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# AGRILINK II PROJECT ENVIRONMENTAL GUIDELINES REFERENCE MANUAL

**for**

## AGRILINK II Project
## Agribusiness Linkages Officers

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# HOW TO USE THIS MANUAL

The goal of this Environmental Guidelines Manual is to provide AGRILINK II Project field-based Agribusiness Linkages Officers with an awareness and understanding of the key environmental issues facing South African agriculture. This will assist them to identify existing problems, through the use of a manual specifying possible courses of action. The Officers will not necessarily be able to identify all problems, nor assist farmers to solve all their problems, but they will be able to guide farmers and other stakeholders in the agricultural sector toward resources to assist them to ameliorate environmental conditions.

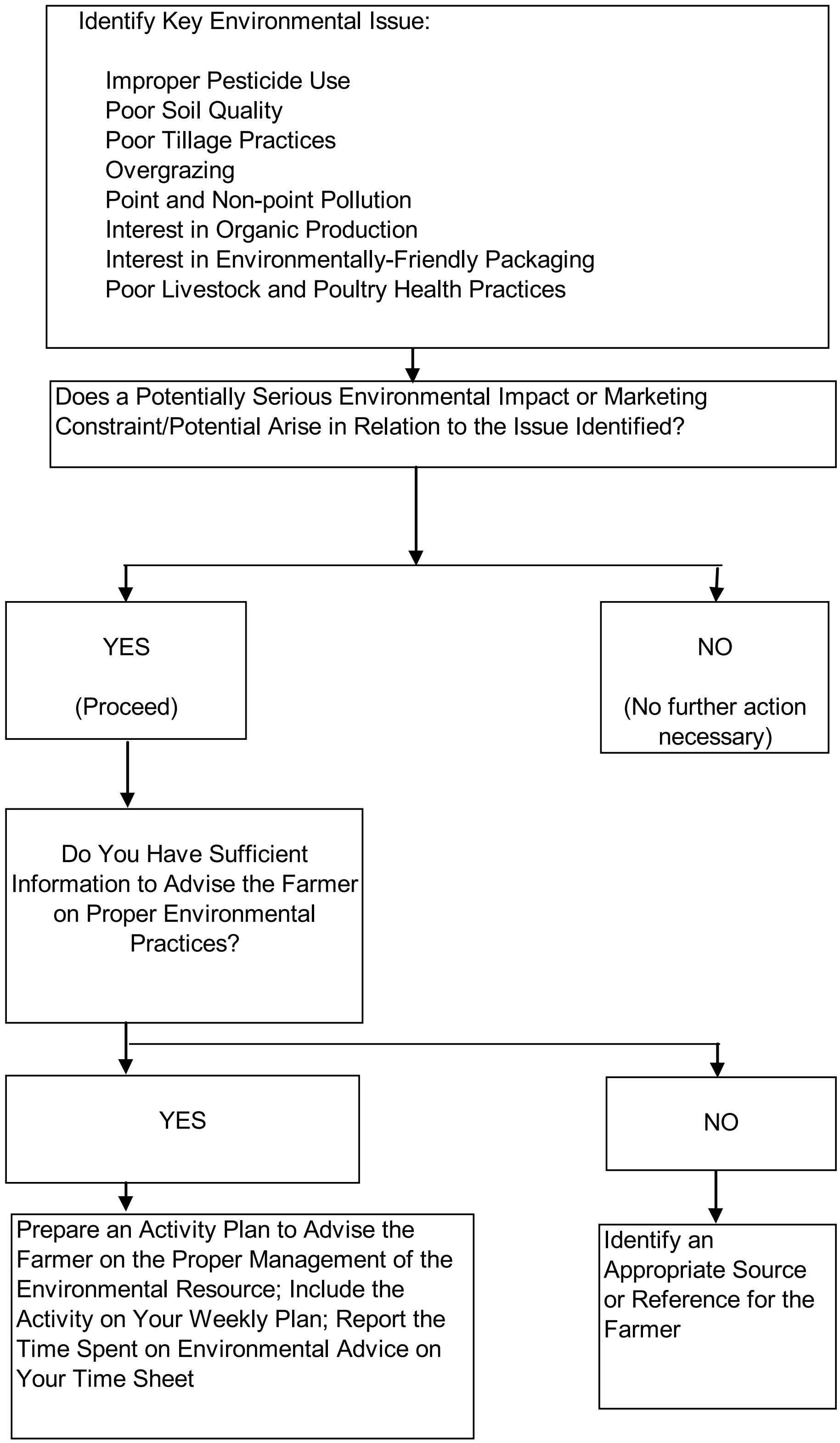
The Manual covers key environmental issues in South African agriculture, including land use, water and soil conservation, environmental contamination, management of chemicals, and national/international regulations for the production of various agricultural commodities. The Manual is not designed for specific locations within South Africa, as precipitation, soil composition, ground water availability and farming activities vary from region to region. It is the duty of the AGRILINK II Project field-based Agribusiness Linkages Officers to collect region-specific information from farmers, the National and Provincial Departments of Agriculture, and agricultural research institutions.

Each section included in this document will challenge the AGRILINK II Project field-based Agribusiness Linkages Officers to further investigate means to achieve agricultural sustainability. An Appendix provides extensive internet-based references with in-depth technical information. Some references have been included in the text as a primary source of information.

The usefulness of the Manual will depend on the background of the particular Agribusiness Linkages Officer and the type of contact an Officer has with farmers. Agribusiness Linkages Officers have a background in the field in which they are working. However, it is recognized that not all Officers have been trained in sustainable agriculture, or in particular aspects of organic production or environmentally friendly packaging. This Manual should be a reference tool for Officers as they confront different problems in agricultural production.

The following decision tree illustrates how an Officer should use the Manual.

## Decision Tree for Determining Approach to Environmental Issues



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# I. Introduction

***Agriculture and the Environment***

Agriculture is one of many sectors in the South African economy that impacts on the environment. Although on the surface it might appear that agriculture would not have a significant impact on the natural environment, given the scale of agricultural activity and its intensive use of resources, it is one of the most important sectors impacting the condition of the natural environment. This manual identifies some of the important environmental concerns in the agricultural sector.

The South African natural resource base is extremely varied, which makes it difficult to generalize about conditions or to make over-arching recommendations on resource use. South Africa lies within the southern temperate zone, with a wide variety of agro-climates. About 31% of the surface area is level to gently undulating, while 19% is steep, rocky and mountainous. Rainfall varies from 1,000 mm in areas east of the Drakensberg escarpment to less than 100 mm on the western coast. Droughts are experienced regularly, and floods are not uncommon. Despite a relatively limited natural resource base, the South African economy has reached high production levels in a wide range of agricultural commodities compared to other countries in the region. However, that production has come at a cost to the environment and it is generally accepted that historical production patterns are not sustainable.

***South African Agriculture and the Environment***

South Africa's development until 1994 led to a dualistic system of agriculture, with one of the most highly skewed land distribution patterns in the world. Support to the agricultural sector, as an extension of broader government policies, produced a highly capital-intensive, large-scale, white commercial agricultural sector, along with a land-scarce, subsistence-oriented, communal property, black rural sector, where 71% of the rural population lives. The historical development of the agricultural sector has contributed to specific agricultural cultivation patterns and practices, many of which are neither environmentally (nor economically) sustainable.

The agricultural sector inherited several environmental problems from this historical development, which differ by type of agricultural production. In the commercial sector, there is extremely high water use, widespread monoculture, exclusive reliance on mechanical tillage, and heavy use of chemical fertilizers and pesticides. In communal areas, lack of water is a serious constraint, overstocking and overgrazing are common, and soil nutrient levels are low and declining. The main topics of this Manual focus on these issues. Given the diversity of production, the Linkages Officer will need to understand which of these issues are relevant for the appropriate agribusiness client.

First, the principles of sustainable agriculture and organic production are covered, considering the importance of re-examining the patterns of agricultural production in the country. Second, specific topics related to the sector are discussed: a) soil and water use/conservation, including tillage practices; b) ground and river water contamination; c) pest management, including pesticide/insecticide and hormone residue standards, and integrated pest management; d) grazing and grassland management; e) human waste management in agricultural areas; f) environmentally-friendly packaging; and finally, g) livestock and poultry health standards.

***Agriculture and the Environment in USAID-funded Projects***

The AGRILINK II Project is funded by the United States Agency for International Development (USAID), and therefore, AGRILINK II Project Agribusiness Linkages Officers need to be aware of the various components of USAID's Environment and Natural Resource Policy, which supports the development of sustainable agricultural practices in all activities.

USAID is involved in agriculture in many countries, including South Africa, assisting to increase production levels in order to increase rural income and reduce the cost to rural and urban inhabitants of efficiently produced food. However, agricultural projects promoted by USAID should be sustainable and follow the environmental guidelines established by the Agency.

In 1976, USAID adopted is first formal environmental procedures: 22 CFR Part 216. These procedures required a systematic review of potentially negative impacts of all USAID projects. As information and experience expanded, USAID developed a Policy Paper in April 1988 entitled Environment and Natural Resources. This Policy Paper focused not just on the prevention of negative impacts, but also on the need to support activities that, as a primary objective, promote sustained natural resource management or environmental protection. The central objective of the Policy is to:

> *"… help developing countries to conserve and protect their environment and natural resources, and to promote long-term economic growth by managing exploited resources for sustainable yields."*

Sustainable production, and particularly sustainable agriculture, is an important component of the Policy. Sustainable production priority areas include land use planning, management and regulation, reforestation and watershed rehabilitation, management of natural areas for sustainable resource yields, efficient production and use of energy, coastal resource management, and sustainable agriculture and agro-ecosystem research and planning.

USAID's policy on sustainable agriculture focuses on the need to increase productivity to meet food needs, using less land, but without the negative impacts of overgrazing, deforestation in mountain and tropical environments, desertification, water-logging, salinization of irrigated land, soil erosion and soil toxification. High levels of fertilizer and external inputs are not considered sustainable under most conditions; however, reliance on modern biology and technology may overcome some of production constraints through improved plant varieties. In addition, the full participation of local people and their positive contribution to resource use is critical.

The Policy paper is explicit that key to environmentally sound and sustainable agriculture is the proper application, storage, and disposal of agricultural chemicals. *"USAID policy is to support more natural pest control efforts through integrated pest management systems."* This policy is addressed in more detail in the section on Pest Management in the Manual.

Another important component of the Policy is the maintenance of natural ecosystems. The security and maintenance of representative and unique ecosystems, habitats and wildlife are vital to development. The maintenance of tropical forests and biodiversity are key to natural ecosystems. One of the fundamental causes of biodiversity loss is unsustainable agricultural, forestry and other practices. Sustainable agricultural practices, as described in the next section of the Manual, are identified as important elements to support biodiversity.

**After Reviewing Section I And Associated Internet Sites, AGRILINK II Project Agribusiness Linkages Officers Should Be Able To:**

- Know the two key components of USAID's Environment and Natural Resource Policy: sustainable production and maintenance of natural ecosystems (biodiversity).
- Recognize that Integrated Pest Management is a key element of USAID's Environment and Natural Resource Policy.
- Identify key elements of USAID's sustainable agricultural policy: sustainable agricultural practices; full participation of local people; reliance on modern biology and technology; and, proper application, storage, and disposal of agricultural chemicals.

# II. Sustainable Agriculture: The Basics

***What is Sustainable Agriculture?***

Conventional farming methods frequently tax the natural resource base in many countries by lowering soil fertility, polluting water sources with soil runoff, fertilizers and pesticides, and reducing biodiversity. Under current farming practices across most of South Africa, soil and water are increasingly degraded, crops yields are declining, and pests are becoming more resistant to synthetic pest-control products.

It is important that conventional agricultural practices are transformed into sustainable farming methods in which the negative impact on the environment is minimized, while maintaining agricultural productivity. By minimizing the impact on the environment, the health of the soil and water are improved, biological diversity is restored to normal levels and pests are controlled with more environmentally acceptable pesticides or with no chemicals at all.

The transition to sustainable farming is not an easy task. A truly sustainable farming system should be economically, ecologically and socially sustainable.

- **Economically sustainable** farms are achieved by the generation of sufficient financial returns to support farm families and to provide an economic base to the local community.

- **Socially sustainable** agriculture promotes the physical, spiritual, cultural and economic health of farm families and communities.

- **Ecologically sustainable** farms are achieved by implementing environmentally acceptable farming methods through which energy flow and effective water and mineral cycles are promoted based on viable plant and animal community dynamics.

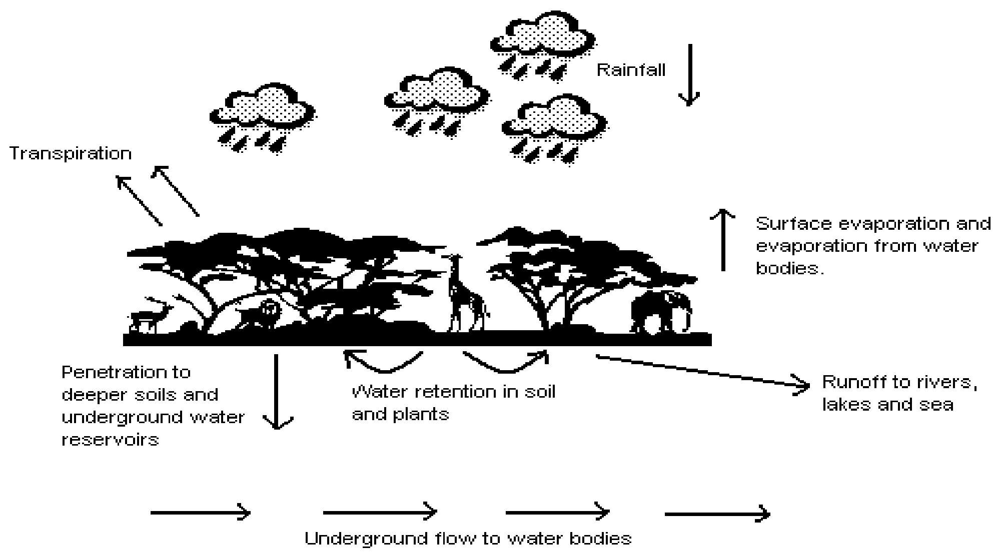
***Plant Nutrient Dynamics and Water Cycles***

A positive energy flow is achieved when fossil-based fuels are partially or totally substituted by renewable or natural energy sources, such as methane gas produced from animal manure, use of solar energy, wind power and others.

Water and mineral cycles, as well as community dynamics, are extremely important when pursuing environmental sustainability ( http://www.holisticmanagement.org ). Water cycles are improved by using methods that prevent pollution of water sources and erosion, by implementing technologies that increase water retention from the soil and the replenishment of water reservoirs, such as aquifers and lakes (http://pasture.ecn.purdue.edu/~abe325/week.1/definitions.html). Mineral cycles become sustainable through the cycling and re-cycling of farm wastes. Raising livestock on a farm is especially useful: for manure, the management of crop residues and the use of crops and other barriers that prevent wind and water erosion.

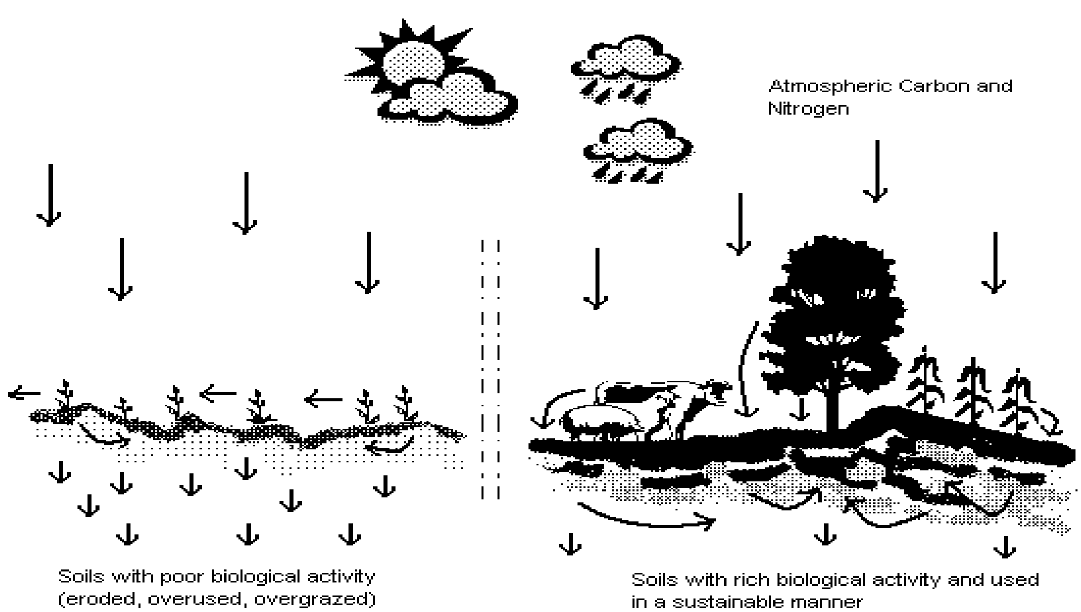
An effective water cycle (Figure 1) requires a biologically active soil and plant ground cover. In healthy soils, most water soaks in quickly where it falls, to be released later through plants that transpire moisture or through seepage into rivers, springs, aquifers and lakes that collect the water that plants and soil do not retain. In exposed and biologically inactive soils, most water runs-off without being retained.

**Figure 1: Water Cycle**




For an effective mineral cycle (Figure 2) to take place, plant coverage and biologically active soils are also required. In rich soils, nutrients cycle continuously between plants, animals and soil. When the soil is exposed and biological inactive, nutrients are leached into water and lost through wind erosion.

**Figure 2: Mineral Cycle**



In nature, communities strive to develop greater complexity, and thus sustainability. When this complexity is reduced by planting mono-culture crops, nature's principles are ignored and soil nutrients can only be maintained temporarily through un-natural means.

Sustainable plant and animal community dynamics are achieved through biodiversity. Healthy ecosystems can be promoted by the use of crop rotation, companion planting, strip cropping, and livestock and crop integration. Community dynamics are also enhanced by the introduction of native plant species, including trees and perennial crops. Farm-scaping ( http://www.attra.org/attra-pub/farmscape.html) is an important tool when converting a conventional farm into an environmentally sustainable enterprise.

***Sustainability Concepts***

Sustainability can best be achieved when farmers understand and apply the following concepts:

- The importance of nutrient re-cycling
- Alternate between crops for soil nutrient enrichment
- Intensify the use of legumes/leguminous trees (such as Acacias) to provide nitrogen to the soil
- Exercise appropriate animal husbandry, when applicable
- Use locally adapted crops
- Maintain the local landscape and vegetation
- Use non-renewable resources minimally (i.e. petrol, coal, plastics, etc.)
- Substitute locally produced organic products, such as manure, compost and biological pest control systems, for chemical fertilizers and un-natural ripening products, as well as hormones and synthetic growth regulators
- Reduce the practice of monoculture, as it depletes the soil of important nutrients like nitrogen, phosphorous and potassium.

**After Reviewing Section II And Associated Internet Sites, AGRILINK II Project Agribusiness Linkages Officers Should Be Able To:**

- Understand sustainable farming practices.
- Understand the basics of water and mineral cycles.
- Know what components are necessary to achieve sustainability.
  - Use internet sites to advise farmers how to achieve sustainability.

## III. Organic Production Principles

Organic farming systems are a sub-set of sustainable agricultural methods. There is growing international agreement on the accepted definitions of organic farming methods, but differences among countries remain, which are reflected in different country-specific standards. This section focuses on areas of general agreement and provides references for specific standards.

If correctly managed, organic farming actively assists in the preservation of eco-systems and the variety of species, protects the soil, conserves water sources and quality, and reduces agricultural impact on the atmosphere. Although the motivation for organic production increasingly focuses on the premium it generates in the market place, for many organic farmers, organic farming systems are used in a holistic approach in which the entire farm is treated as a living organism. Organic systems measure a farm's productivity not only by its yield, but also by taking into account other values and measures, such as soil and water conservation.

Agribusiness Linkages Officers should be able to explain to farmers that organic farming includes the avoidance of pesticides, synthetically-produced chemicals and mineral fertilizers, and the replacement of these products with measures permitted in the marketing of organic produce, but that it also encompasses a set of principles that, once applied, should lead to the certification of the farm's produce by an officially recognized organic certification organization. A non-organic farmer will reluctantly become an organic farmer if he/she does not see immediate benefits in the form of increased profit from the farm. That is why farmers must decide how, when and at what speed they want to move to organic production, according to their own needs and timeframe. After taking into consideration their clients' socio-economic conditions, it is important that AGRILINK II Project field-based Agribusiness Linkages Officers provide farmers the best advice to achieve organic production as quickly as possible.

***When Are Agricultural Products Organic?***

An agricultural product can be classified as organic if it has been grown according to specific standards set by an organic certification organization. In general, organic production does not use synthetic pesticides, synthetic growth regulators or conventional, soluble fertilizers. Organic products may not be genetically modified, irradiated or contain other substances that are not organically produced, such as colorants and preservatives.

***When Can An Agricultural Product Be Certified As Organic?***

Normally it takes 3 years or more before a crop can be certified as organic. Why? Because the soil must be free of all pesticide and synthetic fertilizer residues, and the organic certifying organization must be absolutely sure that record-keeping is well maintained to ensure the produce is organic. Records must show that organic practices, such as long-term soil management and separation between areas that are used for organic production and those under conventional methods, are being followed. Land separation must include the establishment of a buffer zone that wil prevent non-organic products and chemicals from contaminating (through surface level as well as below surface) organically farmed areas.

Full inspections for organic certification must include a review of the facility's cleaning and pest control methods, product transportation and storage, audit control, and maintenance of food integrity. Inspection results must demonstrate that no excluded (unallowable) ingredients or preservatives have been added to the product that will be certified as organic, and that no contact with chemicals or other non-approved substances has taken place.

***How Long Does It Take To Become An Organic Farmer?***

Most certification standards require farmers to allow three years or more for synthetic fertilizer and pesticide residues to disappear from the soil. In the beginning, growers typically observe lower yields and greater pest problems. However, as the system "matures," it is increasingly stable and results in fewer pest problems, easier tillage and satisfactory yields. Unfortunately, certification requirements do not allow for the gradual phase-out of pesticides and fertilizers. Rather, the grower must stop using them entirely on all fields to be certified as quickly as possible.

Not every conventional farming operation can become an organic farming enterprise at the same rate, and usually the conversion must be individually tailored to a farm, a community or an area. The process begins with the development of a plan to restore biological diversity to the agricultural operation, and by developing an agronomically sound and economically viable cropping mix and rotation.

***If It Is So Time And Knowledge-Intensive To Move From Conventional Farming To Organic Farming, Why Change?***

One reason to make the switch is to promote environmentally sustainable agricultural practices! However, farmers also convert to organic farming because organic products are healthier, they can be sold a higher price than conventional products and the organic produce is the fastest growing agricultural market sector worldwide. There may also be employment benefits to organic production, as many of its practices are labour-intensive.

***How Are Pest Control And Soil Fertilization Managed In Organic Farming?***

Fertilization and pest control are managed through practices such as crop rotation, the application of green manure, compost and livestock manure, planting of pest-resistant crop varieties or inter-cropping, manual weed control and timely planting. Depending on the standards followed, farmers may use advanced technologies, such as bio-pesticides, foliar fertilization, bio-fertilizers and conservation tillage.

***Why Are Organically Produced Commodities More Expensive Than Conventionally Produced Commodities?***

Organic products are more expensive for several reasons. First, the amount of labour required to produce organic products can be significantly higher than that for conventionally produced commodities. In addition, as described above, the investment in soil and water quality is expensive. Although organically produced commodities are more expensive, the price may more closely reflect the true cost of growing food than with conventionally produced commodities. The "hidden" costs to conventional farming are reflected in the cost of cleaning-up polluted water, the remediation of pesticide contamination and a reduction in bio-diversity. Some authorities feel that there are potential health problems associated with large-scale conventional farming (e.g. increases in allergies, e-coli, etc. have been associated with certain agricultural practices). There is increasing evidence that if all the costs of conventional farming methods were computed in the cost of the product, organic products would cost the same or less than conventionally produced agricultural commodities.

***What About Organic Livestock And Poultry Production?***

Eggs, meat, wool and dairy products are regarded as organic when the animals from which they originated are fed organic feed and are allowed access to open pastures. They must live under conditions that allow for the animals' natural behavior. Organic poultry and livestock must not be given antibiotics or medication in the absence of illness and must not be feed or injected with hormones or growth promoters. Drugs against parasites are strictly regulated and parasite infestation is controlled mainly through preventative measures, such as rational grazing, balanced diet, sanitary housing and stress reduction. Vaccination against locally and nationally controlled animal diseases is permitted.

***Where Do You Find More Information On Organic Production Regulations And Organic Certification?***

Appendix A has a large number of internet-based sites that offer general and specific information about organic farming practices and principles. For USA regulations and certification, the main site is http://www.ams.usda.gov/nop

In South Africa, organic production is a new field, but information and guidelines can be found at the Organic Agricultural Association of South Africa web site http://www.oaasa.co.za/ . This site will connect you to other relevant sites, for example producers of bio-fertilizers.

The National Department of Agriculture is currently drafting legislation about organic agricultural production. The NDA web site is http://www.nda.agric.za/ . Information about the draft legislation can be found in the AFRISCO (Africa's Farms Certified Organic) web site, under "Organic Standards", at http://www.afrisco.net . This site will provide you with guidelines for organic production in South Africa. More information about organic production and international standards can be found at the International Federation of Organic Agriculture Movements at http://www.ifoam.org

Guidelines on the labeling of certified organic products can be found at http://www.eco-labels.org/home.cfm . The best labels are those that indicate that an independent organization has verified that a product meets a set of meaningful and consistent standards for environmental protection. For the regulations on labeling agricultural products exported to the United States, visit http://www.ams.usda.gov .

**After Reviewing Section III And Associated Internet Sites, AGRILINK II Project Agribusiness Linkages Officers Should Be Able To:**

- Understand what “organic” means.
- Explain the difference to farmers between conventional and organic farming and the “hidden” costs of conventional farming.
- Advise farmers what steps they need to take to convert to organic production, and what challenges they may encounter.
- Understand the long-term benefits of organic farming vs. conventional farming.
- Contact “organic” certification organizations in South Africa to obtain advice on organic certification and labeling.

# IV. Pest Management

Pest management is a major task for agricultural producers, as the damage that can occur to a season's crop can jeopardize the farm's viability. However, over the past decades, it has become increasingly recognized that many pesticides have deleterious side effects on the farm and surrounding area.. In particular, pesticides have been identified as a key source of the reduction of biodiversity.

Pesticides include any substance in the following groups:

- Herbicides – used for the control of weeds or other undesirable plants
- Insecticides – used for the control of insects
- Fungicides – used for the control of fungal infections
- Nematocides – used for the control of parasitic worms
- Rodenticide – used for the control of rodents

Pesticides should be used carefully, and only according to specific instructions. The following section identifies some of the key principles for handling pesticides. The following sections identify the principles of integrated pest management (IPM), an approach increasingly promoted to comply with environmental guidelines and reduce negative environmental impact.

***Pesticide Management***

Pesticide contamination of water sources, food and non-target farm fields is usually the result of one or more of the following factors:

- Improper pesticide application on a field: generally, over-dosage
- Careless handling of pesticides
- Careless storage of pesticides
- Careless disposal of unused pesticides and pesticide containers

Pesticide contamination of ground water by pesticides can be classified as: a) point source contamination; or, b) non-point source contamination. This subject will be discussed under Prevention of Ground Water and River Contamination.

USAID has an explicit policy on the proper use of agricultural chemicals. The policy includes efforts to: a) reduce the use of chemical pesticides to the largest practical extent; b) use only those pesticides that are proven to be safe to the environment and people; c) discourage general requests for pesticides, and assure that pesticides are used in conjunction with natural control programs; d) develop infrastructure in developing countries for all aspects of proper pest and pesticide management, including the regulation of manufacturing, labeling, distribution, worker and public exposure levels, application, storage and disposal; and, e) promote the use of supplementary or alternative vector control methods that are not dependent on the use of toxic chemicals.

It is important that the AGRILINK II Project field-based Agribusiness Linkages Officers know how to advise farmers regarding the handling and storage of pesticides. For general principles on this subject, visit http://www.epa.gov/seahome/pest/src/main.htm , the U.S. Environmental Protection Agency's web site. This site provides simple and effective guidelines for pesticide storage, mixing and loading operations, container disposal and the improvement of management practices. A quick do-it-yourself questionnaire ( http://www.epa.gov/seahome/pest/src/pest_assess.htm ) will provide you with enough information to assess whether a farm's pesticide management has a high, medium or low risk of contaminating water sources, and if human health can be adversely affected.

***Integrated Pest Management (IPM)***

In South Africa, as in many other regions of the world, insects and other pests can have a deleterious effect on agricultural production. In sustainable agricultural production systems, a low level of pests will always be present. However, major outbreaks of pests, resulting in severe economic loss, are minimized. Before instituting any pest-control measures, a farmer must know if the production loss, resulting from the pest, justifies the cost of pest-control.

Integrated Pest Management (IPM) includes such measures as habitat modification, and biological, physical and chemical practices to minimize crop loss resulting from pests. Monitoring and recording pest life cycle information, including natural enemies of these pests, is essential to determine the alternatives to chemical pest control methods.

***What are the Key Components of an IPM Programme?***

1. ***Planning***. Planning should be done before planting, because many pest control strategies will require in-depth investigation. For example, information is required about beneficial organisms present in the area, habitat management, local pests, and previous control methods and their efficacy. Elements to consider in the planning phase include:

    - Options for design changes in the agricultural system (beneficial organism habitat, crop rotations, etc.)
    - Identification of cultivars that are most pest-resistant (IPM does not rely on genetically modified cultivars for pest control)
    - Technical information needs
    - Establishment of monitoring systems and record keeping
    - Purchase of appropriate equipment

2. ***The Pest Manager / Ecosystem Manager***. Also called the "Ecosystem Doctor", a Pest Manager should be identified as a reference for the farmer. The Pest Manager should be knowledgeable about the pests and beneficial organisms in the area, their life cycles and interactions. The Manager must know the best cultivars to plant and their rotation, how to increase the population of beneficial organisms and the steps to take to control pest infestations.

    A crucial step in any IPM programme is to identify the pest. The effectiveness of both proactive and reactive pest management measures depends on correct identification. Help with positive identification of pests may be obtained from universities, the Agricultural Research

Council (ARC) institutes ( http://www.arc.agric.za/ ), private consultants, or local co-operatives. Other farmers are excellent sources of knowledge about local pests.

After a pest is identified, appropriate and effective management depends on answers to a number of questions. These may include:

- What plants are hosts and non-hosts of this pest?
- When does the pest emerge or first appear?
- Where does it lay its eggs? In the case of weeds, where is the seed source? For plant diseases, where is the source(s) of the infection?
- If the pest disappears during some months of the year, where does it go, how does it survive?
- How might the cropping system be altered to make life more difficult for the pest and easier for its natural controls?

3. ***Proactive Strategies (Cultural Control)***. This is perhaps the most important tool to control pests. Cultural controls are manipulations of the agro-ecosystem that make crops less friendly to the establishment and proliferation of pest populations. Proactive strategies concentrate in three main areas:

**Under-surface bio-diversity** Healthy soils with a diverse community of organisms support plant health and nutrition better than soils deficient in organic matter and low in species diversity. Soil biodiversity is affected by the amount of organic matter, soil pH, nutrients, moisture and parent material of the soil (sand, clay, mix). Conventional fertilizers may provide the soil with basic nutrients like Nitrogen, Phosphorous and Potassium, but may also have an adverse effect in the balance of the soil constituents. This, in turn, will affect beneficial microorganism growth and predispose plants to pests and diseases.

**Above-surface bio-diversity** Diversity above ground affects diversity below ground. Plants do not only derive their nutrients from the ground, but provide nutrients to the micro-organisms in the soil that, in turn, convert soil products into food for plants. As different species of plants produce different nutrients for soil micro-organisms, it is important to diversify crops and to maintain a crop rotation programme on a farm.

**Appropriate plant cultivars** To use several cultivars in the same crop may help with the control of pests. It is known that some rice cultivars are resistant to some pests, but may yield less grain than other more pest-susceptible cultivars. Interplanting the two has been shown to reduce pests by up to 75%, reduce pest-management and to increase production markedly.

Mixing crops also reduces pests. Methods of mixing crops are: a) genetic diversity (two or more cultivars of the same species, i.e. rice); b) species diversity (by allowing native plants to grow in rows or fences in and around crops); c) crop rotation (e.g., corn, soybeans or other beans); d) multiple cropping (several crops simultaneously on the same farm); and, e) interplanting, inter-stripping or inter-cropping (growing two crops simultaneously in the same field, by rows, sections or together).

4. ***Cessation or Reduction of Practices that Destroy Beneficial Organisms***. Although technological advances are leading to the production of species-specific pesticides and herbicides, they destroy many other non-target species (e.g., spiders, beneficial insects, native plants, etc.) that are biological enemies of the specific pest.

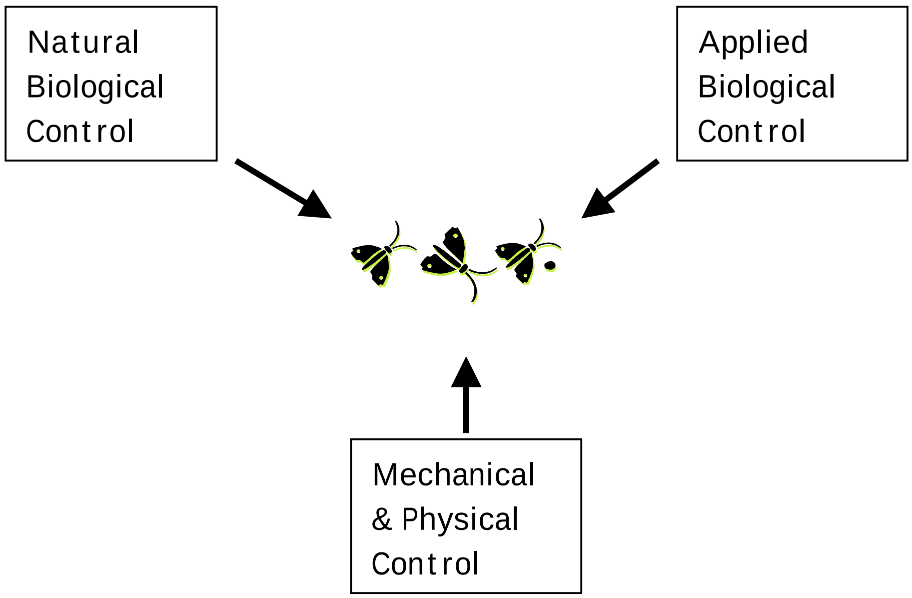
   Monoculture (growing large areas of the same crop) across multiple seasons does not promote the growth of beneficial organisms, either above or below ground, thus reducing biological diversity beneficial for pest control and soil conservation.

5. ***Biological Control***. Biological control is the control of pests through living organisms, such as parasites, predators or pathogens (diseases), by maintaining them below economically damaging levels. Biological control can be either natural or applied. In both types of biological control of pests, it is important to assess the natural beneficial organism in the area and its interaction with the local ecosystems.

   **Natural biological control** Beneficial insects and other organisms, such as bats, other mammals, birds, spiders, fungi and bacteria, should be viewed as mini-livestock, with specific habitat and food needs, which need to be taken into account in farm planning. In a balanced ecosystem, they play an important role in the control of pests, and it is necessary to maintain habitat suitable for these organisms. Mulching (covering with hay between rows of plants in a crop) not only reduces water evaporation from the soil, but also creates a habitat for spiders, which feed on pests.

   **Applied biological control** This method of biological control involves the supplementation of beneficial organism populations; for example, periodic releases of parasites, predators or pathogens. Most of the beneficial organisms used in applied biological control today are insect parasites (e.g., bacteria) and predators (e.g., wasps). These insects control a wide range of pests, from caterpillars to mites. Some species of bio-control organisms, such as *Eretmocerus californicus*, a parasitic wasp, are specific to one host (in this case, the Sweet Potato Whitefly). Others, such as Green Lacewings, are generalists, and will attack many species of aphids and whiteflies.

   It is important to understand that although biological control is a powerful tool to control pests, if wrongly used, it may have a negative effect on crops. For example, some types of beetles, when introduced as predators, may favor a type of crop, but may be detrimental to other crops.




6. ***Mechanical and Physical Control.*** This category of control utilizes a physical component of the environment, such as temperature, humidity, or light, to the detriment of the pest. Common examples are tillage, flaming, flooding, soil solarization and plastic mulches to kill weeds or to prevent weed seed germination.

   Heat or steam sterilization of soil is commonly used in greenhouse operations to control soil-borne pests. Floating row covers over vegetable crops will exclude Flea Beetles, Cucumber Beetles and adults of the Onion, Carrot, Cabbage and Seed Corn Root Maggots. Insect screens are used in greenhouses to prevent aphids, thrips, mites and other pests from entering ventilation ducts. Large, multi-row vacuum machines have been used for pest management in strawberries and vegetable crops. Cold storage reduces post-harvest disease problems in produce.

   These methods of pest control are primarily used in environmentally controlled conditions, including greenhouses or in small intensive production units.

7. ***Use of "Soft" Pesticides or Bio-Rational*** **Pesticides.** If environmentally friendly methods of pest control do not maintain pests below economic thresholds, chemical pest control methods are justified. This situation is most common in the transition to sustainable farming, due to the limited number of organisms that can maintain a balanced farm ecosystem.

   During the transition phase, the farmer should attempt to maintain satisfactory pest control by utilizing bio-rational or soft pesticides. These pesticides are usually pest-specific, and may involve insecticidal soaps, microbial insecticides, pheromones (for trapping and disrupting mating) or insect growth regulators.

8. ***Monitoring***. Every farm should have a pest control monitoring programme. Monitoring involves systematically checking fields for pests and beneficial organisms, at regular intervals and at critical times, to gather information about the crop, pests and natural enemies. Sweep nets, sticky traps and pheromone traps can be used to collect insects for both identification and population density information. Leaf counts are one method for recording plant growth stages. Square-foot or larger grids laid out in a field can provide a basis for comparative weed counts. Records of rainfall and temperature are sometimes used to predict the likelihood of disease infections.

AGRILINK II Project field-based Agribusiness Linkages Officers will find an excellent source for Integrated Pest Management in the following internet sites and in Appendix A:

http://www.attra.org/attra-pub/ipm.html
http://www.attra.org/attra-pub/farmscape.html
http://agrifor.ac.uk

South Africa is in its initial steps towards sustainable farming and there is little information regarding local experience in Integrated Pest Management. The principles offered here must be accommodated to the local conditions of the region and to the each individual farm or region.

**After Reviewing Section IV On Pest Management And Associated Internet Sites, AGRILINK II Project Agribusiness Linkages Officers Should Be Able To:**

- Define Integrated Pest Management (IPM) and explain how it can be applied.
- Advise farmers how to reduce the impact of pests on their crops by using IPM.
- Understand the basics of ecosystem management and be able to contact expert sources for information about pests, their control and the use of beneficial organisms.
- Assist farmers to draw-up a sustainable pest control "plan".
- Understand and be able to transfer knowledge on "farm-scaping" and its use in IPM.
- Understand the biological importance of pest life cycles on IPM.
- Explain to farmers the importance of bio-diversity.
- Advise farmers how to avoid the destruction of beneficial organisms.
- Understand the principles of biological (natural and applied), mechanical and physical pest control.
- Assist farmers develop monitoring programmes for pest control.

### *Pesticide and Hormone Residue Standards for Export*

Internationally recognized, the *Codex Alimentarius* ( http://www.codexalimentarius.net ) or Food-Code Commission, was created by the Food and Agricultural Organization of the United Nations (FAO) and the World Health Organization (WHO) to develop food standards, guidelines and other documents, such as codes of practice for the use of pesticides, insecticides and other chemicals. The programme protects consumer health, ensures fair trade practices in the food trade and promotes and coordinates all food standards work undertaken by international governmental and non-governmental organizations (NGOs).

Under the *Codex Alimentarius*, AGRILINK II Project field-based Agribusiness Linkages Officers will find: a) international standards for the production of all types of food, from cheese to honey; b) internationally accepted Maximum Residue Levels (MRLs) of pesticides, insecticides and other chemicals in agricultural products; and, c) MRLs of anti-parasitic drugs, growth-promotors and anti-microbials in livestock and poultry, and their consumable products, including milk and eggs. Other sections of the *Codex Alimentarius* cover food additive and flavourant standards.

Most countries, including South Africa, the United States of America, Canada and members of the European Union, are members of the Codex Alimentarius and should abide by its regulations.

Pesticide/insecticide residue levels in foodstuffs are generally legislated to:

- minimize the exposure of consumers to harmful or unnecessary intake of pesticide/insecticides;
- control the correct use of pesticide/insecticides in line with the authorizations or registrations granted (application rates and pre-harvest intervals);
- permit the free circulation of products treated with pesticides/insecticides, as long as they comply with the established MRLs.

A Maximum Residue Level for pesticide/insecticide residues is the maximum concentration of a pesticide/insecticide residue (expressed in mg/kg) legally permitted in or on food commodities and animal feed. MRLs are based on good agricultural practice data. Food produced from commodities that comply with the relevant MRLs is intended to be toxicologically acceptable and may be consumed without harm to the consumer.

Information on pesticide/insecticide residues in South Africa can be obtained on-line from the National Department of Agriculture ( http://www.nda.agric.za ) under “regulatory and other services” and “quality control”. All agricultural remedies must be registered in terms of The Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act (Act No.36 of 1947). All agricultural remedies used in the country must have a registration number on the label, which can be verified at the National Department of Agriculture Sub-directorate of Quality Control (Tel: 012-319-6004; Fax: 012-319-6055). Their web site ( http://www.nda.agric.za/act36/main.htm ) provides information regarding all pesticides that are banned and restricted in South Africa.

For information about banned pesticides elsewhere, visit http://www.pesticideinfo.org/index.html , which provides a comprehensive list of banned and restricted pesticides in countries like the USA, Canada, United Kingdom, etc.

The Agricultural Research Council ( http://www.arc.agric.za ) Plant Protection Research Institute of South Africa, under the National Support Services, provides pesticide residue analysis and advice on pest control and chemical usage for farmers. For more information, Agribusiness Linkages Officers can contact the ARC Plant and Protection Research Institute at their laboratories in Pretoria (Tel: 012-808-8000; Fax: 012-808-8229).

**After Reading Section IV On Pesticide And Hormonal Residue Standards For Export And Associated Internet Sites, AGRILINK II Project Agribusiness Linkages Officers Should Be Able To:**

- Look for relevant information in the *Codex Alimentarius* and advise farmers when their farming practices do not comply with the Code.
- Understand what Maximum Residue Limits (MRL) are and how to use this information when necessary.
- Know which pesticides are banned or restricted in South Africa.
- Report the illegal use of banned or restricted pesticides to the South African Department of Agriculture.
- Provide information to farmers on the South African institutions that test for pesticide residues.
- Advise farmers on the correct use, handling, storage and disposal of pesticides.

# V. Soil Management

A sustainable farming system manages the soil to ensure good biologic quality, composition and texture, as well as maintaining an appropriate level of nutrients and biodiversity. There are several important elements to managing soil, of which nutrient management and tillage are two of the most important.

Nutrient management was discussed briefly in Section II. Appropriate nutrient recycling should be promoted for all agricultural systems. Synthetic fertilizers may be one means of ensuring a specific level of nutrients; however, there are certain disadvantages to exclusive reliance on these products. First, these chemicals should not be applied without a proper understanding of the soil type, composition and nutrient availability. Soil testing is an important component of good soil management. Second, commercial chemicals can be expensive and inappropriate application can damage crops and animal species. Finally, there are some hazards to humans with the inappropriate use of fertilizers.

An alternative to chemical fertilizers is the recycling of plant and animal matter on the farm through sustainable methods, such as composting. However, not all farmers have access to organic matter, such as animal manure, and many of the organic materials can be expensive if they need to be purchased. Composting is an important means to ensure appropriate nutrient balance, which is investigated below.

***Soil Nutrients - Composting***

Although it will not be discussed in detail in these guidelines, composting is an important tool for the conservation of soil and the recycling of bio-degradable materials, such as plants, crop residues, human and animal excreta, and any other organic matter. There are many composting alternatives and farmers should be aware of them. The document "On-farm Composting Methods" by the FAO (http://www.fao.org/landandwater/agll/compost/default.stm – downloadable in pdf or MS Word format ) provides information on many techniques used to produce compost by traditional and more advanced methods.

The "Info-Pak" of the South African National Department of Agriculture, contains information (in English, Setswana and Afrikaans) on how to produce compost. You can obtain the "Info-Pak" (free of charge) by contacting the National Department of Agriculture Resource Centre - Directorate of Information Services in Pretoria; Tel: 012-319 7141 or Fax: 012-323 2516 (http://www.nda.agric.za).

***Land Preparation and Tillage***

Another important component of soil management is related to conservation and land preparation, or tillage. Slope, contour and depth are important elements to determine appropriate tillage methods.

In South Africa, as in many other developing countries, farmers cannot afford to respond to philosophical or emotional appeals to care for the soil, meaning that conservation measures must have visible short-term benefits for the farmer. Whatever soil conservation measures AGRILINK

II Project Linkages Officers recommend to farmers, they must be in agreement with the immediate and long-term expected farm profitability that will result. On fertile soils with good rainfall it may be sensible to invest more in sophisticated schemes for controlling water run-off, but not in areas with low and unreliable yields (i.e. due to poor soil composition and scarce plant coverage).

With the diversity of soils and the high degree of variation in precipitation throughout South Africa, there are no "one size fits all" conservation practices that will work throughout the country. To plan for appropriate soil conservation, a system is developed by selecting a set of individual characteristics, each relevant to the conditions of the particular region. The AGRILINK II Project Agribusiness Linkages Officers must be able to recognize this and to effectively advise farmers on the best soil conservation methods applicable to the specific regions they live in and farms they work on.

Various types of tillage systems have been described for soil conservation, all with advantages and disadvantages, some of them are described in the following table:

| SOIL CONSERVATION TILLAGE SYSTEMS | DESCRIPTION |
|---|---|
| **CONSERVATION COVER** | *Establish and maintain perennial vegetation cover to protect soil and water resources on land retired from agricultural production.* |
| **CONSERVATION CROPPING** | *A sequence of crops designed to provide adequate organic residue for maintenance of soil tilth. This practice reduces erosion by increasing organic matter. It may also disrupt disease, insect and weed reproduction cycles, thereby reducing the need for pesticides. This may include grasses and legumes planted in rotation.* |
| **CONSERVATION TILLAGE** | *Also known as reduced tillage, this is a planting system that maintains at least 30% of the soil surface covered by residue after planting. Erosion is reduced by providing soil cover. Runoff is reduced and groundwater filtration is increased. No-till planting, common in North America, is a conservation tillage practice.* |
| **CONTOUR FARMING** | *Ploughing, planting, and other management practices are carried-out along land contours, thereby reducing erosion and runoff.* |
| **COVER and GREEN MANURE CROP** | *A crop of close-growing grasses, legumes, or small grain grown primarily for seasonal protection and soil improvement. Usually it is grown for 1 year or less.* |
| **CRITICAL AREA PLANTING** | *Planting vegetation, such as trees, shrubs, vines, grasses or legumes, on highly erodible or eroding areas.* |
| **CROP RESIDUE USE** | *Using plant residues to protect cultivated fields during critical erosion periods.* |
| **DELAYED SEEDBED PREPARATION** | *Any cropping system in which all crop residue is maintained on the soil surface until shortly before the succeeding crop is planted. This reduces the period that the soil is susceptible to erosion.* |
| **DIVERSIONS** | *Channels constructed across the slope with a supporting ridge on the lower side. By controlling downslope runoff, erosion is reduced and filtration into the groundwater is enhanced.* |
| **FIELD BORDERS and FILTER STRIPS** | *A strip of perennial herbaceous vegetation along the edge of fields. This slows runoff and traps coarser sediment. However this is not generally effective for fine sediment and associated pollutants.* |

| | |
|---|---|
| **GRASSED WATERWAYS** | *A natural or constructed channel that is planted, graded and shaped to inhibit channel erosion. The vegetation also serves to trap sediment that runs-off of adjacent fields.* |
| **SEDIMENT BASINS** | *Basins constructed to collect and store sediment during runoff events. Also known as detention ponds. Sediment is deposited from runoff during impoundment in the sediment basin.* |
| **STRIP CROPPING** | *Growing crops in a systematic arrangement of strips or bands across the general slope (not on the contour) to reduce water erosion. Crops are arranged so that a strip of grass or a close-growing crop alternates with a clean-tilled crop or fallow.* |
| **TERRACING** | *Terraces are constructed of earthen embankments that retard runoff and reduce erosion by breaking the slope into numerous flat surfaces separated by slopes that are protected with permanent vegetation or which are constructed from stone, etc. Terracing is carried-out on very steep slopes and on long gentle slopes where terraces are very broad.* |

In high rainfall areas a number of these measures may produce situations that enhance the breeding of disease vectors as a result of water stagnation or reduction of water velocity in waterways.

Control measures depend very much on the economic situation of the farmer, the degree of importance placed on sediment erosion by environmental authorities, availability of capital, and the state of the region's development.

***Mechanical Conservation of Soils***

The main objectives of the mechanical conservation of soil are:

- To prevent soil erosion by modification of the terrain contour
- To influence surface run-off
- To allow agricultural use of steep slopes

As described in the previous table, various forms of terracing and the inclusion of simple structures on the contour of slopes (like grass, stones, wood) will act as "stop-wash lines" and prevent soil erosion. In many areas of South Africa, where summer thunder-storms are prevalent, it is important to prevent surface water run-off, and to encourage the deposition of suspended material that contains valuable soil nutrients.

***Prevention of Overgrazing***

For many years, the popular belief was that overgrazing implied too many animals per area, but this is not entirely true. From the point of view of the vegetation, overgrazing is a function of the time and timing, rather than the number of animals. (For more information on this subject visit http://www.managingwholes.com/overgrazing.htm ). Grasses co-evolved with grazers, and many years ago large numbers of wild animals grazed on South African land without overgrazing. Why? The difference between then and now is that animals were able to move freely over grazing areas. Grasses need sufficient recovery time between grazing. The critical factor for grazing is timing and management.

It is important that AGRILINK II Project Agribusiness Linkages Officers recognize that examining a piece of land is not just a question of seeing the presence or absence of animals and the quantity of grass available. There might be plenty of old grass, with little or no nutritional value and palatability, while there might be no young grass to replace grazed plants or to produce ground cover. It is more important to examine the health of the vegetation, the amount of effective ground cover and the time of grazing, than to observe the quantity of grass. Increasing the area available to grazers is not nearly as effective as shortening the period during which the plant is exposed to grazing.

How can grazing then heal land? Valuable information on this subject can be found at http://www.managingwholes.com/land_grazing.htm . Basically, the answer to overgrazing is high stock density for short periods of time and frequent movement of livestock in a process that mimics the impact of wild herds. The grass experiences longer recovery periods and the soil experiences sufficient trampling to maintain other processes, such as seed-soil contact, softening of soil for plants to achieve higher cover and better water retention.

**After Reviewing Section V And Associated Internet Sites, AGRILINK II Project Agribusiness Linkages Officers Should Be Able To:**

- Advise farmers on how to apply sound soil conservation principles in relation to the sustainability needs of their region, and to their financial and community needs.
- Understand the various types of tillage systems and know when and where to use them in order to achieve environmental sustainability.
- Obtain information on composting techniques and provide farmers with the best composting methods applicable to their region and financial status.
- Understand the causes of overgrazing and how to avoid them.
- Advise farmers on sustainable grazing techniques and demonstrate to them how livestock can be beneficial to their land.
- Use the references to obtain further information on soil management.

# VI. Water Management: Conservation, Water Usage Methods and Ground Water Contamination

***Water Conservation and Usage***

Water conservation systems can be either internal (in the field, small ponds, soil depressions, etc.) or external (large dams and reservoirs in the nearby region). Whatever system we use, water conservation is largely influenced by local factors. A system of water conservation that applies well to the lowveld may not be of use in the semi-arid regions of North West Province. Seasonal and yearly variability also influence the type of advice that Linkage Officers can provide to farmers. In a dry area it may be sensible to increase surface storage to improve crop yield in most years, but in a wet year this could cause water-logging and reduce crop yield, as seen in Northern Province during the floods several years ago.

AGRILINK II Project Agribusiness Linkages Officers can use the following concepts as general principles in order to advise farmers about water conservation:

i. ***If Precipitation is Less than Crop Requirements.*** When this happens, the farmer must try to increase run-off onto cropped areas, fallowing for water conservation, and use of drought-resistant crops.

ii. ***If Precipitation is Equal to Crop Requirements.*** Here, the farmer must try to conserve precipitation by maximizing storage within the soil profile, and store excess run-off for subsequent use.

iii. ***If Precipitation is Greater than Crop Requirements.*** In this case, the farmer must try to reduce erosion produced by water run-off, implement proper drainage systems and store water for future use.

Broadly speaking, South Africa has a cyclical pattern of precipitation in which several years of drought are followed by several years of rain. As this varies between regions, it is important that Linkage Officers have a general idea of their region's rain patterns.

Several techniques to modify the terrain in order to conserve water include:

i. ***Broad Bed and Furrow System***. This basically consists of beds 100 cm. wide, divided by furrows 50 cm. wide. The technique works best on deep black soils in areas with dependable rainfall averaging 750 mm. or more.

ii. ***Ridging and Tied Ridging***. This method is also known as furrow blocking, furrow damming, furrow diking, and basin listing. The principle is to increase surface storage by first making ridges and furrows, and then damming the furrows with small mounds, or ties. Graded ridges alone will usually lead to an increase of surface run-off, compared with flat planting, while tied ridges will decrease the run-off and increase water storage.

iii. ***Conservation Bench Terraces.*** This method is used in gentle slopes, and has been used extensively in drier areas of North America. Results of the American experience show that the method is suitable and economic for the region's high-input, large-scale mechanized farming.

iv. ***Contour Furrows or Contour Bunds***. Contour furrows are a variation on the theme of surface manipulation, which require less soil movement than conservation bench terracing, and are more likely to be used by small farmers or in lower rainfall areas. Cropping is usually intermittent on strips or in rows, with a catchment area left fallow. The principle is the same as Conservation Bench Terraces: to collect run-off from the catchment to improve soil moisture on the cropped area.

Methods to collect and divert rain water into fields and reservoirs include:

- Natural run-off
- Collected and diverted run-off
- Inundation methods
- Flood diversion

Further information on these topics can be obtained at the internet sites recommended in Appendix A. A particularly good site, where information regarding the main advantages and disadvantages of the different water conservation systems is found, is the Food and Agriculture Organization (FAO) web page http://www.fao.org/docrep/T0321E/T0321E00.htm

For information on soil tillage and the management of run-off water, please consult http://www.fao.org/ag/agl/public.stm#Lwdms, which has relevant information applicable to Africa, including irrigation water management training manuals, with emphasis on the following fields:

- Water management irrigation manuals
- Water harvesting training
- Training in the planning and management of irrigated agriculture and effective water use
- Participatory training and extension in water management

The manual "Soil Management and Conservation for Small Farms – strategies and methods of introduction, technologies and equipment" (http://www.fao.org/ag/agl/public.stm#iwmtm ) could be an excellent source of information when advice is required by small farmers.

**After Reviewing Section VI, Water Conservation And Water Usage, And Associated Internet Sites, AGRILINK II Project Agribusiness Linkages Officers Should Be Able To:**

- Advise farmers on how to apply sound water conservation principles in relation to the sustainability needs of their region, and to their financial and community needs.
- Advise farmers in the techniques used to modify the terrain in order to conserve water.
- Use references to obtain further information on soil and water conservation.

***Prevention of Ground and Surface Water Contamination***

Agriculture is the largest consumer of fresh water in the world, and is one of the major causes of the degradation and contamination of surface and ground water through erosion and chemical and organic runoff. The implications of this on water quality are paramount. The associated food-processing industry, which is unregulated in countries like South Africa, is also a significant source of organic pollution of water sources. Aquaculture, a growing industry in South Africa, is now recognized as a major problem in fresh water, estuarine and coastal environments, leading to eutrophication (excessive accumulation of nutrients in water sources, like lakes) and ecosystem damage.

The principal negative environmental and public health impacts of the problems associated with poor global fresh water quality are:

- Five million people die annually from water-borne diseases.
- Ecosystem dysfunction and loss of biodiversity.
- Contamination of marine ecosystems from land-based activities.
- Contamination of groundwater resources.
- Global contamination by persistent organic pollutants.

In the past, dilution was a form of pollution remediation, but this can no longer be utilized, as world water systems are becoming saturated with pollutants. This means that **fresh water will become the principal limitation of sustainable development.**

Water entering the soil gradually percolates downward to become groundwater if it is not first taken-up by plants, evaporated into the atmosphere or held within soil pores. This percolating water, called recharge, passes downward through the root zone and unsaturated zone until it reaches the water table. Effective programs for the protection of groundwater focus primarily on the recharge process because this controls both the quantity and the quality of water reaching the saturated zone. Water is far easier and less expensive to manage at the land surface then after it becomes less accessible and more dispersed underground.

There are two types of water pollution to ground and surface water, they are: a) non-point or "diffuse" source; and, b) point source water pollution. As the name implies, **non-point source water pollution** has no obvious point of entry into receiving watercourses. Generally, all types of agricultural practices and land use, including animal feeding operations (feedlots), are treated as non-point sources. Non-point sources respond to hydrological conditions, are not easily measured or controlled directly (and therefore are difficult to regulate) and focus on land and related management practices.

In contrast, **point source water pollution** represents those activities in which wastewater is routed directly into receiving water bodies by, for example, discharge pipes, where they can be easily measured and controlled. Obviously, non-point source pollution is much more difficult to identify, measure and control than point sources.
Non-point source pollutants, irrespective of source, are transported overland and through the soil by rainwater or irrigation water. These pollutants ultimately find their way into groundwater, wetlands, rivers and lakes and, finally, to oceans in the form of sediment and chemical loads carried by rivers. The ecological impact of these pollutants range from simple nuisance, to major ecological catastrophes, affecting mammals, birds, fish and human health.

Groundwater becomes contaminated when water percolating through the soil carries pollutants downward to the water table. Gasoline or other liquids that seep into the ground or leak from underground storage tanks can also become groundwater contaminants. Once in the saturated zone, these chemicals move with the groundwater, forming a region of contaminated water called a plume. Because contaminants flow with groundwater through the saturated zone, the quality of water in a particular well depends on the land areas, perhaps miles away, from which this part of the aquifer is recharged.

It may be years before a contaminant plume originating at the land surface appears in a well or water source some distance away. By the time this is detected, the contamination is likely to be widespread, and it may take decades or even centuries for the aquifer to purify itself naturally. In rivers and streams dissolved contaminants are rapidly swept downstream, diluted and subjected to biological and chemical decay. Goundwater conditions, in contrast, act to preserve contaminants.

The following table (from FAO Manual "Control of water pollution from agriculture - FAO irrigation and drainage paper 55", E.C. Ongley, 1996, http://www.fao.org/docrep/W2598E/W2598E00.htm ) summarizes the most common water pollutants and their impact on surface and ground water:

| AGRICULTURAL ACTIVITY | IMPACT | |
|---|---|---|
| | **SURFACE WATER** | **GROUNDWATER** |
| Tillage/Ploughing | Sediment/turbidity: sediments carry phosphorus and pesticides adsorbed to sediment particles; siltation of river beds and loss of habitat, spawning grounds, etc. | |
| Fertilization | Runoff of nutrients, especially phosphorus, leading to eutrophication causing taste and odor in public water supply, excess algae growth, leading to de-oxygenation of water and fish kills. | Leaching of nitrate into groundwater; excessive levels are a threat to public health. |
| Spreading of Manure | Carried-out as a fertilization activity; spreading on frozen ground results in high levels of contamination of receiving waters by pathogens, metals, phosphorus and nitrogen, leading to eutrophication and potential contamination. | Contamination of ground-water, especially by nitrogen |
| Pesticides | Runoff of pesticides leads to contamination of surface water and biota; dysfunction of ecological system in surface waters by loss of top predators due to growth inhibition and reproductive failure; public health impacts from eating contaminated fish. Pesticides are carried as dust by wind over very long distances and contaminate aquatic systems thousands of miles away (e.g. tropical/subtropical pesticides found in Arctic mammals). | Some pesticides may leach into groundwater, causing human health problems from contaminated wells. |
| Feedlots/Animal Corrals | Contamination of surface water with many pathogens (bacteria, viruses, etc.), leading to chronic public health problems. Also contamination by metals contained in urine and feces. | Potential leaching of nitrogen, metals, etc. into groundwater. |
| Irrigation | Runoff of salts, leading to salinization of surface waters; runoff of fertilizers and pesticides into surface waters, with ecological damage, bio-accumulation in edible fish species, etc. High levels of trace elements, such as selenium can occur with serious ecological damage and potential human health impacts. | Enrichment of groundwater with salts and nutrients (especially nitrate). |
| Clear Cutting | Erosion of land, leading to high levels of turbidity in rivers, siltation of bottom habitat, etc. Disruption and change of hydrologic regime, often with loss of perennial streams; causes public health problems due to loss of potable water. | Disruption of hydrologic regime, often with increased surface runoff and decreased groundwater recharge; affects surface water by decreasing flow in dry periods and concentrating nutrients and contaminants in surface water. |
| Silviculture | Broad range of effects: pesticide runoff and contamination of surface water and fish; erosion and sedimentation problems. | |
| Aquaculture | Release of pesticides (e.g. TBT[1]) and high levels of nutrients to surface water and groundwater through feed and feces, leading to serious eutrophication. | |

[1] TBT .= Tributyltin

Another problem that may be present in rural areas in South Africa is contamination of water sources (like wells) from water that seeps from septic systems, leaky sewer lines, cow-sheds and stables, or fields spread with manure. Contamination by bacteria, viruses, or parasites, is common in these cases. Water contaminated with sewage-related microorganisms can transmit diseases such as cholera, typhoid and hepatitis.

***How Can We Help the Farmer to Understand His Role in the Prevention of the Contamination of Water Sources?***

Protection of groundwater quantity and quality can best be accomplished by controlling potential contaminant sources and by managing land uses in prime recharge areas. With the knowledge of local geology and groundwater flow directions, estimates can be made of the land areas contributing recharge to a particular well or to an aquifer as a whole. Controls can then be established to ensure appropriate land uses and chemical practices within the recharge areas.

Farmers have a wide range of choices in how to manage their farms, and these choices determine the efficiency of chemical use, as well as the success of the harvest. Pesticides and fertilizer applications can be designed to efficiently meet crop needs while minimizing losses to groundwater. The types of chemicals used, the amount and timing of applications and a variety of other farm management practices all interact to affect crop yields and leaching losses.

The first step in protecting groundwater quality is to determine the locations of prime recharge areas. The second step is to identify management options that would help to protect the quality of recharge in these areas. The level of management appropriate to a particular area depends on the vulnerability of the aquifer, the extent to which it is relied on for high quality water supplies, and the number and type of potential contaminant sources. The protection of recharge quality can be as simple as not dumping used motor oil down the drain or as comprehensive as a community-wide aquifer protection plan incorporating land-use and contaminant source control regulations. Recharge protection is the key to any effective groundwater protection program.

AGRILINK II Project Agribusiness Linkages Officers can make decisions to control agricultural non-point source pollution at various levels. At the field level, decisions are influenced by very local factors, such as crop type and land use management techniques, including the use of fertilizers and pesticides. These decisions are based on the best management practices possible under local circumstances and are meant to maximize economic return to the farmer, while safeguarding the environment. Local decisions are made on the basis of known relationships between farm practice and environmental degradation, but do not usually involve specific assessment of farm practices within the larger context of river basin impacts from other types of sources. Decisions regarding use of wastewater, sludge, etc. for agricultural application, are also made using a general knowledge of known impacts and of measures to mitigate or minimize these impacts.

For example, nitrogen is a major pollutant derived from the irresponsible use of organic fertilizers. The following are basic principles to control the run-off of nitrogen into water sources:

i. **Rational Nitrogen Application:** To avoid over-fertilization, the rate of nitrogen fertilizer to be applied needs to be calculated on the basis of the "crop nitrogen balance". This takes into account plant needs and the amount of nitrogen in the soil.

ii. **Vegetation Cover:** As far as possible, keep the soil covered with vegetation. This inhibits the build-up of soluble nitrogen by absorbing mineralized nitrogen and preventing leaching during rain storms.

iii. **Manage the Period Between Crops:** Organic debris produced by harvesting is easily mineralized into leachable nitrogen. Steps that can be taken to reduce leachable nitrogen include planting of "green manure" crops, and delaying the ploughing of straw, roots and leaves into the soil.

iv. **Rational Irrigation:** Poor irrigation has one of the worst impacts on water quality, whereas precision irrigation is one of the least polluting practices, as well as reducing the net cost of water.

v. **Optimize Other Cultivation Techniques:** To obtain the highest yields, with minimum water quality impact, requires optimization of practices, such as weed, pest and disease control, liming and balanced mineral fertilizers, including trace elements, etc.

vi. **Agricultural Planning:** Implement erosion control techniques (see Chapter III) that complement topographic and soil conditions.

***Sludge Management***

Sludge is mentioned here only insofar as the spreading of sludge from municipal wastewater treatment facilities on agricultural land is one method used to get-rid-of municipal sludge in a way that is perceived to be beneficial. The alternatives to dispose of sludge are incineration and land fill. The Food and Agricultural Organization of the United Nations (1991) includes sludge within the category of organic fertilizers, but notes that sludge often contains unacceptable levels of heavy metals. The problems of water pollution caused as a result of sludge runoff are similar to those of manure noted above.

The internet site information system on water conservation and use in Agriculture (WCA) http://193.43.36.27/iptrid/infonet/index.jsp, linked to the Food and Agricultural Organization of the United Nations, provides expanded information on water management and water use in agriculture, and links to other relevant internet sites. Topics at this site include: water resources, water development, water use, water and the environment, water institutions and policies, and regional views on water.

**After Reviewing Section VI On Prevention Of Ground And Surface Water Contamination And Associated Internet Sites, AGRILINK II Project Agribusiness Linkages Officers Should Be Able To:**

- Understand that water is the principal limitation to sustainable development in South Africa and elsewhere.
- Recommend that farmers avoid "dilution" as a method of water pollution remediation.
- Explain to farmers why it is important to conserve water systems free of pollution.
- Explain to farmers how water cycles work.
- Understand the principles of point and non-point source water pollution and how to transfer this knowledge to farmers.
- Understand that water pollution not only includes pesticide and other chemicals reaching water sources, but that animal and human excreta are also important sources of water pollution.
- Know how to stop water pollution, and advise farmers accordingly.

## VII. Human Waste Management in Agricultural Areas

Many rural South African communities do not have the infrastructure to dispose of human waste in a safe or productive manner. Many communities rely on latrines, and frequently they are not used properly, or are not used at all. As the population density increases, water contamination from human waste will be an ever-increasing problem. In recent years South Africa has experienced numerous cholera outbreaks, which highlight the growing problem.

When human and animal wastes are applied as organic fertilizer, without proper treatment, contamination of ponds, lakes and rivers can result. Simple run-off, particularly during the rainy season, causes outbreaks of disease in humans and animals.

Using human waste in agriculture has been criticized by some agriculturists and encouraged by others, but it has been shown that the proper management of human waste can not only be done safely, but it can help to reduce the use of water in rural areas.

***What Are the Advantages of Using Human Waste-Water on Crops?***

- Conserves water
- Provides a low cost method for the sanitary disposal of wastewater
- Reduces the pollution of rivers, canals and other surface water resources
- Conserves nutrients, reducing the need for artificial fertilizers
- Increases crop yields

***What Are the Disadvantages of Using Human Waste-Water on Crops?***

- Health risks for farmers and communities that experience prolonged contact with untreated wastewater
- Potential health risks for consumers of vegetables irrigated with wastewater
- Contamination of groundwater (nitrates)
- Buildup of chemical pollutants in the soil (heavy metals)
- Creation of habitat for disease vectors
- Excessive growth of algae and vegetation in canals carrying wastewater (eutrophication).

Waste-water can be utilized, but a proper educational campaign is necessary where it is used. The campaign must include instruction in the proper methods of destroying pathogenic organisms and making human waste safe (e.g., a six-month storage in composting tanks and reservoirs).

The following is a list of the different focus areas for educational and development programs to manage the application of human and animal waste in communities:

- Enhancing the community's awareness of the effects on human health (potential spread of diseases) and the environment (in particular, water supplies) by inappropriately managing human and animal wastes.

- Instruction in how to appropriately dispose of human and animal wastes (discuss options such as biogas and latrines).
- Training in the selection of a well-organized management system to meet the needs of the local community.
- Technical training in how to build, use and maintain the human and animal waste management techniques selected for implementation (see below for a selection of techniques).

**Human and Animal Waste Management Technologies**

- **Biogas chambers**. These chambers can be constructed for use by an individual household or for several households combined. A biogas plant may be a more feasible option between several homes. More on biogas chambers can be found at http://www.undp.org/seed/energy/policy/ch_8.htm
- **Household latrines**. How to construct latrines is found in http://www.refugeecamp.org/learnmore/latrines/vip_latrine.htm or by contact the School of Health Systems and Public Health, University of Pretoria ( http://www.shsph.up.ac.za/ ) at 012- 841-3346.
- **Public latrines** (in villages).
- **Removal of unhygienic and old latrines**.
- **Aerobic composting** methods to treat human and animal waste excrement. A general document on composting methods can be found at http://www.fao.org/landandwater/agll/compost/docs/On-farm%20Composting%20methods%2014%2005%20021.doc

For further information on the management of human and animal waste, please consult http://www.sandec.ch/files/sandecnews_5.pdf, as well as the other internet sites included in Appendix A.

**After Reviewing Section VII And Associated Internet Sites, AGRILINK II Project Agribusiness Linkages Officers Should Be Able To:**

- Understand and explain to farmers that human waste, if properly managed, can be beneficial to their crops.
- Know what are the advantages and disadvantages of using human waste in agriculture.
- Acquire the latest information on human and animal waste management technologies, the use of biogas and the correct construction of latrines. Linkage Officers must be able to advise farmers on these topics.

## VIII. Environmentally Friendly "Green" Packaging and Labeling

Modern consumer demand and supply chains require packaging materials to protect or preserve perishables and non-perishables. Movements to recycle and reduce packaging have developed in some countries, particularly Western Europe, due to the increasing cost of packaging disposal. However, on one hand there are growing health concerns about the safety of perishable products, and, on the other, packaging reduces supplier losses. Proper packaging reduces waste: a great proportion of our food would have a shorter shelf-life if it were not properly packaged (food waste in Western Europe is 2-3%, while it is 30-50% in developing countries).

**Good packaging materials should:**

- Provide a service to the consumer
- Protect the product
- Have a minimal manufacturing and disposal impact on the environment.

**Characteristics of environmentally friendly packaging include:**

- Construction from renewable resources (i.e. other than from materials produced from fossil-fuels)
- Biodegradable and, preferably, able to be composted
- The cost should not exceed current available packaging materials (new biodegradable plastics must be cost-effective to compete with conventional inexpensive plastics)
- Environmentally friendly manufacturing methods
- Non-toxic after degradation

An example of a recent advance in environmental packaging is the development of bio-plastic materials that are expected to replace petroleum-based plastics. Many bio-plastics can be processed on conventional plastic molding equipment and converted into packaging materials (or other products). A problem is that the new plastics are usually more expensive than the oil-based, traditional plastic materials. Recent advances in production technology have helped to reduce the cost of some degradable resins, but degradable polymers are cost-effective only in specific niche markets.

Renewable raw materials that have been explored for making plastics are:

- **Starch** - a renewable degradable carbohydrate polymer that can be purified from various sources by environmentally sound processes. It is found in high concentrations in plants such as maize, potatoes, and wheat. Starch, by itself, has a severe limitation in that it is water soluble, and articles made from starch will swell and deform upon exposure to moisture. Starch-only plastics are highly suitable for cushioning goods that do not get wet.

- **Polylactic Acid (PLA)** - is made as a result of the fermentation of starch from agricultural products, such as potatoes or maize (by wet milling of maize, or from food wastes). PLA is crystalline and strong (its hardness similar to acrylic plastic), and production costs are falling.

- **Cellulose** and **lignin** from wood, and cellulose from cotton. Cellulose is the main cellular wall constituent of higher plants and can either be used in its original form or modified into cellulose acetate, cellulose butyrate or cellulose nitrate (which is highly flammable).

- **Polyhydroxyalkanates (PHAs)** - There are nearly 100 different polyhydroxyalkanoates (polyhydroxyvalerate, polyhydroxybutyrate etc). These are biological polyesters that are produced by micro-organisms, and which can be biodegraded by a large number of different micro-organisms. The polymers are produced by a fermentation process involving a sugar feedstock and naturally occurring micro-organisms. An alternative way of making these plastics is to produce them directly in plants (research is being conducted on how to do this).

- **Pullulan** -a microbially produced polysaccharide. This water-soluble extra-cellular neutral glucan is synthesized by a fungus. Plasticisers are necessary when pullulan is processed further.

- **Konjac Flour** - the powdered tuber of elephant yam (Amorphophallus konjac). In the presence of water, this can be thermo-pressed into sheets.

- **Chitosan** – de-acetylated chitin, which is a naturally occurring polysaccharide and similar to cellulose in both structure and function. It is derived primarily from shellfish (for example, from a crab's outer skeleton).

- **Triglycerides** - another promising raw material for producing plastics that make up a large part of the storage lipids in animal and plant cells (e.g., soya beans, flax, and rapeseed).

In order to be composted, packaging must be able to biodegrade and disintegrate completely during a composting cycle. Certain quality criteria must be met, including no toxicity and no obvious distinguishable residue in the finished compost. When the product has been certified to the regulatory standards, the compost can be sold for agricultural or horticultural use.

Although environmentally friendly packaging in South Africa is still in its early stages, this field is progressing rapidly in developed countries and legislation is rapidly being implemented. Two very good articles on the use of renewable resources for packaging can be found at:

http://www.mli.kvl.dk/foodchem/special/biopack/FOODBIOPACK.pdf
http://www.orbit-online.net/journal/archiv/01-01/0101_02_text.html

**After Reviewing Section VIII And Associated Internet Sites, AGRILINK II Project Agribusiness Linkages Officers Should Be Able To:**

- Know that there are new environmentally friendly packaging technologies available.
- Encourage farmers to use available environmentally friendly packaging materials (especially natural products), without compromising the quality of their products.
- Be innovative!

# IX. Sustainable Development Livestock and Poultry Health Standards

With a sharp increase in the demand for animal products in many developing countries (a well-documented trend, with increasing incomes), and the pressure created by livestock production the exceeds the absorptive capacity of the environment, it is of critical importance that future production sustains the quality of land, air, water, and plant and animal genetic resources.

The methods by which livestock and poultry products are produced (e.g. meat, milk and eggs) are produced are key to the future management of resources throughout the world. Animal production is one of the most important components of global agriculture, and livestock is one of the primary consumers of the natural resource base. The following are a few issues indicating the importance of livestock production in the sustainability of natural resources:

- Livestock use 3.3 billion hectares of grazing land (Food and Agriculture Organization, 1996), and consume the production of close to one-quarter of the world's cropland. In total, livestock make use of more than two-thirds of the world's land mass devoted to agriculture, and one-third of the total global land mass;

- Livestock is the main source of livelihood for at least 20 million rural families, and an important source of income for at least 200 million smallholder farmer families in Asia, Africa and Latin America;

- Livestock provide the power to cultivate at least 320 million hectares of land (FAO, 1994), or one-quarter of the total cropped area on earth;

- Livestock manure provides the plant nutrients for large areas of cropland. Estimates show that, for tropical irrigated areas, manure provides nutrients with an estimated value of US$ 1.4 billion per year;

- Livestock are an important asset and serve as insurance for millions of families, especially in countries in sub-Saharan Africa, including South Africa.

It is expected that livestock production will increase significantly over the next decade, and it is important that proper livestock management is instituted in rural areas in order to achieve environmental sustainability and profitability for the farmer.

**If not managed properly, livestock production can be harmful to the environment and to humans for the following reasons:**

- Livestock waste run-off can be a major threat to water quality when livestock numbers exceed the absorptive capacity of the farm or when waste disposal is not well managed;

- Animal wastes produce greenhouse gasses that contribute to global climate change;

- Livestock and poultry may be the source of many diseases to people that work with them, including owners, abattoir workers and veterinarians. Diseases such as anthrax can infect people: for example, a recent outbreak in North West Province was reported.

The following table provides a brief description of other indirect livestock production environmental impacts:

**Relative Contribution of Crops (Produced for Livestock Feed) to Sources of Environmental Impact on Soil and Water**

| Crop | Erosion (risk and contribution) | Nutrient Loss (leaching and run-off) | Water Use (soil moisture fertility status) | Nutrient Demand (impact on soil) | Pesticide Use (impact on biodiversity and pollution) |
|---|---|---|---|---|---|
| Maize | ** | *** | *** | ** | *** |
| Wheat | * | *** | *** | ** | *** |
| Barley | * | ** | ** | ** | ** |
| Sorghum | ** | * | * | * | ** |
| Pulses | * | * | ** | * | ** |
| Soybean | ** | * | ** | * | ** |
| Cassava | * | ** | ** | *** | * |
| Sweet potato | * | ** | ** | *** | * |

***, ** and *** indicating low, moderate or high potential impact.**

Source: Hendy, C.R.C., Kleih, U., Crawshaw, R., and Phillips, M. (1995). Interactions between Livestock Production Systems and the Environment: Impact Domain: Concentrate Feed Demand. FAO Consultancy Report for Livestock and Environment Study.

AGRILINK II Project Agribusiness Linkages Officers will find information on appropriate management of livestock techniques and production at the National Department of Agriculture internet site http://www.nda.agric.za

***South African Livestock and Poultry Health Standards***

The South African Directorate of Veterinary Services regulates the laws associated with maintaining disease-free animals (http://www.nda.agric.za/vetweb/Food%20Safety/FS_Food_Safety.htm). The Directorate administers the Meat Safety Act, 2000 (Act no 40 of 2000) and the Abattoir Hygiene Act, 87 (Act no. 87 of 1967) regulations, and is responsible for promulgation of regulations under this Act. The enforcement of the Act is the responsibility of provincial and local authorities throughout the country. The purpose of the Act is to make provision for the maintenance of proper standards of hygiene in the slaughtering of animals (including livestock, poultry and ostriches) for the purpose of obtaining suitable meat for human and animal consumption, and in the handling, keeping and conveyance of such meat and animal products at and from abattoirs.

When animals are slaughtered away from registered abattoirs, it is difficult for Veterinary Services to regulate hygiene in the animal products that people consume. The AGRILINK II Project Linkages Officers can play a positive role by advising farmers on proper health management of their livestock and poultry. Recommended vaccination practices and regular internal and external parasite programs are important to maintain animal health. Advice on vaccination and other profitable animal raising health practices, and disease prevention, can be found at http://www.obpvaccines.co.za/Index.html .

***Regulations for the Importation of Meat Products In Countries other than South Africa***

Each country has its own regulations for the importation of meat and other animal products. These regulations may change from time to time depending on animal disease reports and outbreaks. An example of this was the ban on the exportation of South African meat, following the Foot and Mouth Disease outbreak in KwaZulu-Natal Province. Fortunately, the disease was contained and South Africa is currently regarded as free from the disease, which allows its meat products to be exported to many European countries. However, there has been considerable concern recently over the increase in outbreaks in Zimbabwe, and the potential that this will affect South African livestock (given the porous border between the two countries).

For information about meat regulations and the importation of poultry products into the United States, please visit http://www.fas.usda.gov/itp/ofsts/us.html, the United States Department of Agriculture's web site. For the United Kingdom, food legislation imports are well documented at: http://www.foodlaw.rdg.ac.uk/book/h-imp-a.htm, and for Canada at http://www.inspection.gc.ca/english/anima/meavia/mmopmmhv/table10e.shtml

Appendix A provides other sites of interest regarding livestock and poultry health standards.

**After Reviewing Section IX And Associated Internet Sites, AGRILINK II Project Agribusiness Linkages Officers Should Be Able To:**

- Advise farmers on how to expand the use of their animals and animal products (e.g. the use of manure for the production of compost and biogas).
- Advise farmers on best management practices for their livestock, and encourage them to modify their grazing systems to prevent overgrazing and land deterioration.
- Understand that there are public health issues associated with livestock production.
- Get advice from the Directorate of Veterinary Services when presented with both common and unknown animal diseases.
- Advise farmers regarding the slaughtering of animals, especially if it is not done at registered abattoirs.