

Module 3: Agri-Rural Sustainability and the Environment

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Main objectives of the module:

By the end of the session, participants will be better able to:

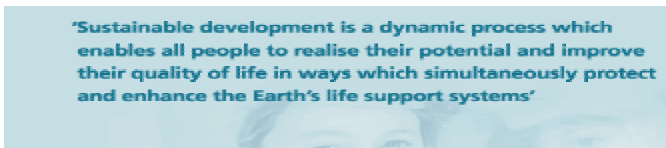
- Understand the concept of sustainable agriculture and “whole farm management”
 - Understand the main elements of good agricultural practice and its affect of the environment
 - Understand integrated pest management and make more informed judgements on pesticide and chemical use
 - Use soil, water and environmental resources sustainably
 - Understand organic production techniques
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3.1 What is sustainability and the environment?

Agriculture has changed, especially since the end of World War II. Food and fibre productivity has soared dramatically due to new technologies, mechanisation, increased chemical use, specialisation and government policies that have favoured maximizing production. Although these changes have had many positive effects and reduced many risks in farming, there have also been significant costs. Prominent among these are topsoil depletion, groundwater contamination, the decline of family farms, continued neglect of the living and working conditions for farm labourers, increasing costs of production, and the disintegration of economic and social conditions in rural communities.

Sustainability has grown from an initial concern, particularly with environmental issues in the 1960s, through many steps to international and national programmes combining economic growth and business development with social and environmental responsibility. Today a movement for sustainable agriculture is gathering increasing support and acceptance within mainstream agriculture and within policy making. Not only does sustainable agriculture address many environmental and social concerns, but it may also offer innovative and economically viable opportunities for farmers, employees, consumers, policymakers and other stakeholders across the entire food chain.

“Sustainability” is a word that is used and defined in many ways. Many people use the word “sustainable” to mean “environmentally” friendly, or as a term that applies mainly to the development of the third world. But sustainability means much more than that. When a resource is consumed at sustainable levels, people can continue to consume the same amount of that resource year in and year out, from our generation and into the next. When a resource is used at unsustainable levels, sooner or later that resource will run out.



“Sustainable development is a dynamic process which enables all people to realise their potential and improve their quality of life in ways which simultaneously protect and enhance the Earth’s life support systems”

Sustainable agriculture integrates three main goals – a healthy environment, economic profitability and social and economic equity. A variety of philosophies, policies and practices have contributed to these goals. People in many different capacities, from farmers to consumers, have shared this vision and contributed to its development.

In 1990 the United Nations defined sustainability as: “meeting current needs without compromising the ability of future generations to meet their own needs.” Therefore, stewardship of both natural and human resources is of prime importance. Stewardship of human resources includes consideration of social responsibilities such as working and living conditions of employees, the needs of rural communities, and consumer health and safety both in the present and the future. Stewardship of land

and natural resources involves maintaining or enhancing this vital resource base for the long term.

In most member states, agri-environment measures have been implemented under Regulation (EEC) No 2078/92 to preserve biodiversity, for example, by reducing or ceasing the use of fertiliser and pesticides on the maintenance of rotational practices. Examples include the introduction of organic farming, integrated pest management, set aside of field margins and specific measures, tested through LIFE nature projects aimed at particular habitats.

Case Study 16 Milden Hall is an example of a farm enterprise that works within the UK Government Department for the Environment, Farming and Rural Affairs (DEFRA) Countryside Stewardship Scheme. This scheme makes payments to farmers and other land managers to enhance and conserve English landscapes, their wildlife and history and to help people to enjoy them.

Case Study 28 The ARSSA and SIMOCA illustrate two projects aimed at cultivating indigenous crop varieties and conserving rare animal species. It is being implemented with the support of the Italian regional agricultural authorities. Similar national and regional programmes are being carried out across Europe. In Bulgaria **Case Study 29 Rodopi** the Ministry of Agriculture and Forestry has developed a programme for alternative agriculture in the Rodopi Masif and aimed at balancing agriculture, the environment and rural livelihoods.

Case Study 32 Bulgarian Protected Areas provides a broader context of conservation and includes regions from which all human activity is totally excluded.

However in most European regions such extreme conservation measures are not possible and in agriculture a systems perspective (whole farm management) is a better way to understand sustainability. The system is envisioned in its broadest sense, from the individual farm, to the local ecosystem, and to communities affected by this farming system both locally and globally. An emphasis on the system allows a larger and more thorough view to be made of the consequences of farming practices on both human communities and the environment. A systems approach gives us the tools to explore the interconnections between farming and other aspects of our environment. It also implies joint efforts between research and educational institutes, farmers, farm-workers, consumers, policymakers and others. Each group has its own part to play and unique contribution to make in strengthening the sustainable agriculture community.

Case Study 18 Stanaway Farm is an example of an educational charity that has promoted agricultural education and good farming practices since 1966. It is a well-known demonstration farm that aims to link the environment and farming. As well as a training centre the farm has a network of public footpaths running across it and with information boards telling visitors about how they grow crops under an integrated and environmentally sustainable management system.

Case Study 27 The Royal Society for the Protection of Birds (RSPB) shows how the largest conservation charity in Europe is trialing good agricultural practices that

will produce food cost effectively and can also benefit wildlife and further develop environmental biodiversity.

The “whole farm approach” takes into account cultural, social and wildlife resources as well as soil, water and air. The majority of Europeans believe wildlife to be especially important to the quality of life and see the loss of plants and animals and environmental pollution as particularly worrying issues. Biodiversity can be easily lost but and is difficult to regain, particularly if species are driven to extinction. A farming system that is lacking in ecological integrity, economic viability or social responsibility ultimately may not be sustainable. The countryside is increasingly becoming a place where more people want to spend their time and most are prepared to support farmers or land agents in regenerating threatened landscapes and habitats. Biodiversity may therefore provide economic benefits, particularly in relation to recreation and tourism.

Case Study 16 Milden Hall shows a farm that has created its own environmental policy and which they follow strictly. This policy covers all aspects of their business - from recycling to energy efficiency, management of water resources and use of pesticides and hazardous substances. The owners organise planned farm nature trail routes for exploring the farm and wildflower meadows. They encourage children in the summer to become more acquainted with nature. They have received a gold award for green tourism as a result.

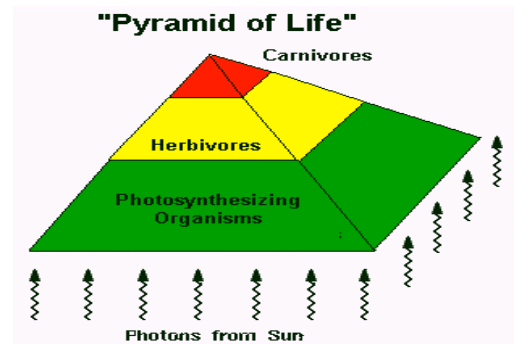
Making the transition to sustainable agriculture is a process. For farmers, the transition to sustainable agriculture normally requires a series of small, practical and realistic steps. Economics and personal goals will influence how fast or how far participants can go in the transition. But each small decision can make a difference and contribute to advancing the entire system further on the "sustainable agriculture continuum." The key to moving forward is the will to take the next step.

3.2 Understanding ecosystems

An ecosystem is the interacting system of a biological community and its non-living environmental surroundings. Ecosystems have two essential functions:

- They enable the energy from the sun to travel through all levels of the food chain
- They allow matter to be recycled

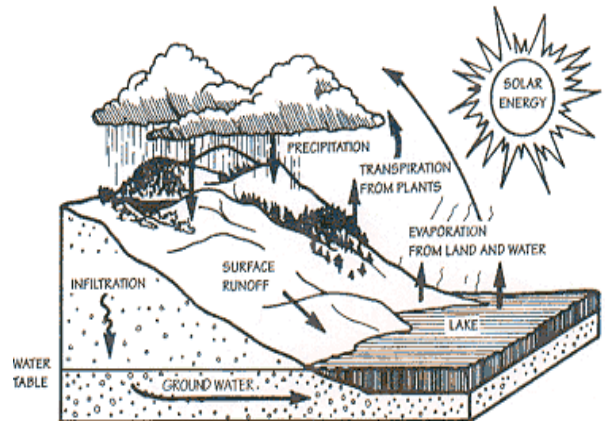
The most important factor determining how many and what kind of organisms can live in an ecosystem is the amount of energy available. Energy in an ecosystem flows from the sun to autotrophs (producers-photosynthesising organisms) then to organisms that eat the autotrophs (herbivores) and finally to organisms that feed on other organisms (consumers - carnivores) (see diagram).



Picture 1: Energy flow within the food chain (Campbell & Reece, 2002)

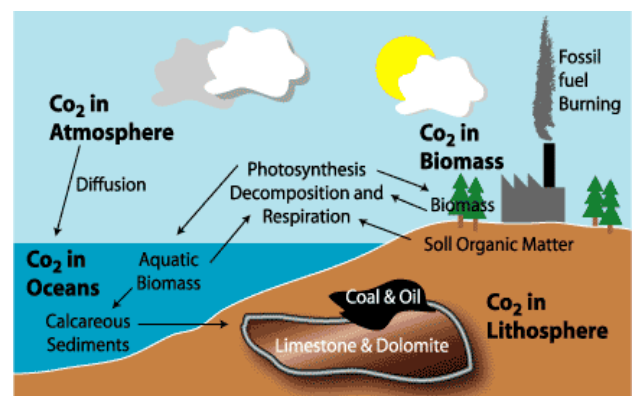
Unlike energy, matter can be recycled. The water, carbon and nitrogen cycles are the three main ways matter is recycled in the environment.

The water cycle - The availability of water is one of the key factors that regulate the productivity of terrestrial ecosystems. The water cycle usually consists of the following steps: evaporation (from lakes, rivers and oceans), transpiration from plants and trees, condensation (Cloud formation), precipitation (rain, snow, hail), run off or returned back into the cycle.



Source: Project WET

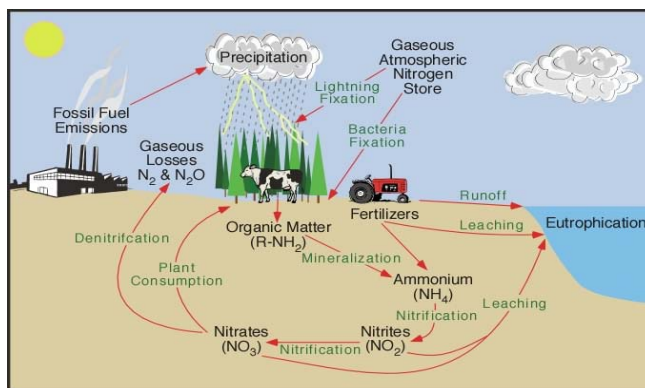
The carbon cycle - carbon cycles through the environment in the form of carbon dioxide (CO₂). The atmosphere of Earth contains 0.04 percent CO₂. In addition, there are several storage areas of carbon in the environment: A large portion of the carbon on the earth is stored in rocks. The earth's oceans hold a large amount of CO₂ because it easily dissolves in water and fossil fuels release CO₂ into the atmosphere.



Source: IPCC

Plants absorb CO₂ from the atmosphere to use during photosynthesis while other organisms release CO₂ into the air during respiration.

The nitrogen cycle - Organisms require nitrogen to produce amino acids. Nitrogen makes up 75% of the atmosphere, but most organisms cannot use this form of nitrogen, and must have a fixed form. The nitrogen cycle produces the fixed form of nitrogen these organisms need. Nitrogen fixing bacteria take in atmospheric nitrogen and produce ammonia (NH₃).



Source: PEER

Other bacteria use the ammonia to produce nitrates and nitrites. The nitrates are used by plants to make amino acids and which are then used to make plant proteins. Plants are consumed by other organisms that use the plant amino acids to make their own. Decomposers convert the nitrogen found in other organisms into ammonia and return it to the soil. A few of these types of bacteria also return nitrogen to the atmosphere.

3.3 Agro-ecosystems and ecology

Agro-ecosystems are communities of plants and animals interacting with their physical and chemical environments that have been modified by people to produce food, fibre, fuel and other products for human consumption and processing. Agro-ecology is the holistic study of agro-ecosystems, including all environmental and human elements. It focuses on the form, dynamics and functions of their interrelationships and the processes in which they are involved.

An area used for agricultural production, e.g. a field, is seen as a complex system in which ecological processes found under natural conditions also occur, e.g. nutrient cycling, predator/prey interactions, competition and symbiosis. Implicit in agro-

C o m p a r i s o n o f N a t u r a l a n d A g r o e c o s y s t e m s		
	N a t u r a l E c o s y s t e m s	A g r o e c o s y s t e m s
Net Productivity	Medium	High
Trophic Interactions	Complex	Simple, linear
Species Diversity	High	Low
Genetic Diversity	High	Low
Nutrient Cycles	Closed	Open
Stability (resilience)	High	Low
Human Control	Independent	Dependent
Temporal Permanence	Long	Short
Habitat Heterogeneity	Complex	Simple

G li e s s m a n , 1 9 9 8

ecological research is the idea that, by understanding these ecological relationships and processes, agro-ecosystems can be manipulated to improve production, improve

sustainability and have fewer negative environmental or social impacts and need fewer external inputs (Altieri 1995). The design of Agro-ecosystems is based on the application of the following ecological principles (Reinjtjes et al. 1992):

1. Enhancing recycling of biomass and optimising nutrient availability and balancing nutrient flow
2. Securing favourable soil conditions for plant growth, particularly by managing organic matter and enhancing soil biotic activity
3. Minimising losses due to flows of solar radiation, air and water by way of microclimate management, water harvesting and soil management through increased soil cover
4. Species and genetic diversification of the agro-ecosystem in time and space
5. Enhancing beneficial biological interactions and synergisms among agro-biodiversity components thus resulting in the promotion of key ecological processes and services

These principles can be applied by way of various techniques and strategies and each will have different effects on productivity, stability and resiliency within the farm system, depending on local opportunities, resource constraints and, in most cases, on the market. The ultimate goal of agro-ecological design is to integrate components so that overall biological efficiency is improved, biodiversity is preserved, and the agro-ecosystem productivity and its self-sustaining capacity is maintained. The goal is to design a pattern of agro-ecosystems within a landscape unit that mimics the structure and function of natural ecosystems.

Numerous areas need to be considered and including:

Water - In many parts of the EU, serious environmental concerns have been expressed at the level of abstraction of water for agriculture by irrigation, particularly in Mediterranean countries. Where usage exceeds the rate of replenishment and the water table falls the environmental consequences can be serious, e.g. salinisation by sea water invading underground supplies, and loss of biodiversity resulting from changes in flow of watercourses. Irrigation can result in water pollution because of an increased concentration of pesticides and nutrients in run-off water. In addition, even greater resources are needed to abstract water from deeper wells.

Concerning water quality, agriculture is a major source of nitrates and phosphates in water. This can lead to eutrophication, with consequent serious effects on the natural environment, and levels of nitrate in drinking water supplies, surface and ground waters, which exceed EU standards. Comprehensive measures to remedy this problem are outlined under the terms of the EU nitrates directive. 87% of the agricultural area in Europe has nitrate concentrations in the groundwater that are above the guide-level value of 25 mg/l, and 22% that are above the maximum admissible concentration of 50 mg/l. (Dobris assessment). In many areas, these levels are increasing, particularly so in areas of high livestock density and existing sources of drinking water having to be closed or are subject to expensive treatments.

Tile drainage can remove the water and salts, but the disposal of the salts and other contaminants may negatively affect the environment depending upon where they are

deposited. Temporary solutions include the use of salt-tolerant crops, low-volume irrigation, and various management techniques to minimize the effects of salts on crops. In the long-term, some farmland may need to be removed from production or converted to other uses. Other uses include conversion to production of drought-tolerant forages, the restoration of wildlife habitat or the use of agro-forestry to minimize the impacts of salinity and high water tables.

Wildlife - The conversion of wild habitat to agricultural land reduces fish and wildlife through erosion and sedimentation, the effects of pesticides, removal of riparian plants and the diversion of water. Plant diversity in and around both riparian and agricultural areas needs to be maintained in order to support a diversity of wildlife. This diversity will enhance natural ecosystems and could aid in agricultural pest management.

Energy - Modern agriculture is heavily dependent on non-renewable energy sources, especially petroleum. The continued use of these energy sources cannot be sustained indefinitely, yet to abruptly abandon our reliance on them would be an economic catastrophe. A sudden cutoff in energy supply would be equally disruptive. In sustainable agricultural systems, the aim is to reduce reliance on non-renewable energy sources and substitute with renewable sources or labour but to the extent that it is economically feasible.

Air - Many agricultural activities affect air quality. These include smoke from agricultural burning, dust from tillage, traffic and harvest, pesticide drift from spraying and nitrous oxide emissions from the use of nitrogen fertilizer. Persistent pesticides can be transported through air and water currents. The fumigant methyl bromide accumulates in the atmosphere and has been identified as an ozone depleting chemical, subject to controls and will be phased out under the Montreal Protocol. Some pesticides move from hot to cold climates, where they break down more slowly and thus accumulate in the environment. Such chemicals have been termed “persistent organic pollutants” (POPs) and are subject in Europe to the Convention on Long Range Transboundary Air Pollution, and covering nine pesticides: aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, toxaphene. Options to improve air quality include incorporating crop residues into the soil, using appropriate levels of tillage and planting wind breaks and covering crops or strips of with native perennial grasses to reduce dust.

Soil erosion continues to be a serious threat to our continued ability to produce adequate food. Numerous practices have been developed to keep soil in place, which include reducing or eliminating tillage, managing irrigation to reduce runoff and keeping the soil covered with plants or mulch. A high proportion of the volume of pesticides applied in field situations end up in the soil. Many pesticides remain active in their original form in soil where they can be toxic to soil flora and fauna and may be toxic to other plants and animals inhabiting or using the soil. Other pesticides break down and form other products that can themselves be toxic. Some pesticides bind to soil particles and can be carried by wind or water with the soil into other environments. Unbound pesticides or degradation products in soil can be washed off the soil surface by water, leached through the soil or volatilized to air depending on their physical-chemical characteristics.

Case Study 31 Soil erosion terraces show how traditional (and sometimes forgotten) practices were often much more effective for conservation than many modern intensive agricultural approaches. The case shows how increasing attempts are being made to re-introduce many traditional approaches into sustainable agricultural practice.

3.4 Plant and animal production practices

Sustainable production practices can involve a variety of different approaches. The specific strategy adopted must take into account topography, soil characteristics, climate, pests, local availability of inputs and the individual goals of the farmer. But despite the site-specific and individual nature of sustainable agriculture, several general principles can be applied to help farmers select the most appropriate management practice. These are:

- Selection of species and varieties that are well suited to the site and to conditions on the farm
- Diversification of crops (including livestock) and cultural practices to enhance the biological and economic stability of the farm
- Management of the soil to enhance and protect soil quality
- Efficient use of inputs
- Consideration of the farmers goals and lifestyle choices

Each are discussed in more detail below:

Selection of site, species and variety - Preventive strategies, that are adopted early, can reduce inputs and help to establish a sustainable production system. When possible, pest-resistant crops should be selected which are tolerant of the existing soil or site conditions. When site selection is an option, factors such as soil type and depth, previous crop history, and location (e.g. climate, topography) should be taken into account before planting.

Diversity – Crop diversified farms are usually more economically and ecologically resilient. While monoculture farming has advantages in terms of efficiency and ease of management, the loss of the crop in any one year could put a farm out of business and/or seriously disrupt the stability of a community dependent on that crop. By growing a variety of crops, farmers spread economic risk and are less susceptible to the radical price fluctuations associated with changes in supply and demand.

Properly managed, diversity can also buffer a farm in a biological sense. For example, in annual cropping systems, crop rotation can be used to suppress weeds, pathogens and insect pests. Also, cover crops can have stabilising effects on the agro-ecosystem by holding soil and nutrients in place, conserving soil moisture with mowed or standing dead mulches, and by increasing the water infiltration rate and soil water holding capacity.

Optimum diversity may be obtained by integrating both crops and livestock in the same farming operation. This was the common practice for centuries until the mid-

1900s when technology, government policy and economics compelled farms to become more specialized. Mixed crop and livestock operations have several advantages. First, growing row crops only on more level land and pasture or forages on steeper slopes will reduce soil erosion. Second, pasture and forage crops in rotation enhance soil quality and reduce erosion and livestock manure, in turn, contributes to soil fertility. Third, livestock can buffer the negative impacts of low rainfall periods by consuming crop residue that in "plant only" systems would have been considered crop failures. Finally, feeding and marketing are flexible in animal production systems. This can help cushion farmers against trade and price fluctuations and, in conjunction with cropping operations, make more efficient use of farm labour. (see also module 4 agro-product diversification)

Soil management - A common philosophy amongst sustainable agriculture practitioners is that a "healthy" soil is a key component of sustainability i.e. a healthy soil will produce healthy crop plants that have optimum vigor and are less susceptible to pests. While many crops have key pests that attack even the healthiest of plants, proper soil, water and nutrient management can help prevent some pest problems brought on by crop stress or nutrient imbalance. Furthermore, crop management systems that impair soil quality often result in greater inputs of water, nutrients, pesticides, and/or energy for tillage to maintain yields.

In sustainable systems, the soil is viewed as a fragile and living medium that must be protected and nurtured to ensure its long-term productivity and stability. Methods to protect and enhance the productivity of the soil include using cover crops, compost and/or manures, reducing tillage, avoiding traffic on wet soils, and maintaining soil cover with plants and/or mulches.

Efficient use of inputs - Many inputs and practices used in conventional farming are also used in sustainable agriculture. Sustainable farming, however, maximises the reliance on natural, renewable and on-farm inputs. Equally important are the environmental, social, and economic impacts of a particular strategy. Converting to sustainable practices does not mean simple input substitution. Frequently, it substitutes enhanced management and scientific knowledge for conventional inputs, especially chemical inputs that harm the environment on farms and in rural communities. The goal is to develop efficient, biological systems that do not need high levels of material inputs.

Farmers frequently ask if synthetic chemicals are appropriate in a sustainable farming system. Sustainable approaches are those that are the least toxic and least energy intensive and yet maintain productivity and profitability. Preventive strategies and other alternatives should be employed before using chemical inputs from any source. However, there may be situations where the use of synthetic chemicals would be more "sustainable" than a strictly non-chemical approach or an approach using toxic "organic" chemicals. For example, a grape grower might switch from tillage to a few applications of a broad spectrum contact herbicide in the vine row. This approach may use less energy and compact the soil less than numerous passes with a cultivator or mower.

Consideration of farmer goals and lifestyle choices - Management decisions should reflect not only environmental and broad social considerations, but also individual goals and lifestyle choices. For example, adoption of some technologies or practices that promise profitability may also require such intensive management that the farmers lifestyle actually deteriorates. Management decisions that promote sustainability nourish the environment, the community and the individual.

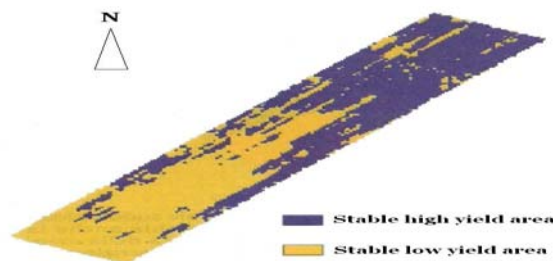
Case Study 30 The Travaglini Forestry Farm show how an unselfish attitude both to the environment and the community, are in itself maintaining the culture, environment and the health of the region.

Over time approaches to farming and throughout history farmers have adapted farming practices accordingly. Today farmers have increasingly complicated choices not only of what to grow but also on how to grow them. Some practices have increased in popularity in recent years, such as field margin management, whole farm planning, integrated farm management, integrated pest management, good agricultural practices, water protection, organic and precision agriculture are now becoming part of conventional agricultural practice. A few of these are outlined in more detail below:

3.4.1 Precision agriculture

Precision agriculture is now a popular production concept growing across Europe and can be defined as an agricultural approach that is designed to optimise agricultural production through the application of effective crop information, advanced technology and management practices. A truly comprehensive approach to precision agriculture must cover all phases of production from planning to post harvest. Information, technology, and management are combined into a production system that can increase production efficiency, improve product quality, allow more efficient chemical and water use, conserve energy, and provide for soil and ground water protection.

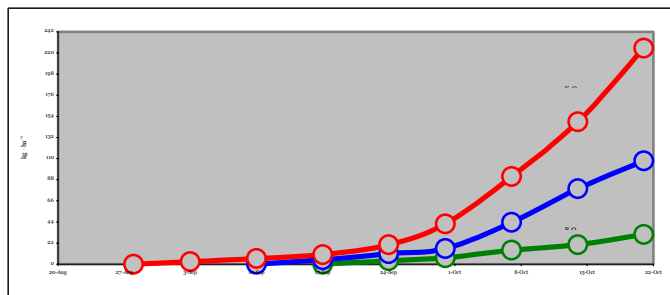
One example is that of variable dose fertilisation. This involves spreading nutrients in areas smaller than the size of the land plot of land and only where needed and in the amounts strictly necessary for the requirements of the plant and soil. Across even a small land plot this may differ considerably (see diagram below).



Land plot with different crop yield areas

Similarly the following graph shows that nutrient uptake of nitrogen, phosphorus and potassium in lettuce shows that 70% of their uptake occurs during the last 21 days

before harvest. Using such scientific approaches considerable costs can be saved by applying the right quantities of inputs at the right time.



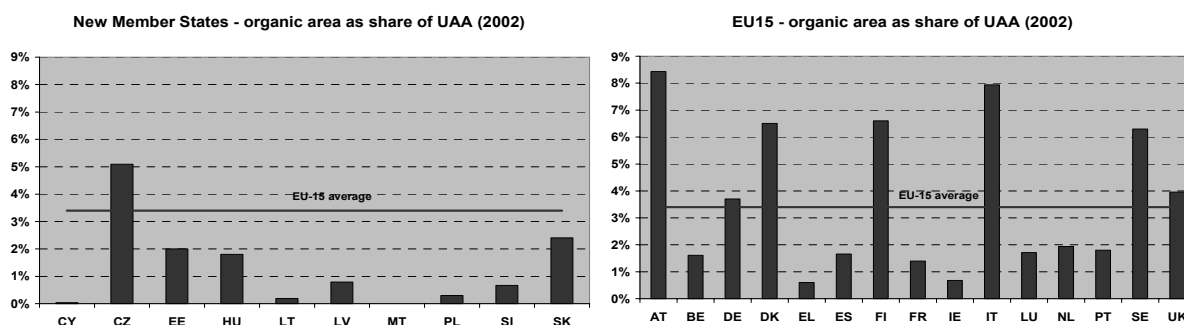
Nutrient uptake curves of lettuce

3.4.2 Organic production

Organic agriculture is best known as a farming method where no synthetic fertilisers or pesticides are used. The Food and Agriculture Organisation of the United Nations/World Health Organisation Codex Alimentarius, goes further and defines organic agriculture as: “a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity. It emphasises the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system.”

Organic farming was developed in the early 20th century, mainly in Germany, the United Kingdom and Switzerland, but it was only in the 1980s that organic farming across the European Union really expanded in response to consumer demand for wholesome and environmentally friendly food products. **Case Study 20 Cooperativa Agricola Valdarnese** is an example of a farm that diversified into organic production in the 1980s.

In 1985, certified organic production (including areas under conversion) accounted for just 100,000 ha on 6,300 holdings across the EU, or less than 0.1 % of the total utilisable agricultural area (UAA). By the end of 2002, this had increased to 4.4 million ha on an estimated 15,000 holdings, or 3.3 % of total agricultural area, 2.3 % of holdings and around 2% of production output and food sales. There is however considerable variation in the share of organic area across EU member states (see table) and in the new member states organic farming is, with some exceptions, less well developed, although all have some organic farming and a system of certification.



From 1992 onwards EU Governments gradually recognised the potential of organic farming and adopted specific legislation and included organic farming in rural development programmes. A multitude of private certification agencies and farmers organisations also defined, monitored and accredited organic agriculture. In the past, differences in definitions were significant, but the demand for consistency by the trade has increasingly led to greater uniformity.

By adopting Council Regulation (EEC) No 2092/91, amended by Council Regulation (EC) No 1804/1999, the European Union was one of the first to set up a policy on organic farming. With this regulation, the Council created a Community framework defining in detail the requirements for agricultural products and foodstuffs bearing a reference to the production methods used in organic farming and foodstuffs.

Organic products are often promoted, marketed and packaged very differently from those products obtained through conventional farming methods in order to add value in the minds of the consumer. Commonly these issues focus on positive aspects for health and the environment. Organic products include crop and livestock products as well as sometimes the materials within they are packed.

Case Study 15 Bioagroturismo la Porta dei Parchi is an organic producer of cheese and meat products that have also been able to develop the activity through innovative promotion and the development of agro-tourism and traditional products and crafts.

3.4.3 Integrated pest management (IPM)

Integrated pest management (IPM) is the integration of various pest control tactics in the context of the associated environment of the pest in ways that compliment and facilitate the biological and other natural controls of pests to meet economic, public health, and environmental goals. The goals of IPM are to achieve the effective management of pests in the safest manner. Wherever applicable, IPM uses scouting, pest trapping, pest resistant plant varieties, sanitation, various cultural control methods, physical and mechanical controls, biological controls, and precise timing and application of any needed pesticides.

Case Study 13 Orto Sole shows how IPM can be environmentally beneficial as well as fit into a product traceability and quality assurance programme for commercial purposes.

Good pest management decisions can be made only after answering questions such as:

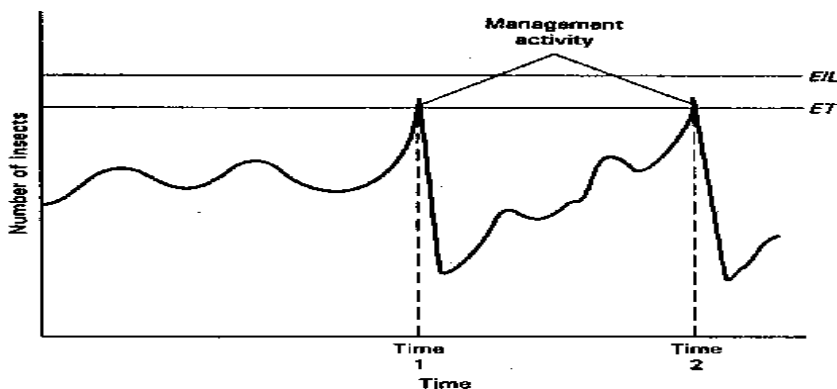
1. What pests are present, and in what numbers and stages of development?
2. What conditions exist that may increase or decrease pest problems?
3. What natural enemies of the pests, such as parasites, predators, and diseases, are present and that may play an important role in control?
4. What amount and type of damage is being caused or may soon be caused by pests?
5. What is the stage of development, condition, and value of the crop?

6. What is the potential for economical injury? How much damage is tolerable? Has the action threshold been reached?
7. What is the history and severity of previous infestations at the site? How were those infestations managed? What were the results?
8. What pest management options are available, and how do the advantages and disadvantages of each apply to the situation?
9. If alternatives are not available, is a pesticide treatment justified for the situation? If so, what is the material of choice?
10. If a pesticide is not justified, what approaches, if any, should be taken?

Field scouting, insect trapping, and action thresholds can be used to provide much of the information needed to help answer most of these questions.

With IPM, the decision to use pesticides is made only when an *action threshold* for a pest is reached and no other alternative management methods are available that will provide effective control. The action threshold is the level of pest infestation at which treatment is justified to keep an increasing pest population from causing economical losses. Fields should not be treated when pest populations are below the action threshold. Applying a pesticide treatment for such infestations would not be an economic or qualitative benefit. When pesticides are needed, the safest and most effective materials should be selected for use.

The action threshold is a key IPM decision-making tool. Thresholds are based on considerable amounts of research and field experience. If an action threshold is approached, but not reached, you should not apply a pesticide at that time. Instead, re-scout the field within a few days to determine the status of the infestation. Pest populations can decline naturally due to mortality from natural enemies and unfavourable weather conditions. Also, many pests, such as caterpillars, change from an active feeding (larva) to a non-feeding stage (pupa) during their development. Such changes will often produce a natural decline in infestations as pupation occurs. Precise timing of needed pesticide applications is extremely important to achieve good pest control. Pest monitoring, action thresholds and a good knowledge of the life cycles of pests are used to determine the best timing of needed treatments (see the following table).



Picture 2: Relationship of the economic threshold (ET) to the economic injury level (EIL) and time of taking action (Source: IAC Wageningen).

3.4.3.1 Pest control methods

There are many methods that can be used to help manage pests. Most often they can be categorised as either chemical or non-chemical methods. Many non-chemical approaches are used to either prevent infestations from initially occurring, or to minimise the severity of infestations. When non-chemical approaches, such as the use of pest resistant varieties, cultural, physical, mechanical, and biological controls are inadequate, chemical control may be justified. The aims of IPM are to integrate or incorporate all appropriate methods into an approach that provides needed pest control in the safest manner and only use chemicals as a last resort.

- ❑ *Cultural controls* exploit the factors related to growing the crop and that also may negate or minimise the occurrences of pests. Some examples include: disease-free seed, good sanitation and the destruction of plant residue to limit the spread of pests, optimum growing conditions to minimise stress on the crop, early or late planting and harvest dates to avoid pest losses, crop rotations and living mulches for weed management
- ❑ *Physical controls* utilise some physical component of the environment, such as temperature, humidity, or light to the detriment of pests
- ❑ *Mechanical controls* involve the use of equipment of manual operations to exclude or disrupt the life cycle of pests. Barriers that exclude pests include fencing, row covers, and plastic mulches. Disruptive operations include ploughing, discing, hoeing, and cultivation
- ❑ *Biological control* is the use of living organisms that function as parasites, predators, or pathogens to help control pests. Such natural enemies are responsible for keeping many pests and potential pests in check. Unfortunately, many pesticides are very detrimental to natural enemy survival and should be used sparingly and only when needed. Wherever possible, chemicals that are the least toxic to natural enemies should be chosen. Some pathogens (disease-causing organisms) have been commercially developed for use as biological insecticides
- ❑ *Planting resistant varieties* can prevent or minimise pest infestations and injury
- ❑ *Pesticides* are chemicals that are used to destroy, repel, or otherwise lower pest infestations to protect crops from damage. Though pesticides pose many potential risks, they also provide the following important advantages and benefits:
 1. Pesticides are readily available and easy to use
 2. Where resistance is not a problem, pesticides are generally highly effective for controlling pests
 3. Pesticide treatments can be rapidly implemented as needed with a minimal lag time
 4. Pesticides can be used over large areas to control large populations of pests
 5. Pesticide treatments are often cost effective, especially if the alternatives require large increases in human labour
 6. When no effective, reliable, non-chemical alternatives are available for many pests and chemical pesticides are the last resort

Pesticides are used in IPM programmes when no effective alternatives are available to keep pest populations from reaching damaging levels. The emphasis is to maximise the benefits and advantages that pesticides offer while minimising any potential risks. Whenever a pesticide treatment is needed, selection of the chemical should be consistent with the pesticide label and all laws and regulations. Additional considerations include: effectiveness against the target organism, compatibility with the host plant, effects on beneficial organisms, degree of environmental and user safety and cost. Wherever possible, use a material that is least toxic to humans and other non-target organisms and is least likely to contaminate ground and surface waters.

3.4.3.2 Problems with pesticide use

Pesticide resistance - In an attempt to achieve better or total pest control, resistance problems have increased because pesticides are applied more frequently and at higher dosage rates. Naturally resistant individuals in a pest population are able to survive pesticide treatments. The survivors breed and pass on the resistance trait to their offspring. With each passing generation, the pest population becomes more difficult to control with the same pesticides as compared with earlier generations. Reducing pesticide use and alternating among classes of pesticides with different modes of action can help to lessen the possibility of pest resistance. Managing pest resistance is very important in helping to prolong the effective life of needed pesticides.

Toxicity to natural enemies and other non-target organisms - Natural enemies of pest species can be very helpful in keeping pest populations at lower levels. These beneficial organisms are often other insects that serve as predators, parasites, or competitors to the detriment of the pest species. Unfortunately, many broad-spectrum, non-selective pesticides are more detrimental to numerous beneficial species than to the pests. The use of such pesticides often causes resurgence in pest populations and at a much faster rate compared to the natural enemies. Without the natural controls, primary (established) and secondary (new) pests are often free to reach damaging levels at faster rates. An increase in pest levels usually results in additional pesticide treatments and which further depresses or eliminates natural enemies and further encourages the potential for pest resistance. Using pesticides as little as possible and selecting effective alternatives that are less toxic to non-target organisms, will increase natural enemy survival and the overall effectiveness of pest control.

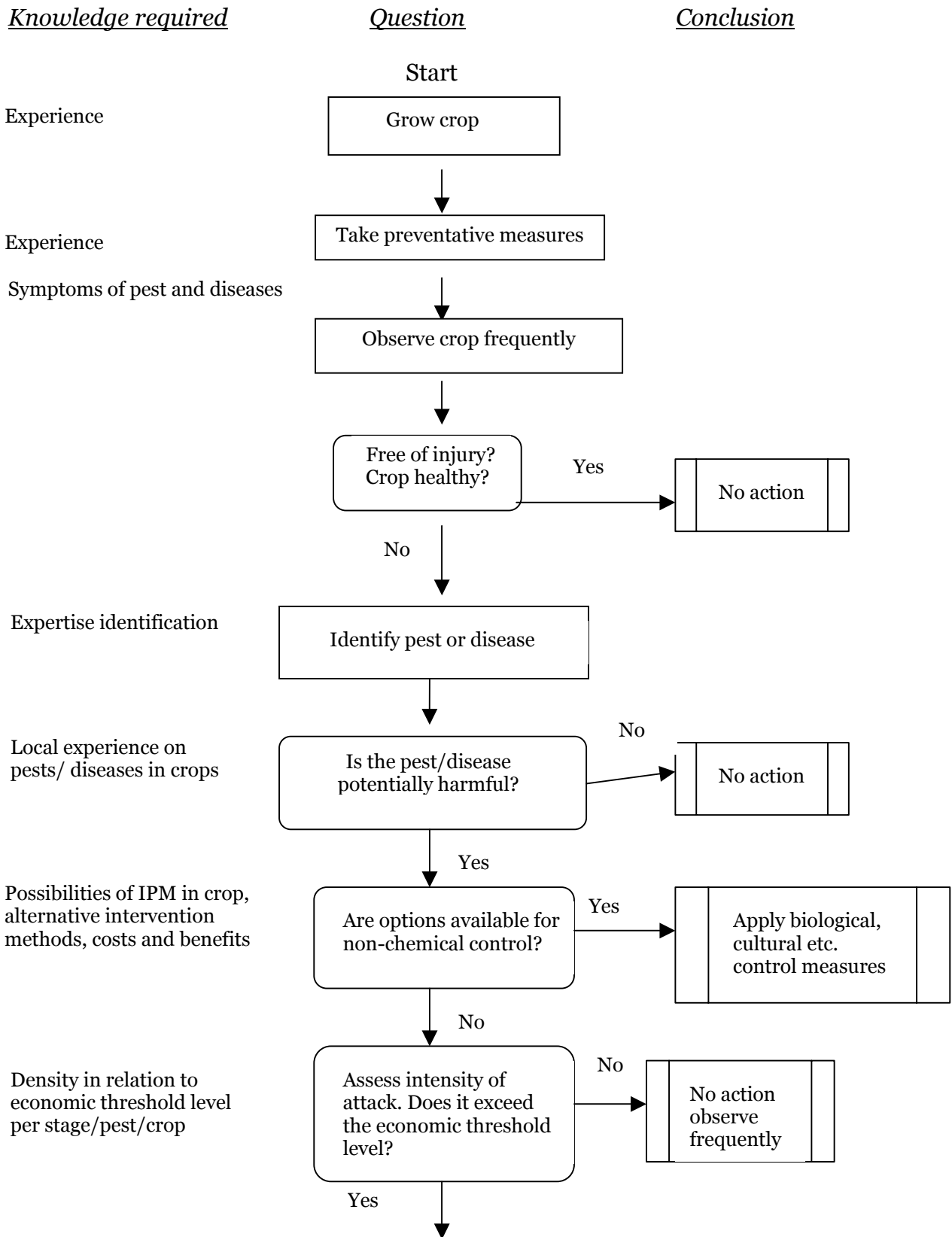
Public health and environmental concerns - The public has become increasingly concerned about the use of pesticides and the possible adverse effects on human health, wildlife, groundwater and overall environmental quality. Pesticide exposure from drift to non-target areas, contamination of ground and surface waters and residues on food are topics of concern to the general public. Applicators should be especially concerned because they may have the highest potential for exposure and thus may have the greatest health risks. All applicators must be sensitive to public concerns about pesticide use and apply materials only in a safe and judicious manner. This is particularly true for vegetable growers who are often viewed by the general

public as being responsible for providing safe and nutritious food. If pesticides are misused, this trust is violated, resulting in negative public relations and serious liability.

Cost of pesticides - The cost of developing new pesticides has risen at an increasingly rapid rate. Many pesticides are petroleum based products and their costs increase with oil prices. Government regulations and more stringent registration requirements have also slowed the rate of development and increased the costs of new products. Concerns about potential product liability have discouraged companies from introducing new products. Increasing problems with pest resistance have likewise resulted in shorter market lives for many pesticides than in the past. All of these factors result in higher costs and potentially lower profits for chemical companies. In turn, this leads to higher prices for pesticide users. Many pesticides are very expensive. When including the costs of fuel and labour, every pesticide application made by the grower is a substantial expense. Imagine the savings a grower could realise if even one unnecessary pesticide application can be eliminated without increased damage to the crop. Maintaining the economic viability of agriculture is also one of the goals of Integrated Pest Management.

Case Study 8 Spencers Farm Shop shows how a farm can maintain a quality control programme that uses both approved pesticides and natural predators.

IPM scheme (Oomen/Kortenhoff)



IPM-SCHEME (Continued)

Knowledge required

Question

Conclusion

Efficacy of pesticides, registration, markets and legislation

Select effective pesticides. Check for registration, resistance and availability

List

Main natural enemies, side-affects to natural enemies, humans, environment, price

Select pesticides least harmful to main natural enemies, least toxic to humans, least harmful to environment, least expensive

Pesticide

Directions for use, local conditions sensitive stages of pest and natural enemy, lifecycle of both resistances, etc.

Select optimal dosage, formulation, application method, timing, frequency, safety interval, alternation for resistance prevention

Plan for treatment

Treatment

Destinies of pests and natural enemies before and after spraying

Verify effectivity of application on pest, natural enemies and development of other potential pests

Learn for solving future problems

Effectivity and side affects

Return to start

If ineffective return to pest identification or to selection of effective pesticide

3.5 Links and examples

Environmental Challenges in Farm Management (ECIFM) This is a web-based learning package from the University of Reading Department of Agriculture. The 8 modules include the historical perspective, current issues, the contribution of agriculture to environmental degradation, sustainability, land protection and countryside stewardship schemes as well as a case study. www.ecifm.rdg.ac.uk

Adlib The agricultural document library is an expanding resource giving access to a wide range of documents relating to agriculture in the UK, including information on government legislation and codes of practice, industry guidelines, fact-sheets, and directories. Documents are collected into three "libraries" - crop protection management plan, whole farm appraisal and environmental management for agriculture and each containing a wide range of resources suitable for farmers, trainers, policy and planning organisations and anyone involved in the agricultural marketing and manufacturing sectors.

www.adlib.ac.uk/adlib

Impacts of agricultural environmental management: Case studies from theory to practice. This document provides information on agricultural environmental management, using six farms as case studies for best practice. It studies diffuse pollution issues including pesticides, fertilisers, and microbial contamination, and methods of reducing this pollution; habitat improvement issues, including habitat management, farm accounts; and current grant schemes available. www.sepa.org.uk/publications/technical/imp_env_man/index.htm

Linking Environment and Farming (LEAF) was formed in 1991 and brings together a wide range of organisations that represent farmers, consumers and environmentalists, to "develop and promote integrated farm management (IFM) - common sense farming practices which are economically viable and environmentally responsible." Details are provided on LEAF, IFM, and the LEAF audit. A list of demonstration farms across the UK are listed and LEAF news is also available. A discussion forum is also provided for registered users (registration is free). www.leafuk.org/LEAF

Green Entrepreneurs www.greenentrepreneurs.net is a EU Leonardo Programme established to design and pilot a web-based information/training resource for entrepreneurs looking to exploit opportunities in the environmental area

Environmental Management for Agriculture (EMA) is an [award winning](#) computer software package that provides a comprehensive suite of tools, information and assessment routines designed to help the farming industry improve its environmental performance. www.herts.ac.uk/aeru/ema

National Campaign For Sustainable Agriculture works for a sustainable food system that is, economically viable, environmentally sound, socially just and humane. www.sustainableagriculture.net

World Sustainable Agriculture Association (WSAA) works to restore harmony between people and the environment. Site includes publications, newsletters, and WSAA activities. igc.apc.org/wsaala/wsaa.html

Appropriate Technology Transfer for Rural Areas is a national sustainable agricultural information service with production and marketing information about sustainable and organic agriculture. www.attra.ncat.org

Alternative Farming Systems Information Center is a resource from the U.S. Department of Agriculture's (USDA) National Agricultural Library (NAL). www.nal.usda.gov/afsic

Evaluating a Rural Enterprise. ATTRA – National Sustainable Agriculture Information Service www.attra.org/attra-pub/evalrural.html

Factsheets: New Perspectives for EU Rural Development (September 2004) www.europa.eu.int/comm/agriculture/publi/fact/rurdev/refprop_en.pdf

Organic Farming Research Foundation

The Organic Farming Research Foundation is a non-profit foundation founded to sponsor research related to organic farming practices, to disseminate research results to organic farmers and to growers interested in adopting organic production systems, and to educate the public and decision-makers about organic farming issues. www.ofrf.org

Organic Agriculture at FAO

Sponsored by the United Nations Food and Agriculture Organization (FAO) www.fao.org/organicag/default.htm

International Federation of Organic Agriculture Movements (IFOAM)

The worldwide movement of organic agriculture is represented by IFOAM. On this page you can find information on laws regulating organic farming as well as links to national organizations working on this issue. www.ecoweb.dk/ifoam

Pesticides and the environment: The eco-toxicology database (ECOTOX) provides single chemical toxicity information for aquatic and terrestrial life. ECOTOX is a useful tool for examining impacts of chemicals on the environment www.epa.gov/ecotox The Extension Toxicology Network (EXTOXNET) provides a variety of information about pesticides www.extoxnet.orst.edu/etn.txt.html

USGS toxic substances hydrology programme provides objective scientific information to improve characterization and management of contaminated sites, to protect human and environmental health and to reduce potential future contamination problems www.toxics.usgs.gov

The US Environment Protection Agency maintains a home page with details of its services and organization on a wide variety of environmental issues www.epa.gov

Integrated Pest Management: IPMEurope www.ipmeurope.org

IPM Forum www.nri.org/IPMForum/index.htm

The Consortium for International Crop Protection (CICP) www.ipmnet.org

Pest Management Resource Centre www.pestmanagement.co.uk

Center for Integrated Pest Management (CIPM) www.cipm.ncsu.edu

Precision Agriculture Center Online (www.precision.agri.umn.edu)

Land allocation decision support system www.mluri.sari.ac.uk/ladss/ladss.shtml

Precision agriculture laboratory www.txprecag.tamu.edu

Agro-ecology home www.agroecology.org

Partnership for environmental education and rural health www.peer.tamu.edu

Environmental Biology www.marietta.edu/~biol/102/ecosystem.html

Agro-ecology

weedeco.msu.montana.edu/class/LRES110/agroecology%2003_lec.htm

Sources to water directives European Commission: Water protection and management www.europa.eu.int/scadplus/leg/en/s15005.htm

Other related websites:

Attra www.attra.org national sustainable agriculture information service

www.genesisqa.org.uk

www.eco-portal.com European Sustainable Agriculture Education

www.fabbl.co.uk

www.assurecrops.co.uk

www.cmi-plc.com

www.littleredtractor.org.uk

www.fwag.org.uk

www.smi.org.uk

www.ecifm.rdg.ac.uk

www.srdc.msstate.edu

www.ruralni.gov.uk

www.sac.ac.uk

www.forwardfarming.org.uk

www.rbat.org.uk

www.nxlevel.org