-step method for defining and integrating project variables and for choosing among project opportunities. Because the steps in the planning process have been lifted out of a "real context" (so they could be more easily presented as pieces of one structure rather than as ends themselves), they may appear neat and well-ordered. In reality, the steps which should be taken in a given project are not clearcut (at least initially) and the variables and components are often difficult to categorize. Therefore, a good methodology helps the user work through the mass of information available to structure steps which are possible and feasible. For example, a planner can use this methodology to determine priority among a number of possible projects and to decide when a project design, perhaps because of a likely imbalance in benefits/costs terms, should be changed.

The key to good planning is applying a problem-solving approach flexibly within pre-determined boundaries. The boundaries, or guidelines, are things which should not be changed--except for very good reasons. Certain aspects of a project can be altered easily--because they represent different methods of accomplishing the project within the same boundaries. Alterations which do change the boundaries must be made only with great caution. These guidelines, once set, provide the basis for any environmentally sound, small-scale agricultural project--regardless of the specifics of the local situation and the project design.

## WHAT ARE THE GUIDELINES FOR ENVIRONMENTALLY SOUND, SMALL-SCALE AGRICULTURAL PROJECTS?

Setting guidelines should be the first step in the planning process. Because this manual has focused on the natural environment and agriculture, the framework is based first on a set of guidelines for ecologically sustainable projects.* Such projects must:

-- keep the soil alive

-- find the ecological values of traditional ways and species

-- increase and conserve natural productivity

* Peter Freeman, 1978.

-- take into account local cycles and trends in land use, water use, and productivity

-- build upon existing social organization and mutual assistance customs for environmental rehabilitation and conservation

-- include cultural (religious or other) values and beliefs in the development of plans for conservation of species and undisturbed wild spaces

-- focus on species with greatest nutritional values: legumes, vegetables, animals with high protein per weight (particularly in very densely populated areas)

To these ecological guidelines, however, the development worker will want to add others (if they are not reflected adequately in those already stated). Other guidelines are based on such things as: 1) the goals or philosophy of the sponsoring agency or individual and the results they must see from their involvement; 2) the results local residents must see from their participation; 3) the realities of the context within which the project will occur (limits of time, money, scope).

For small-scale, community-based efforts, it is likely a development worker would add a set of guidelines based on appropriate technology/appropriate development philosophy. In such cases, among other things, the project should:

-- make optimal use of locally available material and human resources;

-- have strong community support and involvement;

-- be based on community-identified and/or community-realized need;

-- show high potential for enhancing community self-reliance in both short and long-range terms;

-- fit within allocated and available funding limits;

-- place high priority on use and adaptation of traditional technologies;

-- be completed during a certain time frame; and so on.

As boundaries within which the project must operate regardless of specific design aspects, these guidelines serve two major purposes: first they provide a framework for designing projects; second, they can be used to enable the planner to make wise choices regarding feasibility among possible project designs. For example, the planner following these guidelines knows that any design he or she comes up with must include a strong community participation and/or involvement component; the planner judging a project against these guidelines must take a closer look at an effort which does not indicate community support.

Later in this chapter, the guidelines will become an active part of the planning process; it is wise to set them early and then to add or reconsider them if necessary in the process. Meanwhile there are a number of other activities which can be gotten underway.

## Is Learning From Local Agricultural Experience An Important Early Step In Project Design?

Yes. Agricultural practices in many countries are already well-adapted to prevailing environmental conditions. Over many years of trial and error, farmers have developed systems that work; frequently these are balanced ones. By listening and by learning about local practices, it is possible to find information on:

- -- local crop varieties that have shown particular resistance to disease and pests
- -- cropping methods, such as intercropping and multiple cropping, that are designed to get the most out of small land areas
- -- availability and use of organic fertilizers (e.g., manure and compost) that do not have to be purchased
- -- agricultural methods that conserve water, soil, and nutrients
- -- agricultural methods that may require less time, money, and labor than some other alternatives
- -- agricultural tools which are made locally and are suited to local needs

## Is Preparation Of A Community Profile A Necessary Step In Planning?

The "correct" answer to this probably depends upon the stage at which a development worker enters the planning process. If planning is already well underway, a full community profile may not be necessary. On the other hand, if local conditions seem to suggest that community support may be lacking or that receptivity to the project may be hampered, a community profile can be useful for pinpointing possible problem areas.

For the development worker involved in planning small-scale activities within the context of a community situation or in close proximity to one, a profile can be an extremely important tool. It should be structured so that it will provide easy-to-use data on key social, economic, cultural, and natural characteristics of the community or region. The profile does not have to be prepared in great detail, nor should it take weeks and months to complete. The topics suggested here for inclusion highlight agricultural activities; the user will want to gear the profile so it yields data relevant to his or her primary area of concern.

-- Determine the social structure and kinship relationships of the community. Note these particularly as they pertain to agricultural activities such as cultivating, harvesting, marketing, etc.

-- Note the cultural traditions and folkways of the community. Observe the common practices associated with food production.

-- Identify community leaders, their spheres of influence and how these may or may not affect agricultural activities.

-- Look into the economy of the community and the area; look particularly at the economy as it relates to agricultural production, such as cultivation, harvest and post harvest activities.

-- Note land use and ownership patterns.

-- Note availability of such things as credit mechanisms, agricultural extension services and general availability of agricultural information.

-- Determine people's ability or inability to put more time into crop production or to take risks such as introduction of a new crop.

-- Interview a range of community members or local residents to get their perspective on agricultural and personal needs and the priority which each need has.

Once the list of project guidelines is set the planner will want to make sure that the community profile encompasses all the information that is relevant to the community and the project.

## WHY INVENTORY THE NATURAL ENVIRONMENT?

An inventory of the natural environment provides information necessary for assessing project feasibility and for determining potential benefits and costs. For a small-scale project, the inventory need not turn into an intensive study. If nothing else, it can be looked upon as an "insurance policy," for the planner who undertakes such an inventory and uses the information wisely has far more likelihood of both project success and environmental "soundness."

There are at least two levels at which inventories should be done. The first consists of building an overview picture of the larger natural environment. As part of this inventory, the planner should look at such things as watershed characteristics, significant topographical features of the area, general rainfall distribution patterns, general climatic information. In many places this information is easily available through local sources or from observation.

The second inventory involves a much more specific look at the area's natural resources and current practices as they relate to the environment and the potential project activities in the agricultural area. This inventory should cover, among other things:

AGRICULTURAL PRACTICES

-- What crops are grown and why?

-- What local resources are available for food production? Are they used?

-- Are there food shortages or surpluses?

-- What is the major reason for crop loss?

-- Are pests a serious problem? Which ones? Which pest control methods are in use?

-- Do current crops provide adequate nutrition for human diet?

-- Do current crops debilitate the nutrient content of the soil?

-- Do local agricultural practices promote or otherwise enhance watershed management and soil conservation practices?

SOIL

-- What is the organic content of the soil?

-- Are there signs of degradation, such as compaction, erosion, light colored soils?

-- Is wind erosion a factor?

-- What topographical conditions affect soil quality and water-soil relationships?

-- What kinds of organisms does the soil contain? Are there sufficient earthworms, protoyoa, grubs?

-- What fertilizing practices are used, if any? What ingredients are available for composting?

-- What are the major restrictions to the soils carrying/ production capacity?

WATER

-- What are the major local sources of water? Is the same water source used by both animals and people?

-- Is the water good quality?

-- What water-carrying methods are used to bring water to crops?

-- Is the water table relatively stable?

-- What kind of vegetation exists around the water source?

-- Is the supply of water steady year round?

-- Is there much fluctuation in water supply due to heavy flooding or drought?

-- What type of watershed management is used?

CLIMATE

-- What are the rainfall/sunshine patterns?

-- Do floods and droughts present serious seasonal problems?

-- Does altitude affect climatic conditions and agricultural practices?

-- Is wind a predominant feature?

Many other questions can and should be asked. Use the information in this manual to assist with both formulating the questions for the inventory process and for determining the responses.

## What Additional Background Assistance Or Information Might Be Necessary And Available?

At this or any point in the planning process, there may be one or several reasons for seeking additional assistance. For example, preliminary investigation may show clearly that the area requires access to more specialized expertise, as in the case of developing an entire watershed; consultation with ecologists, water resource managers, sociologists, resource economists would be recommended before going very far with the planning process.

Second, even when and if the project seems to be relatively simple and easily tackled, it is a good idea to pass the "package" through a review process and an objective appraisal. The development worker can do this by summarizing the findings to date, making recommendations based on those findings, outlining planned activities and getting in touch so that experts can review and agree or disagree. If possible, the development worker should provide reviewers with good community profile and natural environment information; these can provide an "outsider" with an excellent base from which to assist--even by long distance.

There are a number of ways to bring valuable technical expertise and insight to the planning process:

-- Seek advice from local residents. Their knowledge of local conditions and past environmental impacts is not usually available elsewhere and is a resource which is much too important to be overlooked.

-- Contact local universities and government agencies, and local representatives of international organizations. Often they have a great deal of pertinent information on local soils, climate, terrain, and upon plants and animals native to the region. Or they may have insights and valuable suggestions on other resources.

-- Using local resource people, organize an interdisciplinary team to observe possible project sites. The team can then discuss the project from their respective viewpoints. Collectively, the team may be able to identify potential effects that will have to be accounted for in the project design. Depending upon the type of project, the team might include representatives from several of these fields: ecology, hydrology, soil science, entomology, and so on.

-- As planning continues and investigation continues locally, get in touch with other organizations and individuals around the world. See the list at the end of this book.

The outside review process is a good way for the planner to reality-test his or her thinking. Some planners may prefer to have data reviewed only after the needs identification and assessment process is complete. Other planners may choose to have the material reviewed at several points. For those who wish to use such services, they are available--sometimes locally, at other times through organizations such as VITA.

## How Are These Data Used?

Thorough analysis of the data gathered from inventories, community profiles, interviews and so on can provide a fairly reliable indication of project feasibility and practicability vis-a-vis the local situation.

Data analysis can be undertaken in a number of ways; a needs identification/needs assessment process adapted for use in small-scale projects is the evaluation tool suggested for further development and modification as part of this planning framework.

## What Is The Needs Identification And Assessment Process?

In the needs identification phase, background data are reviewed for the perspective they yield on the local community's view of needs and priorities. Records kept of interviews with local residents can provide particularly good insights, but all of the material collected should be reviewed.

A careful reading and weighing of background data during the identification phase may indicate need for several small-scale project activities. For example, community members may voice strong concern over both the need for erosion control and for improved methods of plowing and harvesting; the inventory of the natural environment may have turned up a need for crop irrigation. If the need is "discovered" by the development worker but is not one voiced by community residents, as in the case of crop irrigation, the development worker must decide where that need fits into community priorities, if at all. Then, most importantly, the development worker must be able to decide which need--given the range of technical, social, economic conditions present--is the one he or she should work to meet.

The needs assessment approach can be used for determining priorities among needs and for getting an excellent start on project design. The approach involves judging each need in terms of a combination of its relevance to the preset guidelines and a practical view of its "do-ability." If one need is clearly an emergency, such as starvation, there is obviously no question of needs assessment or priority ranking. But other cases are not nearly as clearcut and development workers must be able to judge which need, given the combination of surrounding factors, is most likely to be met successfully.

A needs assessment can be undertaken in three steps. The first is to look more closely at each identified need in terms of the size of the effort required and the kinds of resources which would be necessary to meet it. This can be done by preparing a Needs Assessment Sheet, as shown on page 89 , and by filling it out as indicated. Each identified need should be placed on a separate sheet. For each need it is necessary to define question areas which have to be considered when preparing to work to meet that need. The categories given on the sample sheet are offered only as suggestions; the development worker will have to refine, add, and delete to his or her satisfaction based on the specific project. Once the categories are set, the next task is to find the answers.

Step Two involves measuring the answers in terms of 1) overall relevance of any effort to meet the need to stated guidelines and 2) their practicability, or do-ability, given the type of effort required and significant constraints which may exist, such as money, time, expertise, cultural bias.

One readily used way to measure is to set up two scales, numbered from one to ten. One scale is for measuring practicability; the other for looking at relevance. For example:

*Practicability in terms of constraints present and resources needed*

SCALE 1: Low ———————————————————— High

1 2 3 4 5 6 7 8 9 10

*Each component of an effort to meet the need should be viewed in very practical terms. In other words, if providing improved harvesting methods is being considered in terms of the availability of resources required and investigation shows that all resources are available locally, this component would be ranked high. Depending upon other considerations, the planner might move lower on the scale as resources are harder to find, more expensive, etc.*

*Relevance to preset guidelines*

SCALE 2: Low ———————————————————— High

1 2 3 4 5 6 7 8 9 10

*Each component should be viewed in terms of whether it fits within the guidelines, or project boundaries, discussed earlier. As answers indicate that a project goes outside of more and more of the guidelines, the rating moves lower--toward the left. A "high" rating indicates the project is well within the set guidelines.*

# SAMPLE NEEDS ASSESSMENT SHEET

DATE________________ IDENTIFIED NEED______________________

| QUESTION CATEGORIES | ANSWERS | RATING* |
|---|---|---|
| The following question categories are likely to remain standard for any effort, but the specific questions to be rated will change depending upon the need being considered. | Filled in in terms of the specific situation. | *Practicability*<br>SCALE 1: Low 1 2 3 4 5 6 7 8 9 10 High<br>*Relevance*<br>SCALE 2: Low 1 2 3 4 5 6 7 8 9 10 High |

Resource Requirements and Availability. List the resources which would be required to meet the need. Resources can be defined as information, money, technology, people--anything that will or might be needed. Then look at whether the material and human resources are available. Locally? Regionally? If available, what are the costs of using such resources--in terms of money, length of time, etc.?

Scope of Project Required. Look at the project in terms of the network or system of activities of which it is a part. Does meeting this need create others? If so, can they be addressed? Is meeting this need technically, culturally, socially possible within the context of a small community project? Would a larger effort help to insure success? In other words, is there a possibility that a larger-scale activity would be of longer-term value?

Project Design Possibilities. Can meeting this need be accomplished with several, different project designs? Does one project enable use of local resources and expertise, while the other one does not? What would be the differences between these project designs--in social, cultural and economic terms? Does well-tested technology already exist for adaptation or is extensive research required? Will the community participate in project design activities?

Time Frame. Is meeting this need a short or long-term effort? Or can it be met now on a provisional basis and later, in a phased approach, tackled on a longer-term basis? Would a project undertaken quickly now make it more difficult to undertake another effort later? Is there a local timing factor to be considered; for example, do residents have more time available to support a project at one time rather than another, or do local climatic conditions suggest timing constraints?

Community Support. Who expressed this need? Will powerful community members and groups support efforts to meet this need? If the need has not been identified vocally by the community, is there a forum where it can be discussed?

Cultural, Social Considerations. Does meeting the need being considered require dealing with current widely held, social practices? For example, if a new crop were being introduced, would it require different cooking habits? Would a project mounted to meet the need described involve women and therefore have to deal with constraints on their participation, e.g., traditional home duties, lack of access to credit and so on.

* Each significant component of the question area and the answers pertinent to it should be measured for relevance to project guidelines and for practicability in terms of these scales.

Keep the needs identification/assessment process simple. Only if one has lots of time and interest is it possible and necessary to undertake a more complicated methodology. For example, the project guidelines can be priority-ranked or weighted. This is a good idea--if there is time. Often there is not a lot of time available and it is best to do this rating very simply and relatively quickly: the process will give fairly good indication of which need is the one to tackle first.

Once each Needs Assessment Sheet has been completed and the answers rated, average the figures from the scales to determine an overall rating. This process is useful even when the development worker is considering only one project. The average provides guidance to the planner's thinking as to whether the project should be undertaken as is, re-examined to find factors holding down the average, modified, etc.

If more than one need was being investigated, the ratings will show the order in which efforts to meet the needs should be translated into designs for projects which can be reviewed in benefits/costs terms. Keep the ratings handy. If the benefits/costs analysis shows that the project visualized for responding to the priority-ranked need is too costly, it may be necessary to move to a second-ranked need.

## What Is The Next Step?

Based on data from the needs assessment, a tentative design can be proposed for meeting that need. The design includes a statement of the project's goal, its objectives and a detailed plan for accomplishing those objectives. It is this design, or blueprint for project activities, which must then be looked at more closely in benefits and costs terms. If the needs assessment activity has been carried out well, there will be a very high probability that the benefits/costs analysis will be positive.

## HOW CAN BENEFITS AND COSTS BE MEASURED?

In this suggested methodology, criteria for measuring a project in benefits/costs terms are established based on 1) the stated, goal of the project, 2) the project guidelines or boundaries set at the beginning of the planning effort, and 3) the specific components of the project being proposed. The criteria should be categorized so that the project can be looked at in terms of impact on the community in key areas: Social and Cultural Environment, Economic Returns, Technical Resources, Natural Environment and so on. Criteria should be written so that they are self-explanatory.

Once the criteria are set, the project can be measured in benefits/costs terms--again by using a simple scale. The lower end (left) of the scale represents costs, or negative effects; the upper end (right) represents benefits or positive effects. The five-point mark in the middle of the scale represents a situation where benefits and costs are evenly balanced.

| (-)Costs | | | | | | | | Benefits | (+) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

Again a reminder that this material is provided only as a direction for activity. The development worker/planner will have to adapt the approach, and the measurement criteria will have to be set carefully depending upon the particular project context and the goals and philosophy behind it. When setting criteria for a given project, the development worker will probably wish to make them very specific. That degree of specificity is not possible here, but the criteria on page 92 represent a sampling of the types of concerns which could be looked at in benefits/costs terms for a small-scale agricultural project designed to generate income and based on appropriate technology principles and guidelines.

There is no magic about the measuring system used here; this one seems convenient and relatively easy to use. Once each of the criteria has been placed at a certain point on the scale and given a number, it is only necessary to add up the points and determine the average. If the average seems low, the planner can go back and look over those criteria which rated low to pull the average down. Is it possible to pull the rating up by changing a part of the program design? This rating therefore, provides a key to know when and whether to seek alternatives.

DATE____________________

# SAMPLE BENEFITS/COSTS ANALYSIS CRITERIA

PROJECT DESCRIPTION____________________

## ECONOMIC RETURNS

Self-Sufficiency. Rank high a project which can be shown to lead to jobs, skills, training, improved markets or other economic gains which are returned directly to the community and can be shown to increase local self-sufficiency. Move toward the lower end of the scale if a project must rely on continued subsidy and/or it becomes less clear that the economic gains will be returned to the community.

Funding Availability. Rank high a project where funds are available quickly and easily (perhaps from local sources). Move toward the middle for projects where some funding is available but additional funds must be sought. Use the lower end of the scale in cases where funding is not readily available and a long time lag seems likely.

Net Profit. Rank high a project where careful calculation of economic factors indicates that the product or project will bring in more than it cost. Move lower on the scale as the project's economic profitability appear less clear.

## TECHNICAL RESOURCES

Local Technical Support. If the project requires involvement of change agents, technical support groups, extension services, and these are available, rank high. Move toward the opposite end of the scale as availability and access to such support becomes less clear and/or difficult.

Technology Availability. Rank as high a situation where the technology exists and seems adaptable to the situation. Move toward the lower (costs) end as the technology requires more extensive commitments to research and development. Rank high situations where technology makes maximum use of local human and material resources. Move lower toward the opposite end as resources must be obtained from outside sources and this could cause delays and/or failure to use local resources adequately.

Technical Impact. Rank high a project in which the technology or project once launched can be maintained by local residents--this implies training in upkeep and repair and arrangements for replication. Move lower on the scale in situations where provision for these activities has not been made. Rank high a project which introduces a technology which seems to require little change in everyday life. Move toward the lower end as the technology seems to require alterations in life-styles, culture, traditional patterns, etc.

## SOCIAL AND CULTURAL ENVIRONMENT

Community-expressed Need. Rank high a project based on community-expressed need. Move toward the opposite end as community involvement in need identification becomes less clear.

Social Returns. Rank high projects which can be shown to bring cultural and social gains to the community. Move toward lower end as social and cultural gains become less clear and/or the effects of the effort seem likely to be socially or culturally descriptive. Rank high a project which enables residents to participate with least risk. Move toward the lower end of the scale as it becomes clear that participants run more risk, i.e., as their investment demands a level of commitment which would have serious consequences were the project to fail. Assume for project feasibility that the smaller the degree of change required in local custom, the easier it will be to get the project underway. Rank as high projects which require little change; move lower as more change is required.

## NATURAL ENVIRONMENT

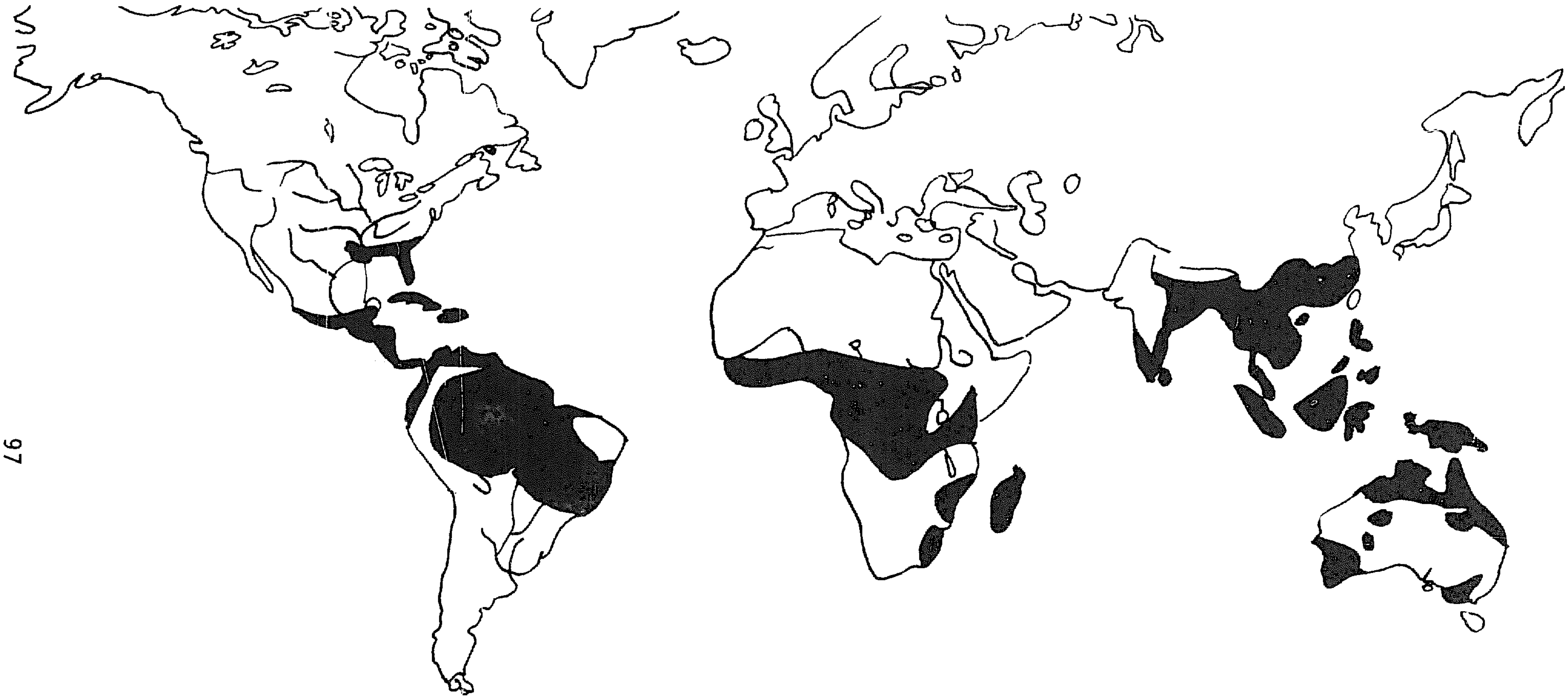
Relevance to Guidelines. Rank as high a project which meets all or most of the guidelines for an ecologically sustainable activity. Move lower as the project fails to meet these guidelines.

Use of Alternative Control Methods. Rank high a project which makes maximum use of biologically sound control measures; move lower as the project must rely on chemical control methods.

# APPENDIX I.

ACCION International
Action International Programs
AFRICARE
Agricultural Cooperative Development International
Agricultural Development Council
Agency for International Development
American Association for the Advancement of Science
American Committee for International Conservation
American Council of Voluntary Agencies for Foreign Service, Inc.
American Friends Service Committee
Aspen Institute for Humanistic Studies
Boston Industrial Mission
CARE, Inc.
The Cary Arboretum
Catholic Relief Services
Center for International Environmental Information
Christian Children's Fund
Church World Service
Clark University
CODEL, Inc.
Columbia University
The Experiment in International Living
Friends of the Earth
Foundation for the Peoples of the South Pacific
Heifer Project International
The Institute for Ecology
International Institute for Environment and Development
International Institute of Rural Reconstruction
Lutheran World Relief
Meals for Millions Foundation
The Mohonk Trust
National Audubon Society
Natural Resources Defense Council
Near East Foundation
Overseas Development Council
OXFAM America
Partnership for Productivity
Presiding Bishop's Fund for World Relief, Episcopal Church
Save the Children/Community Development Foundation
Sierra Club Office of International Environmental Affairs
Technoserve, Inc.
Threshold
United Church Board of World Ministries
Walnut Acres
World Education
World Vision Relief Organization
World Wildlife Fund
YMCA

APPENDIX II.



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