What is an ecosystem

Introduction

The climatic regions of the Earth gave origin to a large variety of natural environments. Each habitat is formed by a community of animals and plants, called ecosystem, that, in order to survive, must adapt to the surrounding environment exploiting its resources as best they can. 550 million years ago plants began to grow on the Earth, creating the first environment that was suited for animal life; initially mosses and ferns were dominant, then conifers developed, and then flowering plants. At the same time, also herbivorous animals evolved and the foundations for the complex ecosystems of today were laid.

Terrestrial biomes

The ecosystem: a complex system

An ecosystem is a complex system composed of organisms living in a given habitat. Plants and animals are the biotic components of the ecosystem, while the subsoil, water, air, light, temperature, the climate, rains are part of the **abiotic components**. In an ecosystem, the **biotic components** that inhabit it and the abiotic ones establish a set of relationships with each other that characterise the ecosystem itself and bring it to a temporarily “balanced” state.
According to their task within an ecosystem, the biotic components (living organisms) can be divided into:
• **producers** (plants, algae and some bacteria): these are “autotrophic” organisms that produce by themselves the organic matter they need to live and grow, using such simple inorganic molecules as water, carbon dioxide (CO_2) and nitrates
• **consumers** are defined as “hetero-trophic” organisms, since they cannot produce their own nourishment, but feed on producers (for instance, the herbivore consumers, such as cows and sheep, that eat grass) or on other consumers (carnivore consumers, such as lions or man)
• **decomposers** are fungi and bacteria that feed themselves by decomposing the tissues of dead organisms.
Each ecosystem contains a given amount of **organic matter** that includes all its vegetal and animal organisms: the weight of such matter is called ‘biomass’, and is calculated dry and per surface unit occupied by the ecosystem.

Energy transfer

The relations between the different components of an ecosystem are so close that, if one of them is damaged, the whole ecosystem is affected. The main relations are those established between energy flows and nutrient flows. The ecosystem is an open system as far as energy is concerned, that is energy continuously gets in and out of the system. The energy enters mainly from the sun, goes through and biotic community and its food chain, and goes out as heat, organic matter and resulting organisms. More into detail, the organisms produced are able to catch and use the solar energy in order to transform some inorganic compounds into organic compounds, through the photosynthesis. These compounds are used by producers in two ways: to live and to grow (the organic compounds form new structural elements of plant like leaves and new branches). Herbivores, by eating vegetables, absorb their organic substances and metabolise them, i.e. transform them into other organic substances that can be used for all vital functions (breathing, movements, body temperature, and many others) and use them as structural material in order to grow. Carnivore animals behave quite similarly, eating other animals. The process goes on in this way, from one category of organisms to another one. The transfer of energy through the food chain determines some heat to be lost into the environment, according to the second thermodynamics principle. This means that carnivores will have less energy, while eating, than herbivores, that in turn will receive from their food less energy than the amount used by plants when they metabolise their food (the organic matter that is formed thanks to the photosynthesis process). The energy transfer percentage for a trophic level to the next one is defined as “ecological efficiency” or efficiency of the food chain.

The trophic chain

There are two types of food chains: the pasture chain and the waste chain. The first part of green plants passes through the pasturing herbivores, then moves to the first.-level carnivores that fed on herbivores, then to second-level carnivores that feed on other carnivores. The second part of the dead organic matter passes through the micro-organisms, from these they move to the animals that feed on waste, then finally to their predators, that is, carnivore animals. Food chains are tightly interconnected, this is why we speak of a trophic (or food) network. In natural ecosystems, the organisms that take food from the sun through the same number of passages are considered as being part of the same trophic level. So, the green plants (producers) are the first trophic level, the organisms that feed on plants are the second level (primary consumers), carnivores are the third level and carnivore predators are the fourth level (secondary and tertiary consumers). The source and quality of the energy available determines the type and number of organisms and the development processes for all levels.

Nutrients

Differently from energy that gets in and out of the ecosystem according to a linear process, the matter follows a circular route, passing from the abiotic section to living organisms, and then comes back to the abiotic section. These routes are defined as biogeochemical cycles. Carbon, hydrogen, nitrogen, phosphorous, and calcium are necessary to living organisms in large quantities and therefore they are defined as macronutrients. Other elements like iron, magnesium, manganese and zinc, etc. are necessary in lower quantities and for this reason they are defined as micronutrients. This division is purely academic, as organisms, in order to grow and reproduce, need all those substances in different quantities, according to the physiological moment of their development. Essential substances vary from species to species. Both the numeric development of a population and the individual growth of the organism depend on the element or compound that is present in the environment in the lowest quantity: the limiting factor.

Primary productivity

The primary productivity of an ecosystem is defined as the speed at which the solar energy is turned into an organic substance by chlorophyll in the photosynthesis.
It is defined as follows:
•**gross primary productivity (GPP)**, the total photosynthesis speed (therefore also called total photosynthesis);
• **net primary productivity (NPP)**, the speed at which the organic matter produced is stored, net of that used by the plant to live (therefore also called apparent photosynthesis);
• **net productivity of the community (NPC)**, it is the speed at which the organic matter not used by herbivore and carnivore animals is stored;
• **secondary productivity (SP)**, it is the speed at which the organic matter is stored by consumers (i.e. the heterotrophic organisms that have not photosynthesis capability) for energy purposes.
A high primary productivity rate in the ecosystems is obtained when the physical factors (for instance: water, nutrients and climate) are favourable. The presence of some forms of secondary energy can also help to increase the primary productivity rate. An example is that of estuaries, one of the most productive ecosystems in the world. In estuaries, freshwater encounters seawater. The plants that live there form a wide photosynthetic carpet. Trunks and roots trap large amounts of food particles and, once their vital cycle is over, they decompose, thus supplying the ecosystem with more organic matter. Here, secondary energy is provided by the effect of tides, that on one side promotes the fast flow of nutrients and on the other side promotes the disposal of the produced waste, so that the organisms that live there (sea bass, gilthead, mullet, clam larvae) do not spend energy to find food or dispose of waste and can grow more quickly.

Changes in the food chain

Technological innovations applied to agriculture in the fight against crop-damaging parasites led to the use of large quantities of pesticides for long periods of time. These substances are toxic and their accumulation varied the balance of
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the biosphere, as they have harmful effects on organisms, man included. DDT is a substance that, when introduced into

the environment, provoked damages to the ecosystem, creating a phenomenon of pesticide pollution at world level. Researches that studied the quantity of DDT that is present in the environment, confirmed its presence in fish all around the world, in Eskimo populations, animals that live in polar regions and mother's milk. This passage of DDT through the different levels of the food chain is made possible by the fact that the molecule keeps unaltered, as it does not degrade easily. As a consequence, at each different level (from plants to insects, from insect-eating birds to predator mammals), the concentration of DDT in organisms increased by 10 times. That is to say that, is the mass of the organisms becomes a tenth, the concentration of the pesticide increases by ten times.
The damages caused by DDT on organisms are alarming: when the molecule reaches the sea, DDT slows algae photosynthetic activity, bird eggs get fragile and break easily during hatching because they lack calcium, the number of individuals is reduced and human organs and systems are damaged.

An altered ecosystem

In Borneo, the use of DDT caused the alteration of the ecosystem, directly affecting men. The wide use of DDT to kill malaria-carrying mosquitoes killed all insects, including those that are useful to men, like cockroaches. These insects are the main food for lizards, therefore the number of lizards dramatically dropped, as well as the number of felines that ate lizards. Felines also kept mice population under control. The reduction of felines lad to an increase in the number of mice, that in over-population conditions transmit dangerous diseases to man.
Borneo, after DDT disinfestations campaigns, was affected by infectious epidemics that caused more victims than malaria.

Biomes

Ecosystems are everywhere: a wood, a lake, a river, a lawn, a beach, the sea, even the green areas of our towns. Briefly, every centimetre of our planet is or belongs to an ecosystem. Ecosystems can markedly vary in size. The temperate forest that covers most of North America, Europe and Northern Asia, and the cavity filled with water and life of a beech from the same forest are both considered as ecosystems (in this case, a "micro-ecosystem").
The Earth itself may be regarded as one big ecosystem. The division into smaller and more neatly defined ecosystems is necessary for target studies, but in fact the limits of ecosystems normally blur into each other and many organisms may be part of different ecosystems at different times. For instance, freshwater becomes brackish water near the coast, so the sea ecosystem and the freshwater ecosystem are connected to each other by energy and food flows. The boundaries of an ecosystem may also vary in time, due to a number of disrupting factors, such as the disappearance of a species, man's work, the introduction of exotic species in an ecosystem and others. In ideal conditions, areas having consistent physical and chemical characteristics should have well-defined and easily recognisable ecosystems. But such consistent conditions cannot be found in nature. Especially in the case of terrestrial ecosystems, it is easier to identify associations of ecosystems. In particular, closely related ecosystems that share the same biogeochemical cycles and have similar abiotic components are called "**biomes**". Terrestrial ecosystems can therefore be grouped into many biomes.

Ecosystems on Earth

According to the type of vegetation that mainly characterizes them , ecosystems can be recognized and divided into:

• deserts
• savannahs
• steppe
• temperate forest
• tropical forest
• boreal forest (taiga)
• tundra
• mediterranean vegetation

Water ecosystems can instead be divided into:

• freshwater ecosystems: lakes and ponds, rivers and torrents, marshes and swamps;
• marine ecosystems: reef; oceans, continental plateaus, nutrient upstream-flowing areas, estuaries.
But there are not only natural ecosystems on Earth, there are also those that have been artificially created by man as soon as his development led him to organise his social life and way of living and producing in specific manners.
Artificial ecosystems can be divided into:
• urban-industrial ecosystems (metropolises);
• rural ecosystems (small towns);
• agro-ecosystems (farmlands).

The ecological succession

The history of an ecosystem from birth to maturity is called **ecological succession**. The ecological succession is essentially an uninterrupted sequence of changes in the biotic and abiotic components of an area, which leads to a stable ecosystem (the one that is defined as the "climax"), in which components are balanced, i.e. no one prevails over the others, making then disappear. The sequence of communities that replace each other with time within the ecosystem is called "sere" and the different transition stages are called “seral stages”. It is the populations themselves that sometimes alter the environment in which they live and cause themselves to disappear in favour of other species of organisms. Examples of this type of evolutionary process can be easily found in nature, where the formation of any new environment (due to a fire in a wood, to the detour of a river, a deserted farmland, etc.) initially causes the so-called **"pioneer"** organisms to spread, i.e. organisms that can grow despite the harsh conditions of the area (few nutrients). The living activity of these first organisms alters the environment, creating new conditions that are favourable to other, more demanding, organisms. The latter develop, often causing the pioneer organisms to disappear.
To understand it better
For instance, moss, lichens and grass are often pioneer species on solidified lava or rocky substrata. These organisms can actually break up the rocky substrata to take the minerals they need to survive. In addition, once dead, they provide that organic matter that decomposes into the “soil”, that will be used by the vegetal species that will settle there at a later stage to feed on and grow. An example of an ecological succession is what happens on sandy dunes: the first vegetal species that settle there are very adaptable and can use the very few nutrients available. These first pioneer species fix the sand through their root apparatuses, making the dunes more stable and, once dead, enrich the soil with organic matter. This creates a richer environment, which is fitter to sustain the life of the more demanding organisms that slowly replace the pioneer ones, the composition of the species becomes more and more diversified and more and more complex natural feeding and competition processes develop.

An artificial ecosystem

The agro-ecosystem A typical example of an artificial ecosystem is a farmland or agro-ecosystem. This is a natural system altered by man through farming. It differs from a natural ecosystem for four reasons:
• **it is simpler**, because the farmer gives priority to one type of plant only, fighting against all those animal and vegetal species that might damage it;
• **the energy** is supplied by man, through machinery, fertilisers, plant chemicals, selected seeds, farming practices
• **the biomass** (harvest) is removed when ripe. This makes the ecosystem an open system, i.e. one that depends on external sources to reintroduce fertilising substances, fit for feeding a new process of birth and development of organic matter (the plants). A natural ecosystem fertilises itself, instead, since the biomass remains in its original place
• **the use of polluting substances**, such as chemical fertilisers, parasite killers and other non-biodegradable chemicals, that build up in the ecosystem or disperse in the subsoil, sometimes seriously polluting underground water-bearing layers, seas and rivers.
A house is also a small artificial ecosystem. Items, food, solar energy, water, etc. come from the outside and the solid and liquid waste generated by human activities is disposed of outside. The same applies to the city. It depends on external sources for the supply of food, building materials and other resources it needs to develop, and disposes of its

waste outside (dumping grounds and incinerators), that do not contribute, therefore, to the survival of the city as an ecosystem.

Man and ecosystems

The ecosystem is important for men

Terrestrial and water ecosystems are complex and perfectly organised natural "factories" that produce all that is required for life on Earth and to cover man's basic requirements: food, fibres, water. Some of these functions of the ecosystems are essential to man, such as air and water depuration, climate control, the nutrient cycle, soil fertility. In addition, some ecosystems (beaches, woods, lakes, high mountains, secluded valleys) are our ideal places for recreation, tourism and meditation, so we can say that the ecosystems have permitted our society and economy to develop. 50% of the world's population are still engaged in farming, forestry and fishing. This proportion becomes 70% if we take the sub-Sahara, Asian and Pacific countries alone. 25% of the world's countries have economies that still depend, almost entirely, on the sectors above. Farming alone produces 1.3 trillion dollars of food and fibres a year.

Man and the ecosystem

The human processes of farming, industrial production and consumption (or use) of commodities are carried out by similar rules as those of the matter and energy flows of the natural ecosystems. Also in the production and consumption of commodities, matter and energy are derived from nature, pass through the productive processes and get to the consumption stage. Waste and scrap are generated and disposed of in the environment during the production and consumption of commodities. The main differences in the matter and energy flows of natural and human artificial ecosystems are:

• the speed at which resources are taken from nature and waste is given back to nature (excessive exploitation of exhaustible and renewable natural resources);

• quality of materials involved in this flow (pollution).

Both factors often prevent the artificial ecosystems from expanding, and, lacking control and corrective measures, they risk destroying their life and perhaps that of many other natural ecosystems. The speed at which natural resources are taken away is actually so high as to cause these resources to quickly disappear, so that no new productive processes can be fed. The amount and speed at which waste is produced often largely exceed the depuration and assimilation ability of the environment, also because much of this waste is non-biodegradable in the short term.

Delicate Ecosystems

Ecosystems and Sustainability

In 1987 the World Commission on Environment and Development (WCED) issued its first report, the Brundtland Report (from the name of the Norwegian Prime Minister Gro Harlem Brundtland who at the time was President of the Commission). In 1992 was called the World Conference on Environment and the Earth Summit in Rio de Janeiro; on both occasions, the principle of "sustainable development" was officialized on a global scale. Sustainable development aims not to compromise the possibility of future generations of complying with their own development and counting on the same amount of resources we currently enjoy. This is possible only preserving the quality and quantity of our heritage and natural resources. Agenda 21 is the twenty-first century action plan and the official document approved by all the nations of the world in Rio de Janeiro. Since then, the United Nations "Commission on Sustainable Development" reviewing the implementation of Agenda 21 directives in all countries which have subscribed to the action plan.
Herman E. Dally, economist at the World Bank, in 1991 outlined sustainable development according to three essential aspects regarding the use of natural resources by mankind:

- using renewable resources at rates that do not exceed their capacity to renew themselves

- emitting slag and pollutants in the atmosphere without exceeding the carrying capacity of the environment
- stocking non-renewable resources on a regular basis over time

The carrying capacity of an ecosystem

The carrying capacity of an ecosystem is its natural capacity of producing regular resources for the species living in it without posing risks for their survival. Every year thousands of species become extinct, ranging from microorganisms to large mammals. The estimated average extinction rate has become from 1000 to 10,000 more rapid over the last 60 million years. Hence, there is reason to believe that another mass extinction could take place, the first ever caused by mankind rather than as a result of a natural process. 9 species out of 10 are endangered especially by the decay and destruction of their habitat. Men have altered most lands, converting forests and meadows to agricultural use, drying out swamps and overbuilding to create new cities. Every year 16 million hectares of forests are destroyed, mostly in tropical regions, where the highest biodiversity occurs. Other ecosystems as freshwater and terrestrial regions have been polluted by human activities. The loss of a single species affects many other ecosystems. Biodiversity, in fact, provides crucial services as the air we breath, filtering of the water we drink as well as food and medicines, etc. When ecosystems lose their biodiversity they also lose their resilience, which is their capacity to adapt and become more sensitive to the impact of climate change or alien species invasions. Men should find a way to live complying with the carrying capacity of ecosystems whilst, currently, excessive consumption of resources is causing their depletion. In the past one hundred years the world population has grown tenfold thanks to technological development. In most countries having a high per capita income there is a steady population growth but resource consumption continues to increase.

Ecological Footprint

Many different calculation models assess the ecological impact of a population. One of them is estimating the ecological footprint: this measurement method evaluates how much biologically productive land is employed to produce the goods consumed and to assimilate the waste generated by an individual, a family, a city, a region, a country or the whole of mankind (WWF definition). In Italy, the ecological footprint is 4,2 hectares per capita (2005 data): this means every Italian needs 4,2 hectares of land for his lifetime consumption. National ecological availability, though, is only 1,4 per capita hectares and therefore the ecological deficit is equivalent to 2,8 per capita hectares!

The Agroecosystem

The agricultural ecosystem

A typical example of artificial ecosystem is a cultivated field or agro-ecosystem. This is a natural system altered by men through agricultural activity.
It’s different from a natural ecosystem for four main characteristics:

- simplification: a farmer favours a plant species removing all other animal or plant species which could damage it
- the energy intake employed by men in the form of machinery, fertilizers, pesticides, selected seeds, processings
- the biomass (harvest) which is removed when ripe. This makes the ecosystem an open system, which means it depends from external processes to reintroduce fertilizing substances suitable to nourish a new growth and development process of organic material (plants). A natural ecosystem, instead, self-fertilizes as the biomass remains in its original setting
- the introduction of pollutant substances which, in the case of intensive agriculture, are chemical fertilizers, antiparasitics and other chemical non biodegradable substances which accumulate in the ecosystem or which seep in the subsoil, in some cases getting to the point of seriously polluting groundwaters, seas and rivers.

A home is also a small artifical ecosystem. Objects, food, solar energy, water, etc. are introduced inside houses from outdoor and solid and liquid waste generated by human activities is removed outdoor. The city functions in the same way. A city, in fact, depends from external areas for water and food supplies as well as building materials and other resources necessary for its development and waste generated in a city is unloaded outside the urban area (in landfills and incinerators), which means everything which doesn't contribute to the survival of the urban ecosystem is deposited in these areas.

Land to feed us

Cultivating land and feeding on its products has always been an acitvity men carry out keeping into consideration climatic and environmental conditions typical of every territory.
Men have slowly overcome limits set by the environment thanks to progress and modern technologies and have thus been enhancing environmental stress. Men have therefore modified landscapes to increase productivity transforming land into cultivated fields, reclaiming wetlands, terracing slopes, and converting forests into pastures. Agriculture has an impact on the environment with regards to the quantity of resources employed and substances it generates – both natural and chemical – which are released in various environmental compartments, soil, water and atmosphere. For example, to grow a cornfield, besides solar energy, also requires soil minerals and nutrients, irrigation water, and chemical fertilizers to sustain plant growth; it's also crucial to protect corn from insects, fungi and parasites attacks, which in a natural environment occurs thanks to the presence of other animal or plant organisms feeding on these insects.
To prevent parasites from attacking and feeding on fields, though, men often intervene using powerful insecticides which are harmful for the whole environment and for humans. The introduction of these substances in the environment and the use of natural resources affect the natural balance of the environment which becomes vulnerable. The environment tries to compensate the effects determined by agricultural activity as well as the effects generated by human activity. If conditions of strong climatic change occurred, especially on a global scale, whether the latter were caused by excessive inputs generated by human activity or as a consequence of the natural development of the planet, agricultural systems would become incapable of maintaining the high levels of production required as fields rely directly on the conditions of the soul, atmosphere and water.

Agriculture and climate change

Earth's climate is changing and there is scientific evidence about this. The average temperature of the planet has been rising by 0,8 °C in the past century (in Europe it has been rising by 1 °C). It's been time since some gases have been identified as causes for global warming and the so-called "greenhouse effect", especially carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O), naturally occurring in the atmosphere, but produced in high concentrations by human activity, as the use of fossil fuels for transportation and industrial activities, land-use change and deforestation.
General climatic conditions have become more variable. Rainfall has increased in northern European regions together with the frequency of hurricanes and storms, whilst in southern regions is occurring a decline in rainfall and increased drought. Statistical analyses show that the risk of catastrophic events taking place in the future is increasingly higher along with related potential economic losses.
Southern Europe and the Mediterranean Sea basin, in particular, are among the areas at greater risk of drought, whilst mountainous areas as the Alps risk undergoing deep changes in the structure of glaciers and water flows due to temperature rise. In the following decades, cultivated lands will probably undergo great variability of annual yielding times as harvesting will be anticipated to summer and starting crop rotations will be necessary in spring, introducing species requiring less water in comparison to corn and the few selected crops currently selected.
In the light of the great impact of climate change occurring on the whole planet in the medium and long term, the political background governing and shaping the policies of each country with regards to the agricultural sector is expected to face a double challenge: on one side, the necessity of reducing atmospheric emissions of "greenhouse gases" (GHG), and on the other side, the need to adapt human activity to new climatic conditions to reduce its negative impacts on humans. In

particular, agriculture could contribute greatly to the mitigation of climate change, considering its strong impact on the environment: it can, in fact, reduce high methane and nitrous oxide emissions (generated from manure used to fertilize and related zootechnical activities), enhance the capacity of cultivated lands of absorbing carbon dioxide from the atmosphere, provide useful raw materials to generate renewable energy.

And how does agriculture affect climate change?

Agriculture represents the third most important sector with regards to greenhouse gases emission, in close correlation with the livestock sector, as it produces 9% of total GHG emissions in the atmosphere generated by human acitivites The greatest agricultural impact is given by nitrous oxide (N2O) emissions generated by the application of fertilizers on farming soils (5%), followed by methane (CH4) emissions generated by manure and ruminant digestive processes. The role played by agriculture with regards to atmospheric emissions depends, in fact, from the type of farm located on a territory and intensive or extensive livestock activities taking place. Moreover, it should be considered that greenhouse gas emissions generated by agricultural activites requiring energy use (for example, fuel for machinery, electricity for lighting and to carry out activities within plants, etc.) aren't estimated, according to common European policies, within the emissions produced by the agricultural sector but are assigned to the energy sector.The same goes for the evaluation of carbon which can be naturally absorbed by soil (a phenomenon termed "carbon sequestration"), helping to reduce excessive carbon dioxide in the atmosphere: this type of activity isn't considered within the agricultural sector, but estimated in relation to soil use and land-use change. For these reasons, measuring the impact of agriculture on climate change is more complex than for other sectors as the industrial sector, as estimates of greenhouse gases emissions produced by agricultural systems must also take into account biological and environmental processes involved.

Cultivating according to new climates

If we want agriculture to keep being a productive sector it's necessary to implement solutions adapting old agricultural systems to the new climatic conditions. The goal is reducing the vulnerability of cultivations and increasing the resilience of rural areas from both an environmental and economical point of view, which means enhancing the capacity of agricultural activities of regaining productivity after catastrophic events, as droughts, hurricanes and floods. To adapt to the different availability of resources, farms can modify crop rotation to make best use of water, plan periods of sowing with regards to temperature and precipitation, use crops which are more resilient to heat waves and drought and restore hedges, rows of trees and bushy areas between cultivated areas to reduce water losses from soil and cultivations (increasing areas of shade and reducing plants evapotranspiration).

The agricultural sector can guide activities providing information on current risks regarding climate change and potential adaptive measures which farms can implement. In Europe, some of the Member States (Finland, Spain, France, United Kingdom) are already implementing measures aiming to adapt productive agricultural activities to new climatic conditions, and are also conducting studies and researches to assess the impact of climate change on agriculture. In particular, adaptive measures regard the capacity to prevent external extreme events related to climate as floods, hurricanes and drought to limit the effects generated by temperature rise and increased variability of climatic conditions. In Germany, for example, the sowing period of corn and sugar has been anticipated by 10 days, in southern France up to 20 days ahead. In some cases adaption requires forms of investment in machinery and infrastructure to improve, for example, the irrigation system.

The amount of water employed to farm land

Agriculture consumes 70% of the water drawn in the whole world from rivers, lakes and groundwater; in particular, developing countries are accountable for consumption of 95% of the water overally destined to agriculture, especially since the application of irrigated agriculture techniques implemented mostly in China, India and Pakistan. Even if per capita water consumption has lowered since 1980 from 700 to 600 annual cubic metres, water use to cultivate lands has been growing by 100% from 1961 to 2001 and is expected to register an exponential growth in the coming years, also due to constant population growth, expansion of urban areas and growing industrialization of emerging countries. The area covered by irrigated land in Europe is also increasing resulting in depletion of water resources and deterioration of water quality thus provoking desalinization and soil degradation. Currently, about 30-40% of the availability of agricultural products on a global scale originates from 16% of the irrigated agricultural area and it is estimated that in the following years the contribution of irrigated agriculture to food production will tend to grow. Italy destines for irrigation purposes about 60% of the 56 billion cubic metres of fresh water consumed and ranks first in Europe both for water consumption per inhabitant and for the greatest agricultural irrigated area, which is equivalent to 4,5 million hectares. Irrigation is practised with different procedures according to geographical areas and climate zones, with varying degrees of sophistication and technology: irrigating is useful to stabilize the productivity of cultivations and, in tropical countries, to guarantee more crops in the same year as well as higher yields. Irrigation is important also in dry or semi-arid areas, which would otherwise be unsuitable to support some crops. Today, more than 1,2 billion people live in areas where water scarcity occurs and for 2025, according to the United Nations Development Programme (UNDP), more than 3 billion people will become familiar with water stress conditions. On one side, therefore, irrigation is a tool which is becoming increasingly relevant in terms of food availability, on the other side, it constitutes the first form of consumption of water resources on a global scale.

Water waste

The gap between water supplies and water demand is increasing in many areas of the world: in those areas where water scarcity is already occurring, increasing drought will be the major constraint to agricultural growth and development. Climate changes will cause, above all, a decrease in annual water availability in many areas of the world. In Europe, especially in southern and central European areas, water availability will decrease more and more due to the constant decline of summer rainfall and high water demand for cultivations.

Consider that the amount of water sufficient to irrigate one hectare of rice crop would also cover the needs of 100 nomads with 450 head of cattle over three years, or 100 urban families over a two-year period. Moreover, in southern countries of the world, water used for irrigation represents up to 91% of general water consumption (in comparison to a 39% share in high per capita income countries), but agricultural production is equivalent to a third of production in industrialized countries as half of the water destined for irrigation evaporates due to high temperatures or gets lost due to leaks in the water supply distribution networks. To solve the problem of water waste it's necessary to introduce more modern technologies as drip irrigation and renew distribution networks, but often serious financial and political problems limit these options. Men draw to irrigate much more water than the amount which the planet is able to provide: withdrawal for irrigation use, in fact, in many areas exceeds the water capacity of water flows, rainfalls and regeneration of nature reserves.

Due to this imbalance, whenever delays in the arrival of rainfall occur, in comparison to natural cycles, events as famines burst out, as the one hitting some regions in Sub-Saharan Africa some years ago or, even if catastrophic events don't take place, water reserves are slowly consumed until depletion: it is estimated that in Jordan within 35 years groundwater reserves will be completely depleted and that their renewal will take thousands of years. In the United States, since as early as 1960, the Colorado river doesn't reach the sea anymore, save when exceptional rainfall occurs, because large quantities of water are drawn from the river before it reaches the Pacific Ocean.

In the African Sahel region, both due to extended drought and decreased inflow of rivers whose waters have been diverted for irrigation uses, the Chad lake has been reducing by 75% in the last 30 years. But the prime example is the drying up of the Aral lake (which was the world's 4th largest lake) in the heart of Central Asian deserts. Some Asian republics of the former Soviet Union diverted the flow of two rivers that fed the lake to cultivate rice and cotton, two crops requiring large amounts of water, especially when grown in very dry lands. This choice has reduced the surface of the Aral Lake by 70%; causing further salt concentration increases in its waters – which in the past were salty but very rich in fish – worsened by the presence of pollutants and pesticides, which have been carried for years into the lake by rivers or drained from cotton fields, and are now concentrated at the highest levels. Pollution is generating, besides the destruction of the lacustrine ecosystem, also serious health problems for local populations: anemia, infant mortality, rheumatoid arthritis, allergic reactions.

Agrobiodiversity

So far scientists have identified about 1,4 million animal and plant species on Earth and almost every day a new species joins this list. This variety of life forms is crucial for human beings. We depend on it for food, healing substances, water, energy and much more. Biodiversity, though, is increasingly threatened by human pressure, as the world population is in continuous increase and by the decay of natural ecosystems caused by human activities. Wild species risk extinction if the habitats where they live are harassed by pollution, urbanization, and deforestation. This destructive process can be hurried by negative management of agriculture, forests and ichthyic supplies. Agricultural biodiversity is represented by an innumerable quantity of plants which are necessary to feed and heal human beings. Biodiversity is found among the variety of cultivations with specific nutritional characteristics, breeds of cattle that have adapted to hostile environments, insects pollinating fields, micro-organisms regenerating agricultural soils. But also agricultural biodiversity is in danger. Human beings, infact, depend on a number of agricultural products which is increasingly reducing to eat and this lowers the prospect of some cultivated plants and bred animals to have the capacity to adapt to drastic environmental changes. About ten thousand years ago, on the basis of nature's biodiversity, human beings started to collect seeds and wild plants and grow them, choosing the most productive species or the most resistant to adverse climatic conditions. More or less during the same period, humans started to tame also animals, exploiting their strength, eating their meet and drinking their milk. Even today genetic diversity is essential for the global agricultural production to keep being sustainable.

Farmers and agronomists, infact, need genetic diversity to help plants adapt to variable life conditions or to expand production in new areas which haven't yet been cultivated. Genetic diversity of plants (defined as plant genetics) is crucial to enhance yields and have cultivations producing both more food and food with higher nutritional value. Today, four plant species alone – wheat, corn, rice and potatoes – provide more than half of the vegetable calories of the human diet, whilst about dozen animal species provide 90% of global animal protein consumption. Besides the diversity of species used for nutritional purposes, it's fundamental to maintain genetic diversity within each species: many farmes have adopted uniform potato seeds and animal breeds which give greater returns. When diversity is abandoned, though, variety and races can become extinct along with their specific features.

The push for an increase in agricultural production and higher profits, infact, has oriented the choice to a limited number of plant species and animal races which give great returns. This is another legacy of the "green revolution": many farmers, instead of cultivating a wide selection of plants, as in the past, have concentrated on one single culture, which is called monoculture, expecting higher returns and substantially reducing global agricultural biodiversity. Monoculture plants are often hybrid varieties crossbred from original species. A better variety produces more so that farmers have no need to plant older varieties which slowly disappear. Farmers opting for traditional agriculture, instead, tended to cultivate an ample variety of plants and often also raised cattle.

Since the beginning of monoculture farming most traditional agricultural practices have been abandoned. A high number of types of plants and animal races have silently disappeared. This disappearance is known as "extinction" and is irreversible. Agriculture, therefore, is losing its capacity to adapt to environmental changes, as global warming or new harmful insects and illnesses. If current food availability isn't able to adapt to environmental mutations, we could find ourselves in deep trouble.

It's extremely important to protect these resources and be sure they're used sustainably. Farmers, as guardians of the planet's biodiversity, have the chance to cultivate and maintain local trees and plants and provide for the reproduction of native animals, ensuring their survival. The loss of biodiversity, though, doesn't concern agriculture alone. Forests are probably the most important deposit of biological diversity, although every year we lose thousands of hectares of forest cover.

Oceans, lakes, and rivers of the planet swarm with life but over-exploitation and fishing methods which are harmful for the environment threaten aquatic biodiversity. Experts are seriously worried about this rapid reduction of genetic reserves. Drawing from a wide range of unique features allows to select plants and animals capable of responding to mutations in their condition. Moreover, this provides scientists the raw material they need to develop more productive and resistant types of cultivations and breeds. For poor farmers, biodiversity can really be the best defense against famine: infact, in the regions of the world where subnutrition levels are higher, farmers need cultivations which grow well in difficult and adverse climatic conditions rather than types giving high yields under favourable conditions or smaller-sized animals but which are more resistants to illnesses. Even consumers, both in developed and developing countries, benefit from the availability of a great range of plants and animals because this contributes substantially to a nutrient diet: rural communities often have limited access to markets and, for this reason, availability of a wider range of local food becomes essential. Preserving plants, animals and their habitat in the end means safeguarding a series of essential functions which nature supplies. International commitment to preserve plants and animals in genetic banks and botanic and zoological gardens is crucially important.

The International Treaty on Plant Genetic Resources for Food and Agriculture has been adopted to defend this precious heritage and has been enforced on June, 29 2004. The soil, thanks to the silent and constant work of insects, bacteria, mushrooms, and worms becomes fertile and farmers can cultivate food. Livestock, mushrooms and micro-organisms break down organic material transferring nutrient elements to the earth. Ants and other insects keep parasites under control. Bees, butterflies, birds and bats pollinate fruit trees. Swamps and lakes filter polluting agents. Forests prevent floods and limit erosion. Intact ocean ecosystems help keeping ichthyic resources healthy and constant over time thus ensuring the possibility of fishing for future generations.