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SES-EC

Textbook

Enhancing Ecoliteracy through Social-Ecological System Approach

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The basic aim of ecoliteracy is to transfer fundamental lessons learned from nature for the redesign of our economies, industries and society.

The textbook presents the concept of a socio-ecological system that promotes the integration between natural and socio-economic systems for a sustainable development policies and new lifestyles.

The SES-ECO Project «Social Ecological System Approach For Improving Ecological Literacy of Youth» is a European Union KA205 Strategic Partnership Project in the filed go youth (Project Number: 2019-1-TR01-KA205-067388). The partner are from: Turkey, Germany, Bulgaria, Spain, Italy.
The project aims to support awareness-raising about environmental issues with a new approach “social ecological system” to improve ecoliteracy of young people.

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INTRODUCTION

Theoretical Framework of Ecoliteracy

Matteo MASCIA[1]

Reflection on ecological literacy entered the international debate at the beginning of the 1990s and was part of the broader trend of the progressive emergence of sustainability thinking introduced in the previous decade under the auspices of the United Nations, which in 1983 established the World Commission on Environment and Development (WCED) (also known as the Brundtland Commission after the name of its president) with the mandate to seek answers to the growing negative ecological interdependence represented by environmental crises at global, regional and local level: Greenhouse effect, ozone depletion, acid rain, loss of biodiversity, soil erosion, desertification, deforestation, sea pollution, urban pollution, waste disposal, etc. .

The conclusions of the WCED published in 1987 with the report entitled Our Common Future (WCED 1987), propose to the attention of the whole world the concept of sustainable development as a strategic and universal approach to reconcile three fundamental dimensions of human progress that have for too long been considered separate and autonomous, if not conflicting: the economic dimension, as the ability to guarantee income, profit and work; the social dimension, as the ability to remove inequalities, promote social cohesion and improve the quality of life; the environmental dimension, as the ability to maintain the quality and reproducibility of natural resources, to enrich and enhance the historical, artistic and cultural heritage.

The report "Our Common Future" is the basis of Agenda 21 approved at the UN Conference on Environment and Development in Rio de Janeiro in 1992 and its Chapter 36 dedicated to education reconsidered within the vision of sustainable development (UNESCO, 1992). Following the adoption of Agenda 21 by major international and national organizations, UNESCO then changed its environmental education programme (1975-1995) to "Education for Sustainable Development" (UNESCO, 1997). As the concept of sustainable development influenced and reorganized the environmental education process, sustainable development itself was conceived as an educational educational field (e.g. Education for Sustainable Development, ESD) (Bonnett, 2002; Gonzalez-Gaudiano, 2005; Stevenson, 2006). (this text is taken from the introduction made by Anna and her team).

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However, as is always the case when defining new ideas and approaches that affect politics and society, the issues of sustainability and ecoliteracy have their roots in an earlier period. It was during the 1960s and 1970s that new cultural currents began to emerge, bringing with them a project for the transformation of industrial society that paid greater attention to the promotion of human rights, social and economic justice and respect for nature (Mascia, 2014).

These are the years in which a strong interaction is developed between scientific environmentalism, international intergovernmental bodies and non-governmental political associations characterized by the publication of some scientific analyses (Club of Rome, World Order Models Project, World Wacht Institute, ...) that start the debate on the crisis of the industrial society and on the intensification and diversification of the action of international bodies.

In 1972 the famous report of the Club of Rome The Limits of Development (Meadows, 1972) was published, which launched a clear and in some ways dramatic message to the international community on the unsustainability of the rhythms of growth and resource consumption of human societies. In the same year, the International Conference on the Human Environment was held in Stockholm, which drew the attention of the entire world to the planetary ecological situation, giving rise to the United Nations Environment Programme (UNEP), which will become the real driving force behind the UN's environmental activities for years to come.

In the scientific field, literature is enriched through the reinterpretation of reality in the light of the systemic approach. The concept of entropy is taken up and re-evaluated because it contains in itself the concept of degradation, the impossibility of reuse of a resource and death by degradation: on the basis of the second principle of thermodynamics we begin to re-examine the economy, the relationship between ecological systems and economic development, technology with second-order performance (Georgescu-Roegen 1971, Odun, 1970). The thought of complexity is taken as a positive research orientation in the study of environmental issues because it seems to respond better to the need for an interdisciplinary approach that characterizes this type of research. Complex thinking invites us to think in terms of openness, the co-presence of even opposite phenomena and the correlation between them, within an overall organization of natural reality that is never entirely reducible to theories and cognitive principles, but always maintains a margin of indeterminacy and uncertainty.

In the medical sciences, a positive concept of health is affirmed - anchored to the well-being of the human being in its multiple aspects - physical, mental, spiritual, social relations - according to which the factors that determine the improvement of the state of health of the population, do not derive exclusively from the progress of medical care, but mainly from a qualified cultural, social, economic, nutritional development in a healthy and ecologically balanced environmental context (Lalonde, 1974).

In the social sciences there is an approach aimed at prefiguring the advent of a new society, defined as post-industrial, post-modern or information society, as a consequence of the changes affecting all areas of life and where social issues are becoming increasingly important (Touraine, 1970).

In the pedagogical field in 1969 the expression environmental education was introduced for the first time by the School of Natural Resources and Environment (SNRE) of the University of Michigan and in 1977 the "First World Intergovernmental Conference on Environmental Education" was held in Tbilisi, Georgia (USSR). The concluding statement states that the main purpose of environmental education is "to bring individuals and the community to know the complexity of the environment, both natural and human created, due to the interactivity of its biological, physical, social, economic and cultural aspects... to acquire the knowledge, values, behaviors and practical skills necessary to participate responsibly and effectively in prevention, environmental problem solving and environmental quality management" (Tiblissi Declaration).

Even ethical-philosophical reflection, starting from the fundamental and ultimate values on which all the actions of mankind are based, questions with more and more vigour the anthropocentric vision of life in search of a deeper and more correct relationship between man and the whole of creation. Over time, as a direct consequence of the socio-cultural and environmental evolution of our age of culture, other points of view that seek the overcoming of the man-nature contradiction have overlapped with the Western philosophical vision of man as the ruler of nature, proper to the industrialist production model based on the ideology of unlimited growth and the intensive use of energy. In this direction, the paradigm of complex thinking represents a scientific contribution to try to go beyond the alternative between anthropocentrism and biocentrism, since man and environment form a system of high intensity relationships. Every human being does not only benefit from nature, he is an integral part of it and belongs de facto and de jure to the natural world. Complex thinking urges us to consider the unity of the person with the environment without losing sight of its irreducible diversity and specificity (Mascia, 2014).

This new cultural and scientific climate characterised by criticism of the dominant development model is also, and not in a secondary way, the result of growing concerns about the deterioration of the natural environment. In the 1960s, and even more so in the following decade, due to the numerous nuclear tests and the reckless use of pesticides (DDT), it is beginning to be perceived that the effects of the release of radioactive substances and chemical syntheses into the environment have a global fallout that cannot be limited to the neighbouring areas concerned. The metabolisation of these new substances in plants, their uptake through aquifers in rivers and seas, their entry into the food chain to reach human homes in increasing concentrations, shows that any action on the natural environment gives rise to a non-linear and non-local response and triggers an unforeseen and difficult to predict pathway. We begin to understand the existence of ecological interdependence: the earth is a "global unique" constituted by the continuous interaction between living beings and the physical environment. The life of every organism is part of a large-scale process involving the metabolism of the entire planet (Commoner, 1972).

The growing awareness that human beings are not independent from nature, but are part of it - each person is, as Morin says, "100% culture and 100% nature" (Morin, 1990) - obliges human communities in their articulations to develop new knowledge that can make the human environment compatible with the natural environment and cultural evolution with natural evolution.

In this direction, during the 1990s and the first decade of the 21st century, there has been an acceleration of research, analysis and reflection in the direction of an understanding of sustainability through an increasingly precise capacity to collect and process a growing amount of environmental data, as well as an increasingly precise reading of the interrelationships between natural and social systems. It is in this period that we begin to talk about the science of sustainability as a natural evolution of complexity thinking, and which is defined by geologist Paul H. Reitan "the integration and application of the knowledge of the Earth system, obtained especially from holistic and historical sciences (such as geology, ecology, climatology, oceanography), harmonized with the knowledge of human interrelationships derived from the humanities and social sciences, aimed at assessing, mitigating and minimizing the consequences, both regionally and globally, of human impacts on the planetary system and societies" (Retain 2005).

The main place of elaboration of this new scientific paradigm is represented by the interaction between the four major international research programmes on global change: the International Geosphere Biosphere Programme (IGBP), the International Human Dimensions Programme on Global Environmental Change (IHDP), World Climate Research Programme (WCRP), World Programme on Biodiversity Science (Diversitas). The United Nations has relied on this international scientific coordination to carry out the Millennium Ecosystem Assessment (2005) , which represents the most authoritative and complete global report on the state of our planet's ecosystems. Among other things, this report introduces the concept of the so-called Ecosystem Service, which recognizes the fundamental role that natural processes (water cycle, climate regulation, photosynthesis, ...) play in promoting the well-being and quality of life of people and communities.

Other international research teams are part of the International Panel of Climate Change (IPCC), which monitors and validates scientific research on climate change and global warming, and in Europe the European Environment Agency, which has recently published a new assessment of the state of the environment on a continental level.

In the same direction are the studies on the ecological footprint of the Global Footprint Network and the "planetary borders" of the Stockholm Resilience Centre. The latter of 2009 analyzes the impact of global production and consumption patterns on the Earth system divided into 9 sub-systems (climate change, biosphere integrity, change in the biogeochemical cycle of nitrogen and phosphorus, ocean acidification, soil and water consumption, ozone depletion, aerosol diffusion in the atmosphere and chemical pollution) that represent boundaries to be respected to maintain the quality of life of people today and tomorrow within a "safe operating space for humanity". For four of these sub-systems - climate change, biosphere integrity, nitrogen cycle, land use - the safe operating space would have already been crossed with the risk of causing irreversible changes in the earth's ecosystem whose consequences for biophysical and social systems are still uncertain.

The emergence of a science of sustainability has accompanied and stimulated the progressive political, economic and cultural awareness of the need to promote an integrated approach to the different dimensions - economic, social and environmental - that determine the evolution and progress of societies. Scientific and technological

research has made it possible to develop instruments capable of understanding with ever greater precision both the levels of environmental impact and the necessary actions to reduce the consumption of nature by human societies. The reference is to environmental indicators and in particular to the ecological footprint that calculates the weight of a community in terms of biologically productive territory. Other examples are the development of tools for eco-efficiency and measurement of nature consumption in industry, the development of environmental accounting systems for institutions and organisations in the broadest sense, measures for the progress of society and the overcoming of GDP as the only reading instrument for the wealth of a country and a community (Commission Stiglitz, Sen, Fitoussi on the Measurement of Economic Performance and Social Progress).

The most important milestone today is the Agenda 2030 approved by the United Nations in September 2015, which makes sustainability the paradigm of reference for people and the Planet for the 21st century, recognizing that in order to address the serious current problems (not only environmental) and take a virtuous path to renewed prosperity, it is necessary to rethink in depth the relationship with the natural environment and its resources, on which the entire set of human rights depends both intragenerational and intergenerational (Jackson 2015, Sachs, 2015).

Agenda 2030 contains 17 Sustainable Development Goals (SDGs) to be achieved by 2030, broken down into five main dimensions: people and communities, environment and natural resources, well-being and social quality, peace and security, partnership and global solidarity. These, interconnected and indivisible, are oriented towards the promotion of the dignity of the human being as a fundamental and universal right, which commits all segments of society to its full achievement, within a more balanced relationship with the natural environment. The SDGs are associated with 169 Targets, which on the one hand specify the content of each target and on the other represent a sort of operational guide to the development and definition of policies and strategies at national and international level.

Among the characteristics that make Agenda 2030 an innovative document are: its universality because the search for sustainability concerns all countries, both North and South; the search for solutions that take into account the territorial, economic, cultural characteristics of each country to be achieved through a broad process of involvement of local stakeholders; the integrated vision of the problems and solutions that must be activated to achieve sustainable development (Giovannini 2018).

In these few pages we have tried to describe, in a synthetic and certainly not exhaustive way, the socio-cultural context within which the reflection on ecological literacy introduced during the '90s of the last century by D.W Orr and F. Capra, as a contribution to face the great challenge of "building and cultivating sustainable communities" that needs to create a widespread competence that in the Earth Common House everything is connected, everything is related, everything is linked the same research of the common good comes to take on a new horizon intimately related with the need to deeply redefine the relationships between human beings and the natural environment and at the same time the relationships of solidarity between people and communities (Mascia, 2019).

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CHAPTER 1

History of Environmental Pollution

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1. Introduction

Human effects have been harmful to the environment in every period from the first human to the present day. This harmful effect is known to increase even more with the industrial revolution. The damage caused to the environment as a result of human effects has reached threatening lives of humans and all living things in recent years. Environmental problems have been increasing for the last 50-60 years and are considered as the most important agenda item. From the beginning of the 21st century, it would not be wrong to say that human beings are facing environmental problems that they have not seen before. Pollution and exhaustion of natural resources on earth such as air, water and soil threaten the continuity of life.

Despite great efforts to clean the environment in recent years, pollution remains a major problem and poses a constant risk to health. Problems, industrial emissions, poor sanitation, inadequate waste management, polluted water sources and exposure to indoor air pollution from biomass fuels are undoubtedly the largest in developing countries, where many people are affected.

The threat of past, present and potential global environmental pollution and degradation is one of the main factors affecting the environmental formation of the society. Environmental pollution and degradation can be caused by chemical substances, physical factors, or the development of undesirable living organisms. Pollutant is any substance released into the environment as a result of natural processes that have a negative impact on human activity or living organisms. Environmental deterioration means that the environment becomes unusable for the purposes for which it was designed, or the development of living organisms and communities around them has been impaired.

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Figure 1. Environmental pollution from the first human to today (URL-1)

Environmental pollution has reached threatening levels all over the world. Greenhouse gas emissions and acid accumulation, water pollution, waste management, including global environmental pollution, social, economic, legislation, and lifestyle habits that help improve health, including environmental engineering systems, and strengthen environmental systems against contamination is recognized as an international public health problem that needs to be investigated in many respects. Environmental pollutants have various negative health effects from an early age. Some of the most important harmful effects are cardiovascular system, respiratory and neurological system problems, infant deaths, oxidative stress, allergies and various other harmful effects. While the short-term effects of environmental pollutants are often highlighted, broad air pollution hazards from early life and their possible effects on chronic non-communicable diseases of adulthood should also be highlighted.

1.1. Early Man-Nature Relationship

Dirt, smoke, slime and mud have not always been an inclusive word for intolerant and dangerous substances that pollute our world. In 1783, Dr Johnson described the pollution as 'the act of defiling' or 'the contrary of consecration'. According to Johnson, the verb meant 'to make unclean in the religious sense' or to 'taint with guilt' (Markham, 2019). The current use of the word pollution became validity in the nineteenth century. In 1972, British biologist Kenneth Mellanby described pollution as "the presence of toxic substances introduced into the environment by human beings" (Mellanby, 1972), but it could also mean "degradation of natural soil and water regimes by natural displacement or mobilization."

Pollution is older than civilization and has been a problem since our first ancestors appeared. The mixing of physical and chemical waste products resulting from human activity into water, soil and air has been continuing since our species existed on earth. The first diseases were undoubtedly caused by what we call pollution today. The earliest form of pollution may have been caused by defecation action. The presence of human intestinal bacteria, such as Escherichia coli, in drinking water was an indicator of water pollution and a source of disease for prehistoric man as it is today. In China, where a comprehensive system for waste disposal was developed, even in ancient times, the use of human feces as fertilizer was an important element of agriculture even thousands of years ago. For this reason, pollution has been an integral part of medicine and health since prehistoric times. With the discovery of fire, humankind created the first source of significant air pollution and smoke still remains a major problem in the modern world. Burning fuels for heating and cooking contributed to indoor air pollution. It is known that the walls of the caves, which are the living space of the first people, are covered with thick soot layers. The presence of smoke in the confined space made breathing difficult as well as irritated the eyes. In the Palaeolithic age, mummified bodies have a black shade in most (but there are few of them) lungs. Smoke was not removed in the first settlements (one of the reasons may be protection against mosquitoes) and people living in these interiors were exposed to too much smoke (McNeill, 2001). Ancient people were likely to be constantly exposed to smoke, suggesting that they are confronted with sinusitis and lung anthracosis.

Figure *2*. Man-Nature Relationship (URL-2)

Dust pollution also has early origins. Janssen's argued that the limestone miners of Central Europe suffered from silicosis due to carving flint stone from the limestone quarry like those in Obourg (Janssens, 1970). Sometimes exposure to pollutants has affected the course of history. In the recent analysis of the 200,000-year-old Broken Hill hominid in Zambia, evidence of lead poisoning was found due to the ore located under the water supply of the cave habitat (Hammond, 1994). The transition from hunter-

gatherer to nomadic-animal husbandry systems, and ultimately to settled agriculture in the Neolithic period, was one of the most fundamental changes in human history (Ponting, 1991). The transition to settled agriculture has led to the development of the concept of ownership and an increase in food production. Food surplus has led to the development of non-farmers in the community, including priesthood, army and artisans. The collection and distribution of food was the basis of power and development. The ability to produce more in a smaller area was the basis of population growth (Markham, 2019).

Agriculture led to the growth of societies, first to small villages, then to towns and finally to cities and city-states. Although Jericho was a small town in 6500 BC, the temple city of Mesopotamia, Uruk, had a population of 50,000 in 3000 BC. If we make a modern comparison, the population of Toulouse in France was only 55,000 in 1789, approximately 5000 years later (Braudel, 1989). However, the development of towns and cities meant the beginning of the pollution era (Markham, 2019).

The harmful activities of ancient civilizations have caused long-term changes in the environment that can be seen even today. However, these effects occurred only in the relevant region without causing any global changes. Between B.C 3500 and 1800, the characteristics of the soil changed due to the floods of the Tigris and Euphrates rivers. As a result, the productivity of Sumerian agriculture gradually decreased. Water used for irrigation raises groundwater levels. If excess water is not discharged, the soil is saturated with excess water. As a result, the salts dissolve and precipitate as an impermeable layer on the surface. The agricultural area becomes unsuitable for production with the leakage of soils as a result of excessive irrigation. This contributed greatly to the weakening of the Sumerian civilization (Markham, 1994; Mészáros, 2002). This situation, which causes the Sumerian civilization to weaken and disappear, is defined as salinization and can still be seen today. Sumerians, who invented the writing, recorded this incident as 'the world turned white' (Ponting, 1991). Hammurabi (23rd century BC) laws, one of the earliest laws, are mostly related to water (Driver & Miles, 1952). Around 200 AD, pollution issues are explained in Hebrew Mishnah and Jerusalem and Babylon Talmud sources (Mamane, 1987).

The first sewage system was the Roman Cloaca Maxima, which was built during the Etruscan dynasty of Tarquins in the BC sixth century. The first purpose of this enormous building was to evacuate the marsh between Palatine and Capitoline hills. It eventually led to the establishment of the Roman Forum, which became the centre of the Republic and later the Empire. As the hydraulic pioneers of the ancient world, the Romans built a cloacae or sewer network that brought water to the city, as well as an aqueduct labyrinth. Despite the Romans' leadership, public access to sanitation and safe water did not become a priority for most countries until the nineteenth century. The general motivation behind the removal of organic wastes and sewage was the odour problem, the desire for clean drinking water and the dislike of walking around muddy and dirty streets. The direct link of disease-bearing organisms to water pollution has not been proven until the second half of the nineteenth century, when microbe theorists finally proved their case against miasmists (Markham, 2019).

Medieval European towns and villages did not seem to smell very good. Pigs were a convenient way to clean up waste, and what they did not eat would be expected to be

washed by rains. Basic arrangements for destruction were made in many towns and cities. 'Raker' or 'scavenger' teams were often used to remove garbage from the city. However, the water administration developments of the Roman Empire were largely forgotten. However, municipal administrations which were under pressure, were trying to deal with water pollution problems in the early fourteenth century. Sewage and septic were being developed, but their effectiveness was suspect. Septic smelled, overflowed and tended to infiltrate wells. Sewers were generally discharged only to the nearest river or stream in any case (Markham, 2019).

According to the World Health Organization (WHO) and the United Nations Environment Program (UNEP), increased salinity is one of the most important and absolutely most common forms of groundwater pollution even today. Salinity seriously affects 7 percent of the irrigated lands in the world, especially in India (24 percent of the total irrigated area), the USA, Pakistan, Iran, Iraq and Egypt (Meybeck, Chapman, & Helmer, 1990). Thus, pollution can be passed directly from the ancient Sumerian to the modern Middle East.

Figure *3*. Water pollution and scarcity (URL-3)

Research shows that air pollution only had significant results in cities in ancient times. The air of these early cities was filled with the smell of rotting organic household waste, rotting meat, as well as human excrement, as in some new settlements. During a siege, unbearable conditions prevailed in these settlements, as these waste materials, which emit aggressive odours, cannot be removed. According to Egyptian historical records, Hermopolis, between Theba and Memphis on the left bank of the Nile, was surrounded by Nubian troops. The residents, who could not bear the smell of the air of the city formed during the siege, surrendered (Brimblecombe, 1995). Pollution caused by unpleasant odors was very important in ancient cities. Aristotle (384-322 BC), in his work Athenaion Politeia, put a rule on the subject. Accordingly, the manure had to be moved out of the city and placed away from the city walls (Mészáros, 2001). Also, in the ancient times, the smoke-stained marble gave a grayish tone to ancient cities. Smoke and soot represented the most important problems of air pollution.

There are several examples of environmental pollution in China. Before the Tang period (618-907), firs in the Shantung Mountains were burned. During the Tang period, the Taihang mountains slopes of Shansi and Hopei provinces became barren (Schäfer, 1962). Similarly, the forests around the capital Loyang were cut down and destroyed during the Tang dynasty. The body of trees were mostly used as firewood and in order to obtain ink for government offices and were partially burned (Epstein, 1992).

Figure *4*. Tang period agriculture in China (URL-4)

Urban air pollution depends on the size of the settlement given, the area of the settlement and the nature of industrial activity, especially the use of conventional fuels. As urbanization progressed in China, the Mediterranean Basin and Northwest Africa since 1000 AD, more and more people began living in a smoky and sooty environment. Philosopher and physicist Maimonides (1135-1204), who had extensive experience of the towns of that period, states that urban air was “airless, smoky, dirty, dark and sooty” from Cordoba to Cairo (Turco, 1997).

On the other hand, traffic and transportation difficulties have limited the rate of air pollution in cities. The most energy-consuming industrial activities (e.g. tile, glass, ceramic, brick, and cast iron production) were located near forests because it was very expensive to transport large amounts of fuel to cities. In this way, although industrial air pollutants stink air, only a few people in that area were breathing that air. Port cities were the exception to this pollution. Because ships had carried wood and charcoal more economically. Thus, Venice provided energy supply by transporting wood from distant places and protected the glass industry. However, most of the urban air pollution was caused by household fuels such as manure or wood and sometimes smokeless charcoal (McNeill, 2001). The air of Chinese cities was also extremely dirty. Because the advanced water transport system (Grand Canal) in the capital of Kaifeng was using a large amount of fuel. This city which was located 500 km south of Beijing was probably the first city to transform the energy supply in the world from wood to coal. This transition occurred at the end of the 11th century, when the city had a population of about one million. However, coal heating continued. In 1126, Kaifeng was destroyed by

the Mongol invasion, and those who remained in the city died from the plague at the beginning of the 13th century (Hartwell, 2008). Polluting the front of their homes in the UK has been such a problem that in 1345, those who did so started to be fined. In addition, in the 12th century, the removal of waste from the streets was ordered in France. However, the disposal of waste from streets to streams also polluted drinking water resources.

Despite these adversities, some precautions have been taken every period. During the Roman empire, there were attempts to supply water to Rome. In addition, air pollution was not allowed with a law (Makra & Brimblecombe, 2004). In addition, fines were imposed on those who caused pollution in London. The 1306 statement on air pollution from coal threatened criminals with 'heavy ransom' (Brimblecombe, 2011).

1.2. Renaissance

The influence of the Catholic Church on European culture in medieval Europe is an undeniable fact. Churches have been influential in many areas such as culture, science, politics, economy, and one's private life. The periods following the medieval are known as the Renaissance and reform periods. These periods are known as the period when cultural changes are experienced especially on the Church. The Renaissance is partly known as the reintroduction of Greek and Roman thought into the intellectual field. Despite the enlightenment and development during this period, the medieval world had more sanitation consciousness than the later renaissance civilization. However, this sanitation consciousness was not enough to prevent Europe from succumbing to the plague (Ziegler, 2013). The plague in 1347 was a disease caused by a bacteria carried by fleas and spread by rats. This disease emerged after widespread death and starvation due to the scarcity of agricultural land and the increase in population, as well as extreme cold weather and high precipitation. This bacterium, propagated by rats, probably came from rats in the crusader boats returning from the Middle East. These rats developed in Europe's overcrowded and unsanitary conditions. The uncontrolled sewage flow that flows down the streets and the rivers of most European cities, and the population affected by famine provided ideal conditions for plague. It is stated that the pandemic, whose spread cannot be controlled, caused the death of one third of the people in Europe within a few years. The decline of British forests in the fifteenth and sixteenth centuries increased the cost of using wood as fuel, which led to more use of coal for domestic heating. Although there are criminal practices for burning coal and polluting the air, air pollution from coal in this period has been stated in many sources. It is written in some sources that London is left in the coal sea cloud. Moreover, even during the renaissance period, the lack of sewer pipes and the unbearable smell of urban pollution of waste thrown onto the streets had widespread throughout Europe for centuries. In addition, all kinds of waste material flowed open from the gutters before they reached the sewer. The atmospheric lead concentration, which was very high during the Roman Empire, has dropped to its centuries ago level after the collapse of the empire. However, it started to increase again in the Medieval and Renaissance Ages and reached the concentration level determined during the Roman Empire (Boutron, 1995). The increase then continued after the industrial revolution.

Figure 5. Plague pandemic of Europa (URL-5)

The first known law on environmental pollution was adopted in the British Parliament in 1388. According to this law, garbage and waste would not be thrown into rivers, streams and streets. As a result of people's pollution of nature with their own hands, the harm they have suffered reaches an unbearable dimension, it is the first law they have created with the conviction that they will protect themselves with this state law.

1.3. Industrial Revolution

The Industrial Revolution in the 19th century had a major impact on the culmination of environmental pollution. But it is a great mistake to assume that environmental pollution started on this date. Environmental pollution has existed since ancient times. However, the emergence of environmental science and a serious ecological awareness is new. The destruction of forests as agricultural areas and settlements is an example of the damage that human beings have caused to the environment throughout the ages. Forest fire and burning wood in closed areas are the main causes of diseases such as sinusitis and anthracosis (blackening in the lungs) that people frequently catch before ages.

The picture that emerged in the 19th century industrialization is terrible. Facilities in all industrial areas have polluted land, water and air. The novels and writings of those times are the most known proofs of London's pollution in the books. In 1930, 63 people died from air pollution in Mosa Valley, Belgium. In 1952, the disaster in London was much larger. More than 4000 people died from breathing difficulties as a result of

people's destruction of nature. "Contamination of air by smoke and other harmful vapours is entirely due to preventable causes under human control" says Richard Fitter in 1945.

Figure *6*. Industrial Revolution with Environmental Pollutions (URL-6)

The effects of production and consumption on the environment have also changed with the industrial revolution and changing patterns. Although the established factories can produce on a large scale, they also have a large share in polluting the environment by producing waste at the same rate. For example, the wastewater generated in the production processes has been discharged directly without being purified, caused the pollution of lakes and rivers, as well as caused negative effects on organisms of these living environments. Likewise, the leachate formed during the storage of solid wastes from the factories in the storage areas pollutes the soil first and then the groundwater. Some of the most important factors here are the rapid increase in synthetic raw materials and products with the developments in petro chemistry, the diversity of materials used in the production process and the products, and they have very different characteristics than those seen in conventional production processes (not knowing how to behave in nature and how to disappear).

Pollution is caused by both production facilities and end-user wastes, so pollutants now penetrate a much wider geography than before. Similarly, some pollutant gases formed in industrial production processes formed acid rain and became a major problem of Northern European countries for a while. Other types of gases have caused thinning or damage to the ozone layer, causing harmful rays of the sun to enter the living area. It also causes an increase in cancer rates among people. The atomic bomb used during the Second World War and the radioactive pollution experienced after the disaster in

Chernobyl show how great the effects can be. These and many other examples are evidences that show how the industrialized world can cause environmental, nature and living life problems if necessary prevention are not taken.

One of the factors added to the negative changes caused by the industrializing world and rapidly climbing consumption habits is the issue of global climate change, which started to appear in the 20th century and has been increasingly on the agenda recently. Reports prepared by the Intergovernmental Panel on Climate Change (IPCC) also show that water scarcity, droughts, temperature fluctuations, floods and fires in the world have impacts on climate change (ipcc., 2012). These effects have serious consequences both on an individual basis and on a country and territory basis. This situation has led to the emergence of concepts such as climate, water, food and energy security (Tuğaç, 2014). Among these concepts, climate change is defined as the changes that take place over a decade or more in the average state and/or variability of the climate. Global warming is now facing us as a climate change. The reason for this is excessive and unconscious use of resources. These effects of climate change cause precipitation in winter, sudden precipitation in summer and seasonal temperature to be above or below average (Sandalcı and Yüksel, 2011).

Figure 7. Global Climate Change (URL-7)

In addition, the corona virus (COVID-19) pandemic, which has been effective worldwide in recent days, shows that damaging the habitat of wildlife animals primarily harms not only those creatures but also humans. Some microorganisms that do not harm them can cause illness and epidemic in humans. We must respect the environment, the natural environment, and the life and habitat of living creatures. In addition, personal hygiene, public health and environmental health are very important because an epidemic of diseases occurring anywhere in the world can affect not only this region but the whole world. Moreover, especially health, economy, social life, public health,

education, etc it affects all sectors. Struggle with this type of pandemic requires personal struggle, social struggle and eventually a common struggle of all humanity.

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Questions

True /False Questions

1) (T / F) There is not enough effort to clean the environment.
2) (T / F) Environmental pollution can be caused by chemicals, physical factors, or the development of undesirable living organisms.
3) (T / F) Pollution occurred after our first ancestors.
4) (T / F) In ancient times, a comprehensive system for waste disposal was developed.
5) (T / F) With the discovery of the fire, the source of air pollution was created.
6) (T / F) During the agricultural society, there were no crowded cities.
7) (T / F) Ancient civilizations had no harmful activities and effects on the environment.
8) (T / F) Global climate change is one of the most important environmental problems in recent years.
9) (T / F) In the Renaissance, people had more sanitation awareness than people in medieval times.
10) (T / F) Today, pollution factors now penetrate a much wider geographic than before.

Multiple Choice Questions

11) Which of the following is NOT a traditional source of pollution?

a) Industrial emissions
b) Insufficient waste management
c) Polluted water sources
d) Nuclear waste

12) In what century did the current use of the word "pollution" become valid?

a) 20th Century
b) 19th Century
c) 18th Century
d) 17th Century

13) Who are the hydraulic and sewage pioneers of the ancient world?

a) Chinese
b) Egyptians
c) The Romans
d) Indians

14) Which is the pandemic disease during the Renaissance period?

a) Black plague
b) Leprosy
c) Influenza
d) Cholera

15) In which century was the first known constitution about environmental pollution adopted?

a) 11th Century
b) 12th Century
c) 13th Century
d) 14th Century

16) In which country was the first known constitution about environmental pollution adopted?

a) Egypt

b) China

c) England

d) India

17) Which is the biggest pandemic disease today?

a) AIDS

b) SARS

c) COVID-19

d) MERS

18) Which of the following was affected by climate change?

a) Groundwater

b) Amount of water in lakes

c) Temperature

d) All of the above

19) Which of the following best describes the concept of "pandemic" mentioned in the chapter?

a) A disease affecting many persons at the same time, and spreading from person to person in a locality where the disease is not permanently prevalent.

b) A disease that have spread across continents or the entire world

c) Temperatures A disease that have spread across the country.

d) A disease that have spread across the specific region.

20) After the disaster in ……, radioactive pollution has foreseen to be a major problem.

a) Chernobyl

b) Bohunice

c) Leningrad
d) Cernavodă

Correct answers: See annex "Answers"!

CHAPTER 2

Global Environmental Problems

Altan DIZDAR[3], Ertugrul DIZDAR[4] & Cagan DIZDAR[5]

2. Introduction

Environmental problems, rather in relation to socio-economic issues, display a complex picture & can act on a global level. Global environmental problems endanger the sustainability of the environment without recognizing political boundaries; it is a threat to human beings, health, safety & productivity, survival of other species & food safety & water resources. Climate change, global warming, desertification, environmental degradation, destruction of the ozone layer, acid rains, air, water & soil pollution, depletion of natural resources, loss of biodiversity, destruction of the forests, sea & ocean pollution, acidification of the oceans, hazardous wastes, adverse conditions caused by the waste, the results generated by the erosion & unplanned urbanization problem are all among the global environmental problems. So, at an international level, attempts are taking place to solve these environmental problems altogether.

Environmental protection is heavily on the international agenda & these problems can only be solved by the efforts of the non-governmental organizations, public & private sectors, civil society, national efforts & international cooperation & also an important dimension of efforts to protect the environment is to increase public awareness & the participation of whole groups. The triggering nature of environmental problems requires coordination & synergy in the processes for solution efforts.

Figure 1. Global Environmental Problems

Initiatives to find solutions to environmental problems have gradually started to be on the agenda of the international community since the 1960s. The "1.5°C Global Warming" report of the Intergovernmental Panel on Climate Change (IPCC) states that,

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along with global warming, climate-based risks related to health, food safety, water desire, human safety and economic growth will increase. The main aim of environmental policies is to have social welfare to top possible level by keeping environmental quality at a certain level. Although environmental policies differ across countries, the main concept that stands out as a common goal is the "sustainable development". While sustainable & economic and social developments are recorded, it is aimed to reduce the people's affects on the environment by protecting the nature & supply a clean environment to future generations.

As a result of global environmental problems, Ozone Layer Depletion & Increased Ultraviolet Rays are detected where this ozone hole refers to the decrease in ozone volume in the stratosphere (ozone layer) in the spring since the late 1970s. Apart from this event in the stratosphere, ozone perforation is also observed in the troposphere in the spring.The main reason for ozone depletion is that atomic halogens destroy ozone molecules where the main source of these halogen atoms are artificial halocarbons (chlorofluorocarbons - CFC, freons & halons). After these compounds are released on the surface, they are transported to the stratosphere & the destruction mechanism begins & it has been observed that the ozone hole expands with increasing halocarbon emission. Because the ozone layer prevents the harmful ultraviolet rays that reach the world by filtering, the ozone hole has caused worldwide concern & the production of gases that damage ozone is prohibited by the Montreal Protocol. It is suspected that the ozone hole increases diseases such as skin cancer & cataracts, damaging plants & plankton. (Wikipedia)

The fact that environmental problems have a cross-border nature has made it necessary for international organizations such as the United Nations (UN), the European Union, the Organization for Economic Cooperation & Development (OECD), the European Security & Cooperation Organization (OSCE), World Meteorological Organization (WMO), NASA & other international bodies to work for the solution of these global environmental problems altogether.

Figure 2. Air Pollution, Dirt & Smoke on the City

Source : https://unsplash.com/photos/uKvPDQop-JA

2.1. Climate Change

Climate change means when a change occurs in the world's climate system & causes for new weathers. Changes in climate can occur over years because of various reasons but the most important reason happened because of the industrialization & climate has been mainly affected by the human beings' activities & caused to global warming & climate change. (Wikipedia)

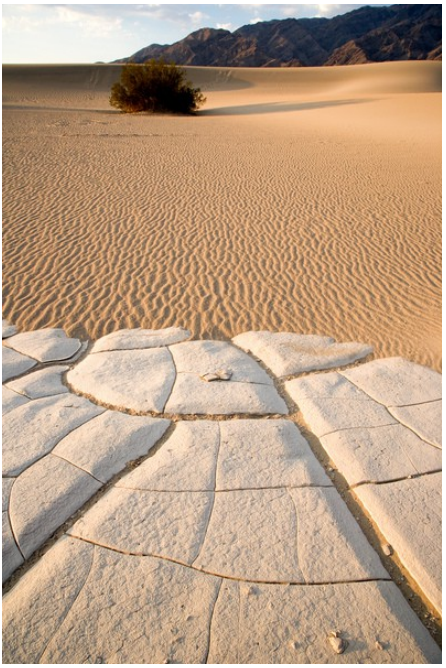
Since the mid-19th century, in addition to the natural variability in the climate, with the industrialization, a new period has begun & human activities also started to affect the climate. With the industrial revolution, the temperature increase that started to be seen on the earth & in the lower parts of the atmosphere (lower troposphere) due to the rapid increase in the accumulation of greenhouse gases released into the atmosphere with various human activities such as deforestation, burning fossil fuels & industrial processes & with the urbanization & it is called "global warming".

Human activities based on "incineration" such as energy production, heating, & transportation have accumulated the existence of CO2 & other "greenhouse gases" in the atmosphere, which has led to global warming by trapping the earth's heat.

The results of this fact are the rising of the level of the seas by the fusion of glaciers at poles & at high altitudes (some countries are flooded); Heavy droughts, floods, hurricanes take place as a result of immediate changes in temperature; the depletion of bacterial species, plant & animal. These results have started to show themselves.

Environmentalist groups state that these possible consequences can be as serious as the impact of a giant meteorite hitting the earth or a major nuclear war.

Figure 3: Desertification & Melting of Ices as a Result of Climate Change & Global Warming



Source : https://picspree.com/en/photos/cracked-and-rippled-desert-landscape-612521
Source : https://picspree.com/en/photos/ice-floes-in-the-arctic-ocean-603545

2.1.1. Causes & Impacts of Climate Change

As the causes of global environmental problems & climate change ; food scarcity, flooding, deadly heat, superstorms & widespread diseases are tried to be overcomed & precautions are taken for the problems brought by the modern life, such as transportation, land use, food & energy. report, the prominent findings as a summary were as follows: To analyse & state these problems, a Special Report on Global Warming of 1.5 °C was prepared & published by the Intergovernmental Panel on climate Change & at this:

The 1.5°C limit, the warming of 1.5°C & above is especially important because it increases the risks associated with long-term & irreversible changes, such as the disappearance of some ecosystems with the examples below:

Figure 4. Hazards of Climate Change

2.1.2. Greenhouse Gases

Various processes & substances can cause the Earth's average temperature to increase or decrease. The most important of these factors are the so-called greenhouse gases. It is known that the presence of these gases in the atmosphere causes the Earth to heat up about 32°C. If the Earth did not have an atmosphere, there would be no liquid water on its surface & the Earth would be an unfavorable planet. In this respect, it can be said that greenhouse gases in the atmosphere are beneficial. However, the increase in the amount of greenhouse gases can also cause climate changes & degradation of nature.

Water, which causes the greenhouse effect, is indispensable for living life on Earth. Ozone acts as a shield that prevents harmful rays from the sun, reaching to the earth. Other important greenhouse gases are carbon dioxide & methane. Retrospective studies show that in the last 250 years, the amount of carbon dioxide in the atmosphere has increased by 36% & the amount of methane by 148%. It is thought that the main factor causing global warming is the increase in the amount of carbon dioxide & methane in the atmosphere.

Figure 5. Greenhouse Gases

Most of the increase in the amount of carbon dioxide in the atmosphere is due to human activities. The use of fossil fuels in particular causes the release of large amounts of carbon dioxide into the atmosphere. In addition, cement production is one of the important reasons of this increase. Two main methods that can be applied to prevent the increase in the amount of greenhouse gases in the atmosphere are to reduce the amount of greenhouse gases released into the atmosphere as a result of human activities & to increase the effectiveness of biological processes using greenhouse gases in the atmosphere. For example, by increasing the number of plants using less fossil fuel or using carbon dioxide during photosynthesis, the increase in the amount of greenhouse gases in the atmosphere can be prevented.

2.1.2.1. How to Reduce Greenhouse Gases?

It is possible to reduce the Greenhouse Gas Emission Amounts by paying attention to the following items:

Technologies that provide energy saving in every field from industry to agriculture must be developed & the use of contribution to renewable energy sources such as solar (photovoltaic), geothermal, biomass & wind must be increased to overcome the climate change.

Figure 6. Windmills to replace fossil fuels; renewable energy sources like wind is one of the precautions needed to decelerate the climate change.

Source: https://unsplash.com/s/photos/windmill?ref=thestocks.im

2.1.3. Carbon Footprint

Each individual causes a different amount of carbon emission depending on where & how they live & each person's carbon footprint is different than the other from the type of food they eat, to their mode of transportation & electricity consumption. For example, the gas we burn while driving, the energy we use to heat the house & the production process of the foods we eat cause a certain amount of carbon dioxide emission.

Figure 7. Ecological Foot Print

Source : http://thestocks.im/
Figure 8. Causes of Carbon Footprint

2.1.3.1. How Can We Reduce Our Carbon Footprint?

We can reduce our carbon footprint by saving energy & changing some of our habits. For example, using public transportation such as buses or trains instead of driving will reduce the carbon emissions we cause. Using energy saving bulbs in our homes, strengthening the thermal insulation of our home, using renewable energy sources if possible is also effective in reducing the carbon footprint. Since cattle & poultry are also effective in greenhouse gas emissions, you can consume less red meat to reduce demand for these animals & thus production. In addition, trees absorb carbon dioxide & produce oxygen. For this reason, we can plant trees to pay our debt to the nature.

Organic or inorganic chemicals are the main causes of chemical pollution & the most common chemical pollutants are the compounds that are used in large areas & are permanent & do not vanish easily in nature. There are many chemicals that end our lives & harm our future generations without realizing what is in our lives. Insecticides used in agriculture are only a small part of these chemical poisons. In addition to these; materials used in dry cleaning activities, chlorinated solvents, oil refineries, coal plants, wrong construction, mining & transportation types are examples for these. Even the daily detergents we use in our home are chemical compounds that pollute the environment.

2.2. Water Resources Pollution/Depletion

Water exists in seas, oceans, rivers, lakes, aquifers & groundwater & water pollution is mainly caused by the activities of human beings such as urbanization, population growth & increased living standards & also influenced by changes in climate & natural conditions. Worldwide, human activities & natural forces are reducing available water resources rapidly. Now, at last, public's awareness of the need for better

control & protection of water has increased & necessary precautions are tried to be taken by all countries. To overcome the pollution & depletion of water, authorities are increasingly evaluating the amount & quality of water & trying to coordinate the control & protection of the water resources.

Figure 9. Water Pollution

Source : https://pixabay.com/illustrations/pollution-trash-degradation-1603644/

For example, distribution of inadequately treated wastewater into natural water systems will lead to degradation of aquatic ecosystems. Also, this will lead to public health problems for the people & living things as this polluted river water may be used for drinking & irrigation. In the world, water pollution is the most important cause for the deaths & diseases around, e.g. due to water-borne diseases (Wikipedia).

Figure 10. Distortion of the environment will spread many diseases everywhere

Source : https://unsplash.com/photos/Sj5vmEumehE

2.2.1. Causes & Impacts of Water Resources Pollution/Depletion

Environmental pollution can damage water resources & the water ecosystem. Rural changes such as environmental pollution, climate change, urban growth & deforestation have direct effects on ecosystems & on water resources. The main pollutants include, for example, organic substances in wastewater discharge & disease-causing organisms, fertilizers & pesticides from agricultural areas, acid rains from air pollution, heavy metals released as a result of mining & industrial activities & activities such as poorly managed farming, forest clearing, road construction & mining can result in large quantities of soil & poisoned particles remaining in the air & they finally merge in the rivers & water sources (sedimentation). This damages the water ecosystem, impairs water quality & prevents internal water transport.

Main consequences of water pollution is the disappearance of biodiversity & aquatic ecosystems where also due to deforestation, sediments & bacterias are appeared under the soil & therefore contaminate groundwater. Also, humans are harmed by the alteration in the food chain & get illnesses when drinking or using contaminated water. As water pollution has a great impact in the environment, we must ensure water availability, its sanitation & sustainable management.

The effects of drawing too much water from both surface water & groundwater are striking & it causes to water depletion. In the past decade, much more water has been drawn from underground springs & the benefits of using underground water are often short-lived, but their negative consequences - for example, low water levels & depleted resources - can continue for a long time. At the same time, climate change is also another reason for the water scarcity.

Figure 11. Main Factors Affecting the Water Pollution & Depletion

2.2.2. Control of the Pollution of the Water :

In fact, the negative role of the industry on the environment is perhaps more than any other factor. Especially industrial enterprises cause liquid pollution & water pollution & indirectly due to water pollution, cause excessive pollution on soil & vegetation & cause rapid destruction of the environment.In addition, industrialization movements & migration to cities causes rapid & irregular urbanization cause to pollution & depletion.

In spraying of pesticides, water resources are contaminated with pesticides as a result of carrying airborne drug particles to the water by wind or discharging factory wastes that produce pesticides into water sources or rivers. On the other hand, the unconscious & excessive use of chemical fertilizers also make the soil barren over time & again creates negative effects with the natural cycle both with water pollution & other effects.

Storms, volcanoes & earthquakes also cause great changes in the water quality & to its ecology but these are not counted as pollution.

To control the pollution of water, it requires correct & appropriate management plans & infrastruture. Wastewater treatment plants belongs to the infrastructure system. Sewage & industrial wastewater treatment plants are usually established to protect water from untreated wastewater. Agricultural wastewater treatment for farms & erosion control at construction sites can also help to prevent water pollution. Nature based solutions are also another approach to prevent water pollution. (Wikipedia)

Figure 12. Pollution of the water

2.2.3. Reasons for the Droughts :

Drought is actually a normal & recurrent climate phenomenon that starts very slowly, develops for months or even years & affects very large areas & is different from other events. Occurs due to decreasing precipitation spread over one or more seasons. However, increasing temperatures & decreasing precipitation in many regions of the world as a result of global climate change increase the frequency & severity of drought events.

It causes serious economic, environmental & social impacts in very large regions & sometimes even in a whole country. Drought occurs in all climatic zones, but the vulnerability of the area to the drought & the degree of effects can vary greatly from one region to another. The causes of drought are easy to understand but their effects are difficult to predict!

The only reason for drought is not the climate change but the overuse, pollution of water resources, improperly planned water infrastructures & mismanagement are strongly influencial on this system & make the basins, countries & even economies even more fragile. It causes us to lose our all strength in front of such a drought & the consequences to be felt violently.

Drought, desertification & land degradation are important environmental tests of our age that may threaten the habitat & the most basic livelihood of the majority of the world's population & create a risk of food safety.

While the decrease in the amount of water is felt as an effect of drought, it also causes the failure to meet the increasing water demand or deterioration of the ecological systems. Besides their environmental effects, their economic effects can also be felt very heavily due to the severity of the drought. Sectors such as agriculture, energy, tourism & forestry are directly affected by drought. The cost of drought in Europe in

2003 was calculated as 11 billion Euros, in 2006, it was determined that the agricultural sector in Spain suffered more than 2 billion Euros due to drought.

In order for drought not to become a chronic problem, water resources should be managed well in both rainy & dry periods. Managing water resources at river basin scale is the first step to preserve the holistic structure of river ecosystems that are actually the source of water.

2.3. Loss of Biodiversity

Biodiversity is the name given to ecological systems, species & gene diversity all over the world or in a certain habitat & the richness of plant & animal species & varieties in a region is called biological diversity & it provides the services necessary for the continuity of the economic & social life of human beings. Biodiversity is also important for ecosystem & nature provided services like flood protection, climate regulation, soil fertility, pollination & food, fuel, fiber & drug production.

Biodiversity loss is the depletion of animals & plants all around the world & also the local reduction or loss of species in a certain habitat whereas global depletion has so far been proven to be irreversible.

Figure 13. Prevention of Loss of Biodiversity is prerequisite for the survival of certain habitats.

Source : https://unsplash.com/photos/2xQcwGfGio8

Biodiversity is also the differentiation between land, marine & other aquatic ecosystems & living organisms from all sources, including ecological structures that are part of these ecosystems. Biological wealth or biological diversity refers to the diversity & variability of living things, their interactions with the complex ecological structures they live in, with each other & with their environment.

2.3.1. Benefits of Biodiversity

People have reached today's level in agriculture & technology as a result of biodiversity & wealth. The benefits of biodiversity & ecosystems are essential for the continuation of today's high standard human life. The plant & animal species that make up the biodiversity are used in agriculture, pharmacy, medicine, animal husbandry, forestry, fishery & industrial areas, also in providing clean water & air. The high number & diversity of plant & animal species that make up biodiversity also provide economic gain to the country. Biodiversity balances ecosystems, makes the planet habitable, supports people's health, the environment & ecosystems.

Figure 14. Classification of Benefits of Biodiversity

Benefits of Plant Diversity: Plants clean the air, prevent erosion, add organic matter to the soil, & relieve soil fatigue. They provide shelter & nutrition to other living things & provide continuity to the ecosystem.

Benefits of Animal Diversity: Humans have used animals for guinea pigs, as a source of food by hunting & domesticated animals from ancient times until today. Some insects provide pollination of plants, ensuring the continuity of plant life & diversity, & thus the continuity of the ecosystem. A significant part of the insects ensures that the organic matter is decomposed & brought back to soil. Some insect species are also the food source of animals such as birds, fish, reptiles.

Benefits of Ecosystem Diversity: Nature based tourism is called eco tourism. Eco tourism has an increasing importance in recent years. Depending on the technological advances & lifestyle, people under stress rest themselves in nature. Stress is relieved by going to national parks & nature.

2.3.2. Categories of Biodiversity

Biodiversity is considered in 3 hierarchical categories according to

Figure 15. Categories of Biodiversity:

Biological diversity is the basis of living resources, which have an indispensable place in meeting the basic needs of people, especially food. The basis of all cultivated

cultivars, that is, cultivated plant & animal species, is based on their wild relatives in nature. Today, wild species are used to obtain new types of agriculture or to improve the existing ones according to the needs of people. Ecosystems have also acquired complex & different structures & functions depending on environmental conditions as a result of the interaction of living & inanimate beings with each other & within themselves in order for wild species to survive, evolve, diversify & acquire new genetic features. It performs important functions in the continuation of natural balances such as integrity & diversity of ecosystems, climate, precipitation regime & species sociology.

Living resources, which are important for food & agriculture & are decreasing gradually, are among the important advantages that a country can have today. The areas of the world that can be cultivated & the water resources are rapidly polluting & disappearing. Scientists are of the opinion that in the near future, people will face a serious food problem. Developed countries are investing heavily in the development of new high-yield seed & breeding varieties & making efforts to retain food trade. In the light of these developments, the biological diversity of the countries becomes a great power, especially in terms of genetic resources. Because wild cultivars are used to develop varieties that are resistant to environmental pressures & have high production potential.

2.3.3. Convention on Biological Diversity

The Convention on Biological Diversity is international legally-binding treaty, signed by the countries & aimed to promote sustainable development.The idea was more than protecting the animals, plants, micro organisms & their ecosystems but also to think about the people & their need for food security, medicines, fresh air & water, shelter & a clean & healthy environment to live in.

The three main objectives of the Biodiversity Convention (CBD) are:

The Convention specifies that each country needs biological resources that need special protection measures & biological resources that have greater potential for sustainable use; It requires identifying & monitoring the categories & processes of actions that may have a negative impact on conservation & sustainable use.

2.3.4. Causes & Impacts of Biodiversity

We are now witnessing a continuous loss of biological diversity that affects natural life & human well-being. The main causes of this loss are changes in natural habitats due to intensive agricultural production systems; build; quarry activities; excessive use of forests, oceans, rivers, lakes & soil; pollution & increasing global climate change.

The great role played by biodiversity in the sustainability of our world & lives makes its ongoing loss more & more unsettling.

In Europe, with the spread of agriculture & animal husbandry for 5000 years, human activities have shaped biodiversity. However, the agricultural & industrial revolutions over the last 150 years have led to sudden & increasing changes in land use, intensification of agriculture, urbanization & land evacuation. This has led to the loss of many experiences (eg traditional farming methods) that support the conservation of landscapes rich in biodiversity.

Europe's high per capita consumption & waste production mean that our impact on ecosystems extends beyond our continent. The European way of life is based on the intensive import of resources & goods from all over the world, which often causes unsustainable use of natural resources outside Europe.

Global & European Union 2020 targets aiming to stop & increase the loss of biological diversity are quite ambitious. Achieving these goals requires implementing effective policies, cross-sectoral coordination, ecosystem management approaches & a better understanding of the value of biodiversity.

EU policies on the subject

Although the goal of stopping the loss of biodiversity is accepted at various levels where the goal has not yet been met, even setting such a target has certainly raised social awareness. Since 2001, policies addressing biodiversity loss & indicators evaluating development have improved significantly.

The EU's 2020 Biodiversity Strategy will enable further integration of the work required to protect biodiversity into the development & implementation of sectoral policies. With its six objectives, this Strategy includes nature (target 1), ecosystems & restorations (target 2), sustainable use of the nature of Europe, land & marine resources through agriculture, forestry & fisheries (targets 3 & 4), alien species (target 5) & It addresses the global effects of the EU (target 6). The Biodiversity Strategy helps to meet the natural capital targets of the 2020 7th Environment Action Program. The main slogan of the Seventh Environment Action Program (7th EAP), which came into force in January 2014 & will guide Europe's environmental policy by 2020, is "Living well within the boundaries of our planet". Both strategies & programs have a long-term vision that will last until 2050.

Vision of the Biodiversity Strategy

Until 2050, the European Union biodiversity & the ecosystem services it provides - its natural capital - are preserved, valued & properly restored due to the essential value of biodiversity & their significant contribution to human well-being & economic well-being, thereby avoiding destructive changes caused by loss of biodiversity.

The main goal of the Biodiversity Strategy

On the one hand, to prevent global biodiversity loss & ecosystem degradation by 2020, & to repair as much as possible, on the other hand, to increase the EU's support to stop the loss of biodiversity.

The 2020 Biodiversity Strategy has further increased expectations in the light of the lessons learned from the implementation of the 2006 EU Biodiversity Action Plan. In addition, it has been implemented in full compliance with the UN Convention on Biological Diversity, which is the most important global biodiversity policy aimed at stopping biodiversity loss & thus ecosystem services loss until 2020.

Figure 17. Protection of sea & fishes with the plants

Source : https://unsplash.com/photos/jPFqcpfn_Fw

Natural parks, natural habitats should be created, organic farming should be preferred & people should be educated on these issues in order to include the generations of these creatures, whether they are plants or animals.

Farmers should be made aware of the negative effects of overgrazing, over-harvesting of plants & destruction of forests to gain land in terms of biodiversity. Destruction of coastal habitats & excessive & uncontrolled fishing must be prevented. In addition, mechanisms for the protection & control of these species should be developed.

Biodiversity is the common wealth of the whole world. Biodiversity needs to be preserved in order to be able to transfer this diversity to future generations by meeting today's needs.

2.4. Land-Use Problems in Urbanisation, Agriculture & Forestry

In Land-Use, most problems arise from Urbanisation, Agriculture & Forestry & these problems must be solved by taking careful precautions. Rapid population growth in the world increases the pressures on the natural environment. With the speeding of urbanization & industrialization process, the natural environment is significantly

polluted & consumed. Cycles in the natural environment are severely interrupted, deteriorated & causing problems that are difficult to solve day by day due to wrong land use. Unenvironmentally & unsustainable planning & the projects produced accordingly make the world more risky & uninhabitable for all living things. Especially the opening of areas that are risky in terms of natural disasters & which are not suitable for settlement cause an increase in life losses & material damages caused by natural disasters.

Due to global climate change, urbanization & wrong land use, damage caused by floods, erosion, droughts increases day by day. Thus, disasters, which are mostly caused by natural processes, turn into disasters of human origin due to human activities.

Agriculture is also heavily effected especially by the lack of infrastructure & misuse & faces the threat of land's desertification & erosion. Forests must be protected & they mustn't be opened to residentials & at most attention must be given to prevent the forest fires.

2.4.1. Types of Lands & Their Usage

Types of Land-Use & Types of Lands are defined in Figure 18. Types of Usage of Lands & Types of Lands, Correct Land-use must be chosen from the Correct Land Type:

Soil, which is one of the most important elements of the ecosystem, is very important in terms of its non-renewability & indispensable place of human & living life, as well as ensuring the continuation of the primary chain of vegetative production, the food chain that expresses the survival of herbivorous & carnivorous life. Soil, among other natural environment elements, faces more serious problems in terms of purchasing, selling & renting.

Incorrect land use means that lands are not used according to their ability capabilities. In other words, it is the use of lands without taking into account the geological, geomorphological (slope, topography, aspect etc.), vegetation, hydrological & soil properties. In addition to the pressure of the population, the decisions taken by the political authority have been effective in the "wrong land use", which expresses the unconscious & overvaluation of the potential of the natural environment.

The land, which has many ecological, economic & social functions in the realization of sustainable development, is a limited resource & its use is limited by the climate, soil, geological & geomorphological structure of its location. It is sensitive to natural events & human activities, it is easily disrupted & loses many functions when used without care.

Land use & benefiting from the land means, firstly usage of the land for agriculture & forestry, then all kinds of land use, including making residential areas,

utilizing for transportation, making trade, art, industry, commercial activities & holiday places.

Natural resources are left to the next generations by being further developed without consuming. Where agriculture will be made; where will the animal be grazed, where will be forested, where will litter be poured? When these questions are solved, renewable resources are not damaged. A new city is not established on agricultural land; a mountain skirt that needs to be afforested does not open to settlement. Land use plans are of great importance & are strictly implemented. Therefore, other than natural disasters, anthropogenic disasters will not be observed in the modern world.

Figure 19. Proper Urbanisation & Increase of Population is important in Land-use

Source : https://unsplash.com/photos/3ttFTqPQs5A

Land capability classification for basic soil studies & planning based on climate conditions must be done by combining usage & conservation data to determine the most suitable use of the land without causing soil degradation.

To take a decision on a land-use, the past & present applications of land use in a field must be determined & analyses must be done on how it should be in the future according to its current potential. Paralel with the natural & human resource determination made in the areas to be used in land use planning, it is defined as “land use decision development” to provide concrete suggestions on how the existing land use will be in the most appropriate form depending on the analyzes done (SWOT analysis).

Figure 20. Agriculture is prerequisite for food scarcity & Forests are necessary for a clean environment.


Source : https://unsplash.com/photos/2UqMez6xpQ0 ; https://unsplash.com/photos/F_hft1Wiyj8

2.4.2. Causes & Impacts of Land-Use Problems

General Causes of **Improper** Land Use can be summarized as follows:

The opening of agricultural areas to settlements & industrial facilities & the misuse of agricultural lands is a basic problem for land degradation. Because of the rapid urbanization which have started to be seen with the rapid population growth in the world, have become a threat to the world life & non-suitable settlements are started to be opened on productive lands, destroying the nature & the environment. Construction of airports in alluvial lands, construction of dams, roads, factories, tunnels, channels, etc. to first class agricultural lands & the misuse of productive agricultural areas is the main causes of land degradation.

The filling of the coastline & the area behind it with secondary residences & tourism facilities causes degradation of the lands & loss of area against the use of agriculture, grazing & forestry purposes.

Opening areas not suitable for agriculture & settlement to agriculture & settlement & opening sloping areas that are not suitable for agriculture to agriculture, grazing accelerates erosion, so the soil-plant-water balance turns upside down. In such areas, erosion reduces the yield value. This situation will not work in terms of agriculture, forestry & stockbreeding.

Acid rains from fossil fuels, industrial, mineral, domestic & nuclear waste, etc. causes the land to be degraded chemically & biologically. Pollutants that reach the soil from various sources (industrial & domestic wastes, pesticides & fertilizers, tanks & pipelines where oil products are stored, leaks from machinery & vehicles, etc.) cause various environmental problems & make the surface, ground & groundwater unusable

for agricultural purposes, leads to product loss, shrinkage of the product pattern, degrading the quality of the soil & decreasing the yield value of the land.

Overgrazing that is animals eating the grass until the soil level & early grazing that is opening grassland before full growth to grazing & weakening of grass cover; directly leads to a decrease in the yield value of the land. As a result of overgrazing in the world especially in semi-arid regions, both the yield power of the grasslands decreased & the erosion events gradually increased. Also grazing in forest areas will lead to destruction of the forests & will cause to fires.

Figure 21. Precautions must be taken to prevent Forest Fires

Source : https://unsplash.com/photos/7Je8Q8f-rmE

Excavations for mining purposes from the areas on land, especially forest, grassland & agricultural lands are among the reasons for wrong land use. Wells, galleries etc. opened after mining excavations & failure to cover up, exposure of soil losing natural vegetation against water & wind erosion may cause negative consequences. The effect of land degradation caused by mining is enormous & leads to irreversible consequences.

Figure 22. Distortion of the soil, as a result of Mining activity, the soil becomes bare & useless and hills are formed because of excavations

Source : https://unsplash.com/photos/Mk2ls9UBO2E

Over-unconscious application of agricultural spraying-fertilization, over-unconscious irrigation, use of wrong equipment, stubble burning, etc. pollutes the lands & turns lands open to erosion.

Passing roads through productive agricultural areas/forests & passing highways through flat plains & valley floors is among the reasons for wrong land use. According to the ideal land use planning, roads should be located at the intersection of flat areas & mountainous areas (settlements, landslides, slopes without earthquake risk) along with settlements.

The only reason for the destruction damage that occurs in the upper parts of the streams & the resulting loss of life is the housing inside the stream beds therefore in the design of the settlements, this condition is very important & must be respected.

Dropping solid & liquid garbage to random lands (wild storage) is among the reasons for wrong land use & is effective in losing the land's yield value. The main physical processes of wrong land use occur due to water & wind erosion, losses & other adverse changes in the soil occurs.

Erosions are very important; if no precautions are taken, serious problems can arise. Water erosion is the most effective & widespread type of erosion that causes land degradation among other types of erosion (wind erosion, glacier & wave erosion, avalanche & mass movements, etc.). The excessive cutting of forests for commercial purposes causes the effect of water erosion to worsen ; it is also common for forests to be burned down for reasons such as opening fields for obtaining settlements, tourism construction, etc.

Another wrong way of land use that leads to the decrease of the yield value of the soil or the land & the deterioration of its quality is soil contamination. Soil pollution is

generally caused by air, water pollutants & agricultural activities. Soil pollution, one of the environmental problems, is also considered as a type of land degradation, as it reduces the yield value of the soil. Factors causing soil pollution; unconscious & extreme in agricultural fields. The use of pesticides, artificial fertilizers, industrial wastes & toxic substances released from various applications, wastes of mineral processing plants, sewage waters, wastes of industrial facilities, exhaust gases, pesticides used to combat fertilizers & harmful organisms.

Figure 23. As a result of improper land use, the land loses its yield value by passing through certain stages & transformed into useless areas in terms of agriculture, forestry & animal husbandry.

If these rules are not respected, wrong land-use will lead to erosion, flood, landslide, desertification & land degradation & afterwards a complete ruin of the environment will occur which will not be irrevertable.

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QUESTIONS:

True /False Questions

1. (T / F) Each individual causes a different amount of carbon emission depending on where & how they live & each person's carbon footprint is different than the other from the type of food they eat, to their mode of transportation & electricity consumption.

2. (T / F) Transportation, industrial processes, electricity & fossil fuel use cause low energy consumption.

3. (T / F) The amount of waste material in the world is at a very low level. This situation is good for the natural resources & living areas of the Earth.

4. (T / F) The mass production of fattening animals with increased meat consumption causes the release of large amounts of methane gas into the atmospehere.

5. (T / F) We can increase our carbon footprint by saving energy & changing some of our habits. For example, using private cars will reduce the carbon emissions we cause.

6. (T / F) Organic or inorganic chemicals are the main causes of chemical pollution & the most common chemical pollutants are the compounds that are used in large areas & are permanent & do not vanish easily in nature.

7. (T / F) Water exists in seas, oceans, rivers, lakes, aquifers & groundwater & water pollution is mainly caused by the ships on the sea & does not influenced by changes in climate & natural conditions.

8. (T / F) Rural changes such as environmental pollution, climate change, urban growth & deforestation have direct effects on ecosystems & on water resources.

9. (T / F) Only animals cause liquid pollution & water pollution & indirectly due to water pollution, cause excessive pollution on soil & vegetation & cause rapid destruction of the environment.

10. (T / F) Drought is actually a normal & recurrent climate phenomenon that starts very slowly, develops for months or even years & affects very large areas & is different from other events & occurs due to decreasing precipitation spread over one or more seasons.

11. (T / F) Drought does not occur in all climatic zones & the vulnerability of the area to the drought & the degree of effects don't vary greatly from one region to another.

12. (T / F) Biodiversity is the name given to ecological systems, species & gene diversity all over the world or in a certain habitat & the richness of plant & animal species & varieties in a region is called biological diversity.

13. (T / F) Due to global climate change, urbanization & wrong land use, damage caused by floods, erosion, droughts increases day by day.

14. (T / F) Forest, which is one of the most important elements of the ecosystem, is very important in terms of its non-renewability & indispensable place of human & living life, as well as ensuring the continuation of the primary chain of vegetative production, the food chain that expresses the survival of herbivorous & carnivorous life.

15. (T / F) Incorrect land use means the use of lands without taking into account the geological, geomorphological (slope, topography, aspect etc.), vegetation, hydrological & soil properties.

16. (T / F) Construction of airports in alluvial lands, construction of dams, roads, factories, tunnels, channels, etc. to first class agricultural lands & the misuse of productive agricultural areas is the main causes of land degradation.

17. (T / F) The opening of agricultural areas to settlements & industrial facilities & the misuse of agricultural lands can be considered as a form of correct land-usage.

18. (T / F) Acid rains from fossil fuels, industrial, mineral, domestic & nuclear waste, etc. causes the land to be degraded chemically & biologically.

19. (T / F) Dropping solid & liquid garbage to random lands (wild storage) is among the reasons for wrong land use & is effective in losing the land's yield value.

Multiple Choice Questions

20. Which one of the following is not a threat to human beings in the scope of Global environmental problems?

a) Health & safety

b) Survival of other species

c) Food safety

d) Building type

21. Which one of the below is not the classification of the global environmental problem?

a) Increased water, soil & air pollution,

b) Increase of the biodiversity

c) Climate change & Greenhouse effect

d) Ozone Layer Depletion

22. Climate change means:

a) when a change occurs in the world's climate system & causes for hot weathers

b) when a change occurs in the world's atmoshere system & causes for new weathers

c) when a change occurs in the world's climate system & causes for new weathers

d) when a change occurs in the world's atmosphere system & causes for cold weathers.

23. Climate change has been mainly affected by the ;

a) Plants & biodiversity,

b) Animals,

c) Sun,

d) Human beings' activities

24. According to the Special report on Global Warming, what is degree that shouldn't be exceeded?

a) 3.0°C

b) 1.5°C

c) 2.0°C

d) 1.0°C

25. Various processes & substances can cause the Earth's average temperature to increase or decrease & the most important of these factors is:
    a) Greenhouse gases,
    b) Rotation of the earth,
    c) Getting closer to the sun,
    d) Forests

26. It is thought that the main factor causing global warming is the increase in the amount of ;
    a) Nitrous Oxide & Water Vapor in the atmosphere,
    b) Ozone & Perfluoro Carbons in the atmosphere,
    c) Carbon Dioxide & Methane in the atmosphere,
    d) Hydrofluoride Carbons & Sulfurhexea Fluoride in the atmosphere

27. It is possible to reduce the Greenhouse Gas Emission Amounts by paying attention to the following items:
    a) Green areas should be decreased in the cities,
    b) The tax system for elderly vehicles shpuld be rearranged,
    c) Wastewater should be treated,
    d) Forest areas should be increased.

28. Technologies that provide energy saving in every field from industry to agriculture must be developed & the use of contribution to renewable energy sources must be increased to overcome the climate change, such as :
    a) Solar (photovoltaic),
    b) Geothermal,
    c) Biomass & wind
    d) Fossil fuel

29. Distribution of …….. into natural water systems will lead to degradation of aquatic ecosystems.

    a) inadequately treated wastewater

    b) adequately treated groundwater

    c) inadequately treated drinking water

    d) adequately treated sea water

30. Main consequences of water pollution is the disappearance of biodiversity & aquatic ecosystems where also due to ……, …… &……. are appeared under the soil & therefore contaminate groundwater.

    a) Forestation, sediments & gasses

    b) Deforestation, sediments & bacterias

    c) Sediments, roads & tunnels

    d) Urbanisation, forests & gasses.

31. ……., …….. & …… ……. are important environmental tests of our age that may threaten the habitat & the most basic livelihood of the majority of the world's population & create a risk of food safety.

    a) Forests, parks & traffic jams

    b) Urbanisation, buildings & country degradation

    c) Drought, desertification & land degradation

    d) Uncivilisation, forestration & transportation types

32. …… is the depletion of animals & plants all around the world.

    a) Global Warming

    b) Climate Change

    c) Biodiversity Loss

    d) Change of Seasons

33. Biological diversity refers to the diversity & variability of ;

a) Living things, their interactions with each other & with their environment

b) Plants, their interactions with the animals & with the forests

c) Animals, their interactions with the plants & with the rivers

d) Human beings, their interactions with the forests & with the ground water

34. Which one of the following is not the classification of benefits of Biodiversity?

a) Plant Diversity

b) Animal Diversity

c) Urbanisation Diversity

d) Ecosystem Diversity

35. Which one of the following does not belong to category of biodiversity?

a) Genetic Diversity

b) Species Diversity

c) Ecosystem (Process) Diversity

d) Sea Diversity

36. Which one of the following is not the main objective of the Convention on Biological Diversity which is internationally signed by the countries?

a) Protection of biological diversity

b) Sustainable use of biological resources

c) Consuming the natural resources without restriction

d) Use of benefits arising from the genetic resources & sharing them equally & fairly

37. Which one of the following is not a main cause of Biodiversity loss?

a) changes in natural habitats due to intensive agricultural production systems;

b) excessive use of forests, oceans, rivers, lakes & soil;

c) pollution & increasing global climate change,

d) changes of the routes of the roads

38. ……. is heavily effected especially by the lack of infrastructure & misuse & faces the threat of land's desertification & erosion.

a) Transportation

b) Agriculture

c) Food

d) Buildings

39. Which one of the following is not a type of Land-Use?

a) Transport

b) Agricultural

c) Residential

d) Desert

40. Which is not a cause of improper land use?

a) Opening agricultural areas to settlements

b) Passing the roads from non-productive agricultural areas

c) Opening areas not suitable for agriculture

d) Uncontrolled population growth

41. As a result of improper land use, the land loses its yield value by passing through certain stages & transformed into useless areas in terms of ……..., …… & ……

a) transportation, forestry & parks

b) parks, forestry & buildings

c) agriculture, forestry & animal husbandry

d) food, agriculture & residents

Correct answers: See annex "Answers"!

CHAPTER 3

How Ecosystems Work

Belda ERKMEN[6] & İbrahim ÖRÜN[7]

3.1. Concept of an Ecosystem

An ecosystem is an area with a specific landscape model such as hot desert, grass land, river, ponds, lakes or estuaries etc. The composition of the ecosystem depends on its geographical characteristics such as mountains, lakes, rivers, coastal areas or islands. Climatic conditions such as rainfall, sunlight, the temperature etc. also control ecosystems. The geographical, climatic and soil features create its non-living (abiotic) component. These characteristics form conditions that support its living-thing (biotic; comminity plants and animals) live in these specific conditions. (Bornmann and Likens, 1967). An ecosystem can be different size as large as a whole forest or as small as a tree.

Ecosystems are broadly divided into terrestrial and aquatic ecosystems. These create the two main habitat conditions for the all living organisms. Terrestrial ecosystems include desert, grass land, forest and aquatic ecosystems include ponds, river, streams, oceans and estueries etc. Terrestrial or aquatic ecosystems are self regulating, open system where inputs and outputs with other systems are free (Bornmann and Likens, 1967). Thus ecosystems have both biotic and abiotic component that are specific to a region giving it its own particular features. In the field we can easily observe a set of characteristics of each ecosystem, including what does the ecosystem look like, its structure, composition of biotic parts (Elmqvist et al., 2010).

3.1. Structure and Function of an Ecosystem

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The ecosystem term first used by the British ecologist Arthur Tansley in 1935. An ecosystem is a structural and functional unit of biosphere that includes living (plants, animals, microbes) and non-living things (air, water, soil) interacting as a system. The living thing is reffered to the biotic parts, biocenosis, in conjunction with the abiotic components, the biotope, encompassing the physical region of life (Odum and Barret, 2005). According to E.P. Odum (2005) the biotic community and its surrounding environment function together as a ecological unit called as an "ecosystem".

Since we know that ecosystems are consist of many interacting abiotic and biotic components, these interactions must hold the key to what ecosystems can do. Functional ecology describes how components work in an ecosystem, containing how biotic parts respond to environmental changes and how energy and matter move through ecosystems. All natural ecosystems have a main structure and components and each components has a definite status to play in the functioning of the system. Each ecosystem functions through several energy transfer mechanisms and biogeochemical cycles. Both living and non-living parts of the system interact with each other through several functional aspects to comprise natural ecosystems. The functional aspects of ecosystems include the flow of energy and cycling of materials through structural components of the ecosystem (Şekercioğlu, 2010). According to Woodbury (1954), ecosystem is a complex in which animals, plants and habitat are regarded as one unit, the matter and energy of one passing in and out of the others.

3.1.1. Producers, Consumers and Decomposers

From nutrition point of view, the biotic components can be categorized as autotrophs or heterotrophs according to their food source. Life on land and in water is possible because of the existence of the autotrophs, photosynthetic organisms such as the alg and plants. These organisms require only inorganic nutrients and sunlight to produce organic nutrients for their own energy and for all the other organisms. They are called producers, therefore, form of the basis of the living world (Benerje et al., 2013; URL-1). Photosynthetic organisms possess chlorophyll and carry on photosynthesis in marine and freshwater habitats.

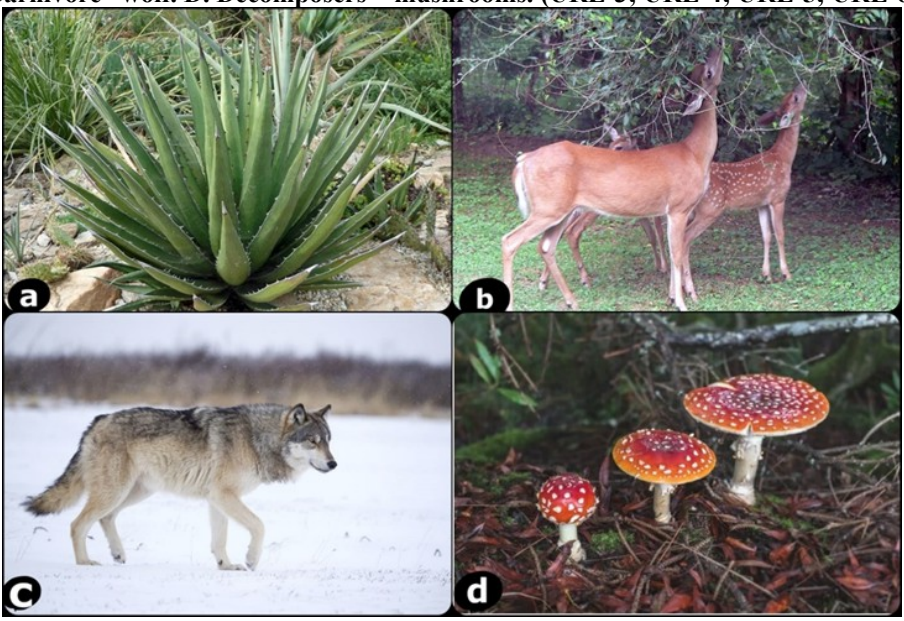
Another large group of organisms is the heterotrophs. They are called consumers because they get their energy that was generated by a producer. There are four types of consumers. Herbivores are animals that eat plants or algae. Carnivores feed on herbivores and sometimes other carnivores. Omnivores are animals that eat both plants and animals. Detrivores are plants and animals that feed on detritus, which consist of organic materials go back into the soil. Bacteria and fungi, including mushrooms, are decomposers. They obtain nutrients by breaking down complex organic matter found in plant and animal bodies. These substances are taken up by plants once again (Odum and Barret, 2005; URL-2)

3.1.2. Energy Flow in the Ecosystem

All ecosystems can not function without energy. In many ecosystems, sun is the only ultimate source of energy. Energy flows through on ecosystem via photosynthesis.

We know that, sunlight is first captured by plants and photosynthetic bacteria and store it in their tissues to make food from simple inorganic materials (Likens et al., 1987; Kooijman et al., 2010). As organic nutrients pass from one part of the ecosystem to another, such as when a carnivore eats an herbivore, only a portion of the original energy amount is transferred. Consequently, during cellular energy release, an important portion of the energy stored in organic molecules is lost as heat. Heat escaping from plants and animals can not be recaptured and reused by living organisms. All heterotrophs are dependent for their food on producers, either directly or indirectly. So there is unidirectional flow of energy from the sun to producers and then to consumers. The laws of thermodynamics support the concept that energy flows through on ecosystem. The first law expresses that energy can neither be created or nor destroyed (Bornman and Likens, 1967; Odum and Barret, 2005). This clarifies why ecosystems are depend on a constant supply of energy which is used by photosynthetic organisms to synthesise organic nutrients. The second law states that, energy is always being transformed from a more useful to a less available form such as heat (Odum and Barret, 2005). Under natural conditions, energy tends to flow higher level to the lower one.

Figure 1. Biotic components. a. Producer – green plant. b. Herbivore – deer. C. Carnivore –wolf. D. Decomposers – mushrooms. (URL-3; URL-4; URL-5; URL-6)



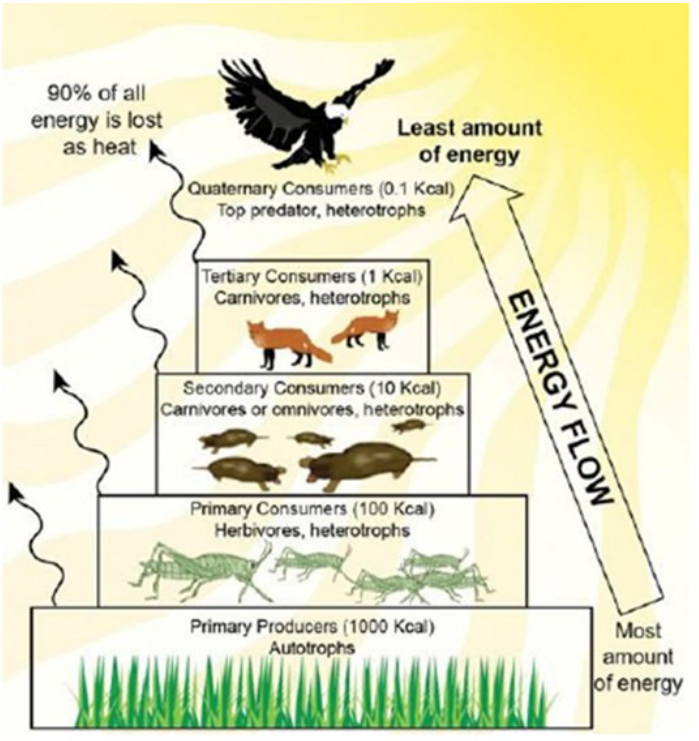
3.1.3. Food Chains

In an ecosystem, the sequential chain of feeding relationships, or who eats whom is called food chain. It determines how energy moves from one organism to another within the system. A trophic level is a level of energy (organic form – nutrient) in a food

chain. Flows of energy in a food chain, 80 to 90 percent of the energy transferred is lost as heat (second law of thermodynamics). The shortness of food chains can be attributed to the loss of energy between trophic levels. Generally, only about 10 % of the energy of one trophic level is available to the next trophic level. So, this also limits the number of levels in most terrestrial food chains (Barnes et al., 2018; Cebrian, 2015). Longer terrestrial food chains are rarebecause food chains generally do not have a large enoughproducer base to supportmany levels of consumers. Organisms are classified in a food chain according to their position or trophic level. Green plants – producers are the base of the grazer food chain and belong to the first trophic level. (primary consumers) and carnivores that feed on grazers are in the third trophic level, and so on.

The transfer of energy with large losses between sequential trophic levels is sometimes depicted as an "Ecological Pyramid". Energy transfer from one trophic level to the next generates a pyramid based on the number of the individual organisms or the amount of living matter and total dry weight at each trophic level. Ecological pyramids are used for comparing biomass and energy transfer between trophic levels (Bornman and Likens, 1967).

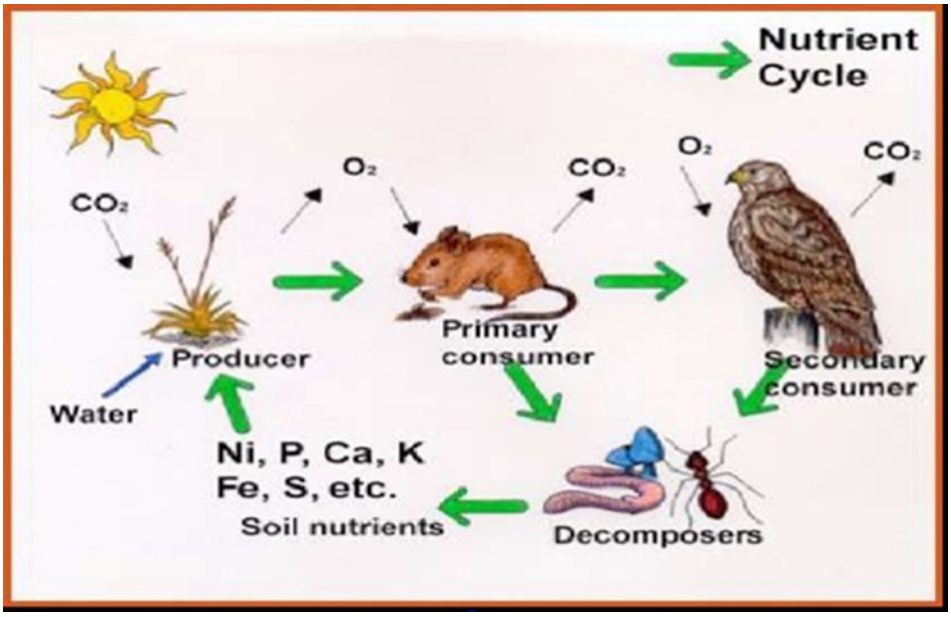
Figure 2. Energy flow through an ecosystem. (URL-7)



3.1.4. Nutrient Cycle in Ecosytem

The pathways of transfer of elements among living (biotic) and non-living (abiotic-geologic) components of the ecosystem known as “the element cycles” or “nutrient cycles”. It is the cycling of nutrients needed by living organisms, through different compartments of the biosphere (Kooijman, 2010). It involves movement of nutrient elements in an ecosystem. All ecosystem functions are related to the growth and reproduction of its biotic communities. These linked processes can be described as avariety of cycles. The maintainability of natural ecosystems depend on energy from sun and their reliance on the recycling of nutrients, which provides a constant supply of life’s essential ingredients.

Figure 3. Food chains are descriptions of who eats whom. (URL-7)

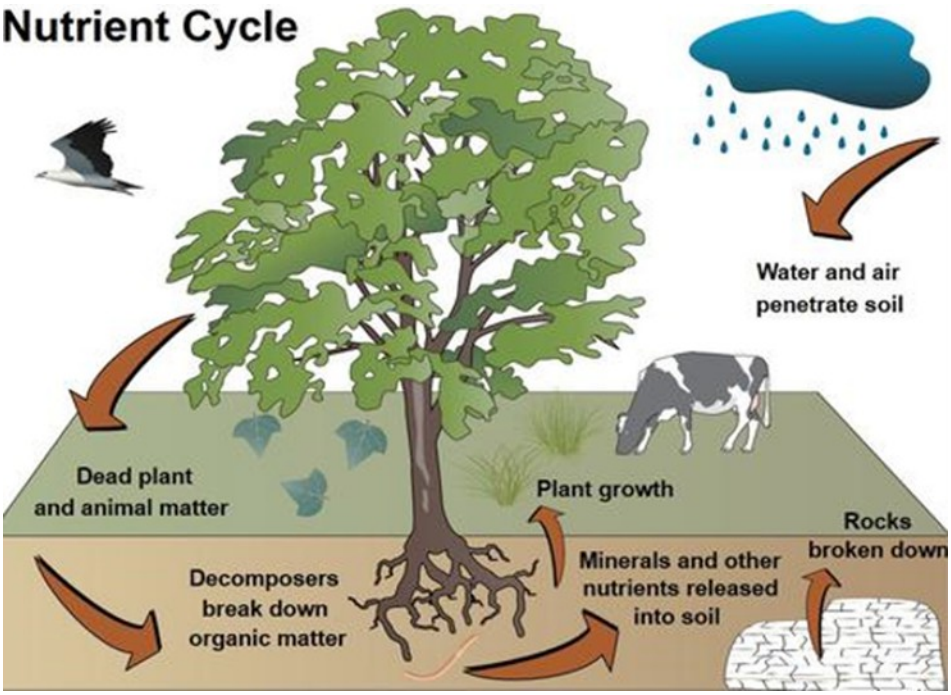


Nutrients comprise more than 40 elements known to be essential for a variety of life precesses of living organisms (Cebrian, 2015). Nutrients can be classified as macronutrients that required in large quantities, e.g., carbon, oxygen, hydrogen, nitrogen, etc. or micronutrients that required in small quatities e.g., iron, zinc, copper, iodine, etc.

In ecosystems, nutrient elements flow from the surrounding environment through food chains but are ultimately released back into the environment. Plants take up nutrients in the ionic form and animals obtain them in organic forms through consumption of living or dead organisms. Nutrients are in general used by microorganisms in any mineral or organic form. Exchange of nutrients between living organisms and their surrounding environment is one of the essential aspects of ecosystem.

A nutrient or biogeochemical cycle can be divided broadly into two types: a. sedimentary and b. gaseous. The carbon and nitrogen cycles are gaseous, meaning that the reservoir for this type of nutrient cycle exists in atmosphere. The sulphur and phosphorus cycle is a sedimentary cycle; the nutrients are taken from the soil by plants, passed to heterotrophs and ultimately returned to the soil by decomposers (Likens et al., 1981; URL-2)

Figure 4. Nutrients cycle between these components of ecosystems. (URL-9)



3.1.5. The Water Cycle

The water cycle describes the existence and movement of water on, in and above the earth. Water is always in movement and is always changing states, from liquid to vapour to ice and back again. Small fraction of Earth's water is available to living

organisms. Evaporation, precipitation and condensation are the basic processes in water cycle.

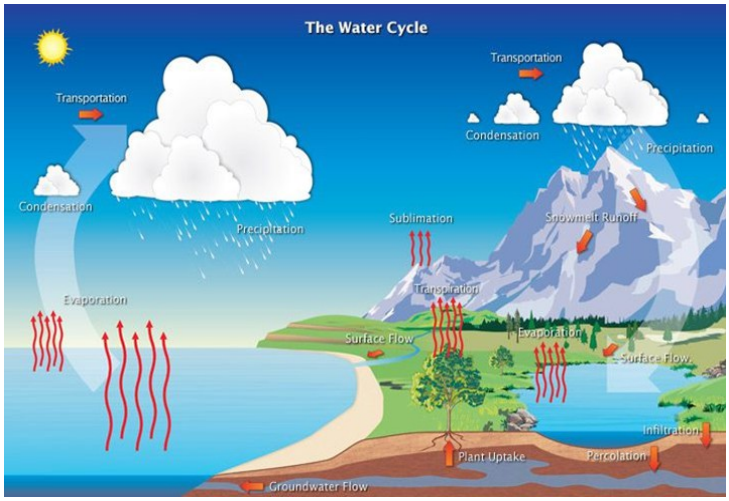
During the water cycle, freshwater is distilled from salt water through evaporation. In evaporation process, water changes from liquid to a gas or vapour state. Next, condensation occurs. Condensation is the process in which a gas in the air is converted into liquid water. Condensation is responsible for the formation of clouds, cools and falls as rain over the oceans and the land (Bets, 2010). Precipitation is the primery connection in the water cycle that provides for the delivery of atmospheric water to the Earth. Some of the water from precipitation (e.g., rain, snow) infiltrates into the subsurface soil and rock. An amount of infiltrated water depends on a ground cover or soil type (Bets, 2010).

3.1.6. The Carbon Cycle

Carbon is one of the main substances that make up living tissues. Life is an event dependent on the existence of large organic molecules. Large molecules also contain carbon in their structure. There can be no life without carbon. The natural source of carbon dioxide in the rock is volcanoes. However, over millions of years, a balance has been established between the new carbon that has come into play and the carbon that has been deactivated as limestone and fossil fuel. The carbon dioxide in the atmosphere and the carbon dioxide in the water are in equilibrium.

The movement of carbon between living organisms and environment is called the carbon cycle. Carbon is inevitable part of carbohydrates, fats, proteins and other biomolecules that necessary for all living things. In the environmental carbon cycle, carbon dioxide has two sinks: The atmosphere and the surface water. Atmospheric carbon dioxide (CO_2) is taken up from the air by plants and other photosynthetic organisms. The carbon dioxide (CO_2) is converted into nutrients by photosynthesis that are used along the food chain. When organisms respire, carbon is reentered to the atmosphere as carbon dioxide (CO_2). All organic substances produced are not immediately converted to carbon dioxide as a result of respiration and decomposition. The organic matter produced by the plants was buried without decomposition during geological times, and coal and lignite, and oil from the plankton in the seas remained buried.

Figure 5. The water cycle (URL-10)

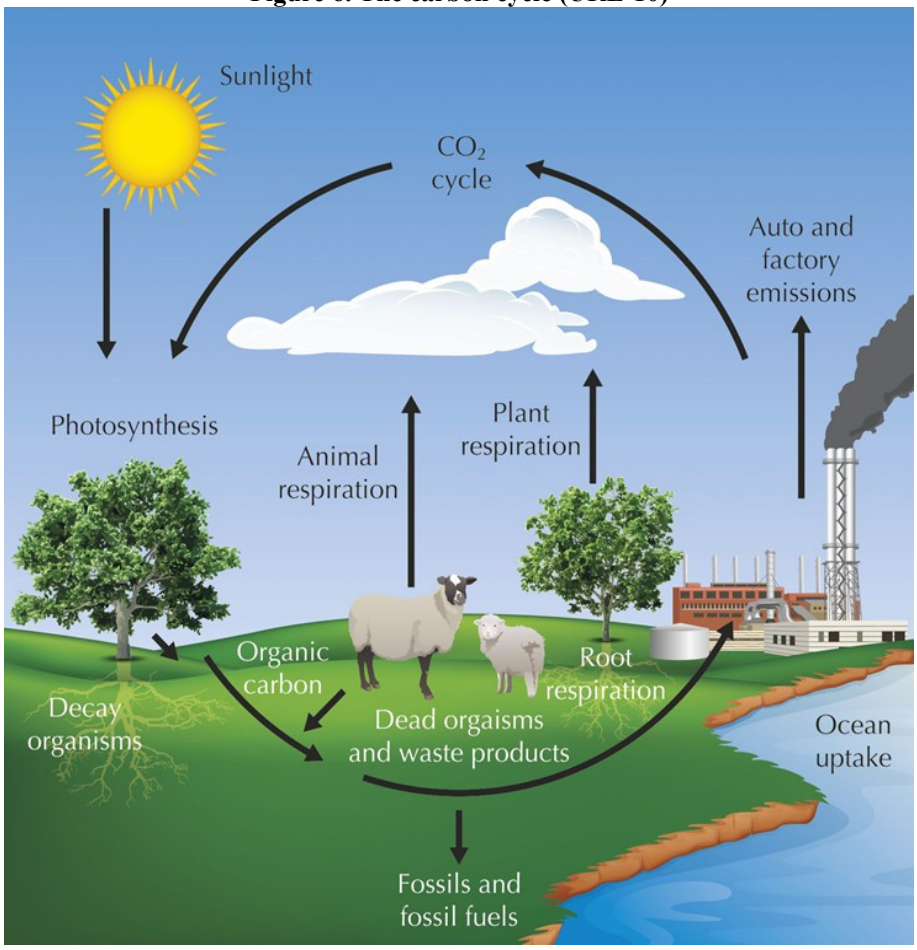


In aquatic ecosystems, atmospheric CO_2 dissolves into water to produce the bicarbonate ion (HCO_3^-), which can be obtained and fixed by algae and bacteria which are the base of the aquatic food web.

Both plants and animals return fixed carbon to the soil in the waste they excreate. When they die they return their carbon to the environment. These processes complete the carbon cycle. Generally, decomposition of organisms returns carbon dioxide (CO_2) to the atmosphere (Kooijman, 2010; Woodmansee, 1990).

Some carbon lies deep in the earths as cool, oil, natural gas, the materials we call "fossil fuels". Fossil fuel is product of complete or partial decomposition of plant animal remains as a result of exposure to heat and pressure in the earth's crust over millions of years. When these fuels are exracted and burnt, they releases carbon dioxide (CO2) and carbon monoxide gas into the air.

Figure 6. The carbon cycle (URL-10)



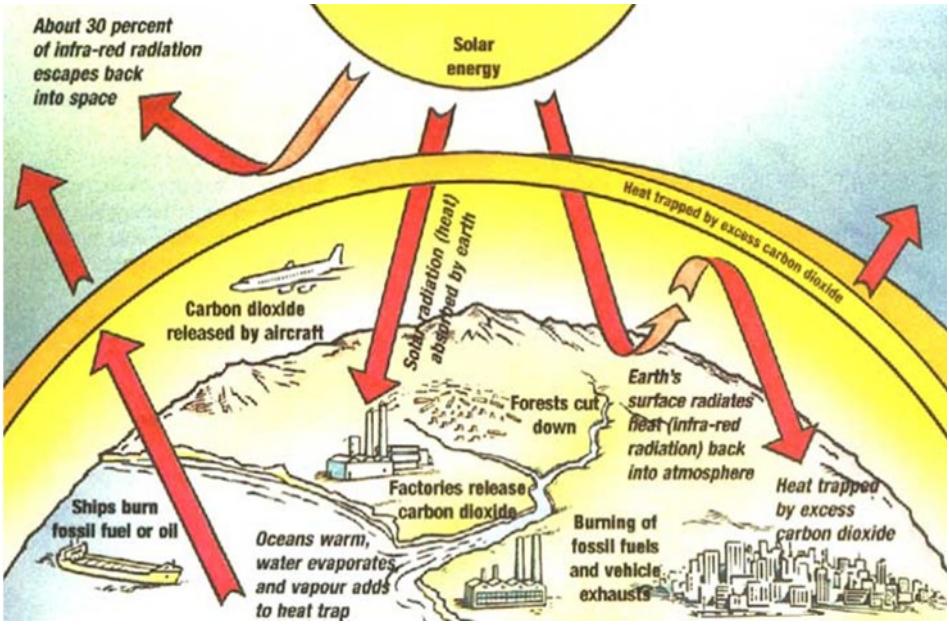
3.1.6.1. Global Warming

Man, the most active in the ecosphere among all living things, is on the way to change the ecological cycles as well as many aspects of nature. For example: Extracting fossil fuels from where they are buried and using it, destroying the natural vegetation of the earth, significantly affects the carbon balance in the ecosphere. Since the industrial revolution, the carbon dioxide produced by humans using fossil fuels intensively has already changed the natural balance of the carbon cycle in the ecosystem.

In the past 100 years, global atmospheric carbon dioxide (CO2) levels have increased by around 30 %. Increase in carbon dioxide (CO2) levels in the atmosphere is resulting from deterioration in the carbon cycle, mostly attributed to fossil fuel burning and several human activities. This has increased greenhouse ability of earth's atmosphere and cause the earth to get hotter. This fact is referred to as "Global

Warming" (Kooijman, 2010). The climate chage requires deep cuts in emissions, as well as the use of alternatives to fossil fuels worldwide.

Figure 7. How to greenhouse effect works (URL-11)



3.1.7. Nitrogen Cycle

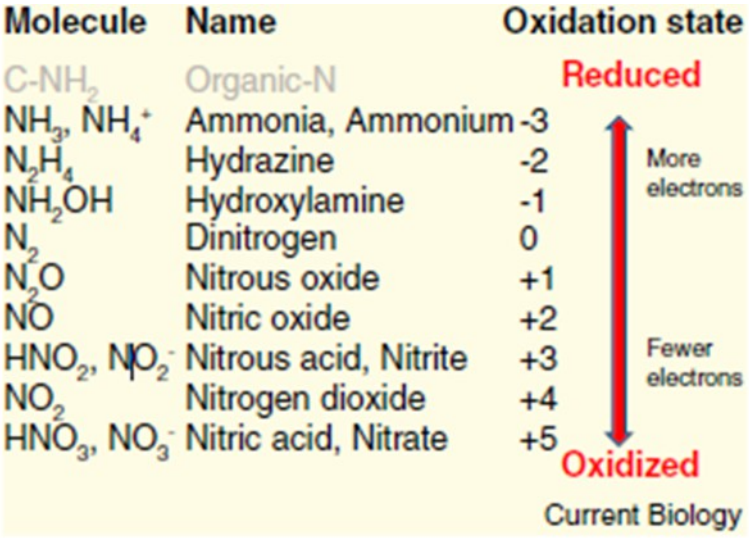
Nitrogen, the most abundant element in the atmosphere, is essential to life. Apart from proteins that are the basis of the living body, it is found in the structure of nucleic acids, various hormones and vitamins that serve as heredity.

Nitrogen gas (N_2) makes up 78 % of the atmosphere but it can not be absorbed directly by plants without undergoing a transformation. This nitrogen moves through both biotic and abiotic parts of ecosystem. It is mainly cycling through biological processes. This process is called "Nitrogen Cycle" (Stein and Klotz, 2016).

The basis of the nitrogen cycle is the transformation of free nitrogen in the air into inorganic salts and then into organic molecules containing nitrogen in living things; It also forms the conversion of organic molecules into inorganic salts by breaking down

through biological decomposition. In soils with less nitrate salts, vegetative production will be that much lower. In terms of human societies, nitrogen deficiency in the environment means protein deficiency, namely nutrition and hunger problems. For this reason, it is of great importance to convert the nitrogen gas in the air into chemical form that plants can use both naturally and artificially.

Figure 8. Nitrogene cycle intermediates. (Stein and Klotz, 2016)



There are four major biologic transformation steps in nitrogen cycle: nitrogen fixation, ammonification, nitrification and denitrification (Markov, 2012).

a. **Nitrogen fixation:** Nitrogen fixation occurs when particular bacteria convert the nitrogen gas (N2) to ammonium (NH3) which the plants can use. This process converts nitrogen gas (N2) into form that plants can absorb through their root systems. Some bacteria (Rhizobium) have a sumbiotic relationship with certain legume plants, other bacteria live freely in soils or water such as Cyanobacteria or Azotobacter.

b. **Nitrification:** Nitrification is the process of nitrates during the nitrogen cycle. Nitrate is a valuable nitrogen source for plants. Nitrification can ocur in a two-step process: ammonium ion is converted by Nitrosomonos into nitrite first ($NH4+ + O2 \rightarrow NO2 + H2O + H+$) and then NO2- is converted to NO3- (nitrate). Plants absorb NH4 and NO3- from the soil and utilise these ions to bring out proteins and nucleic acids.

c. **Ammonification:** In this process, decomposer bacteria convert the nitrogen-rich waste compounds into simpler ones.

d. **Denitrification:** The conversion of nitrate back into nitrogen gas such as N2O, NO and N2 which are released to the atmosphere, we call “Denitrification”. Denitrification has a negative effect on agriculture as it results in an overall loss of nitrogen from soils.

Various measurements show that the nitrogen cycle in nature is a fairly regular, balanced cycle. The main losses in this cycle are; the accumulation of nitrates transported to the seas by groundwater and rivers in the bottom sediments occurs when they exit the cycle. However, it is thought that the nitrogen gases added to the air by volcano eruptions are in amounts to compensate this loss.

Humankind affects the nitrogen cycle as well as all cycles. The most important effect of humans on the nitrogen cycle is through the detection of nitrogen in the air for fertilizer production by human hands. The conversion of nitrogen into fertilizer through industry has reached significant levels today. In order to feed the increasing population, the use of inorganic fertilizers in the world is increasing every year. Nitrogenous fertilizers account for more than half of all fertilizer consumption. Artificial determination of nitrogen is a very energy-intensive process. This energy is provided by fossil fuels. Therefore, another environmental effect of the determination of nitrogen as a fertilizer is seen in the use of fossil fuels.

Apart from fertilizers used in agriculture, sewage water, residues from various nitrogenous chemical industries increase the amount of nitrates and other nitrogenous chemicals in lakes, rivers and coastal sea waters. This together with phosphates contributes to the eutrophication event. Another effect of humans on the nitrogen cycle is through nitric oxides (NO) from fossil fuels used in industry and vehicles. Nitric oxides are the main gases that contribute to the air pollution of large cities.

3.1.8. Phosphorus Cycle

Phosphorus is one of the basic substances necessary for living things like nitrogen. Nucleic acids in cells, ATP, which provides energy transfer, in the structure of the cell membrane; It is also found in teeth and bones. Phosphate rocks in the earth's crust are the main reservoir of phosphorus in nature and the second largest reservoir is water. The basis of the phosphorus cycle is the transport of phosphorus from the land to the sea and from the seas to the land.

The phosphorus cycle is the biogeochemical cycle which phosphorus transport and chemical transformation through the lithosphere, hydrosphere and biosphere. The phosphorus cycle is a slow process which involves phosphorus (P) transformation steps: Weathering and precipitation, mineralization and immobilization and adsorption and desorption (Eckert and Nishri, 2014; Flippelli, 2009).

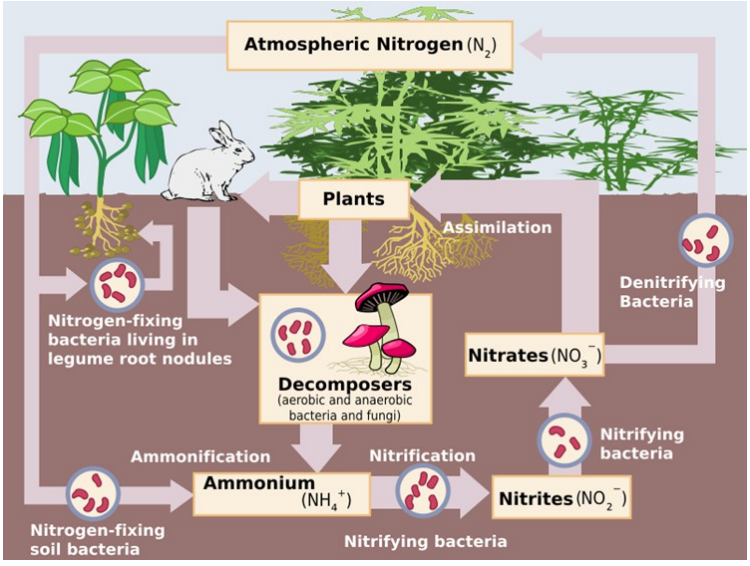
Some of the phosphorus in the phosphate rocks in the earth's crust becomes dissolved in water by erosion. This inorganic phosphate is taken up by plants mostly in the form of orthophosphate dissolved in water. It is passed on to herbivorous and carnivorous animals through feeding. Organic phosphates in plant residues, animal cadavers and secretions are converted into inorganic form by decomposing

microorganisms. Thus, it can be used by plants again. The part of phosphorus in living reserves is quite small compared to rock and water reservoirs.

Most of the phosphorus remains in oceanic sediment moves on to land due to a geologic uplift. On land, phosphorus is liberated from the rocks by weathering and then phosphate ions in the soil where plants are able to absorb phosphorus and grow. In addition to plants, animals eat plants and drink water and incorporate some of the phosphate into their body. However when plants and animals die and the decomposition animal wastes results in the return of phosphate ions back to producers via the water or soil.

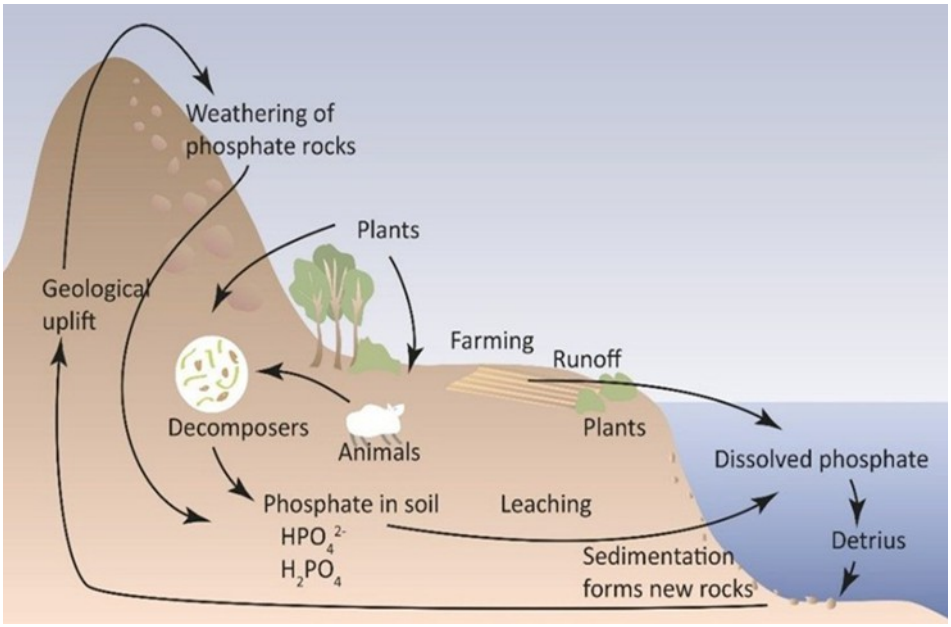
Various weather conditions such as rain and erosion help to wash some phosphate found in rocks into aquatic ecosystems where become trapped in sediments. Phosphorus found in oceanic sediments does not become available to plants on land (Eckert and Nishri, 2014). The shallow sea sediments return to the land again with the formation of mountains as a result of the geological movements of the earth's crust over a period of millions of years. Thus, phosphorus is recycled.

Figure 9. The Nitrogen Cycle (URL 10)



The effect of humans on the natural phosphorus cycle has been to further accelerate the flow of phosphorus from land to sea, which is already fast. Since the beginning of the 20th century, phosphate rocks have been widely used for use as fertilizers. These phosphate fertilizers added to the soil, just like nitrogenous fertilizers, do not stay in the soil for a long time. A significant part of it flows into the seas with underground and surface waters. New phosphate deposits are constantly being processed to compensate for the phosphate loss from the soil.

Figure 10. Phosphorus cycle (URL-12)



3.1.9. Sulphur Cycle

Sulfur is also one of the chemicals necessary for life. It is found in the structure of some amino acids found in all living things. Since it is found in abundant quantities in litosphere, it is generally not considered one of the limiting substances. Therefore, its importance is mostly in terms of air pollution (Kooijman et al., 2010). The main natural sources of sulfur are sulphurous compounds such as hydrogen sulfide gas from volcanoes and swamps. These compounds rise to the surface of the litosphere as a result of geological erosion; with the formation of sedimentary rocks in the seas, they return to the rock.

The sulfur in the sulfur compounds that rise to the surface of the stone sphere reacts with the oxygen in the air and takes the form of sulfur dioxide (SO2), sulfur trioxide (SO3) and finally sulfuric acid (H2SO4) when it comes into contact with water vapor. Sulfur in the air generally returns to the soil in this form, namely sulfuric acid, by rains and enters the cycle. In oxygen-free systems, sulfur is exchanged between two groups of bacteria in different chemical forms (Benerje et al., 2013. Sulfur bacteria use the oxygen in sulfated substances to convert them into hydrogen sulfide. Some bacteria also use H2S gas as an energy source. These bacteria are called “chemosynthetic bacteria”.

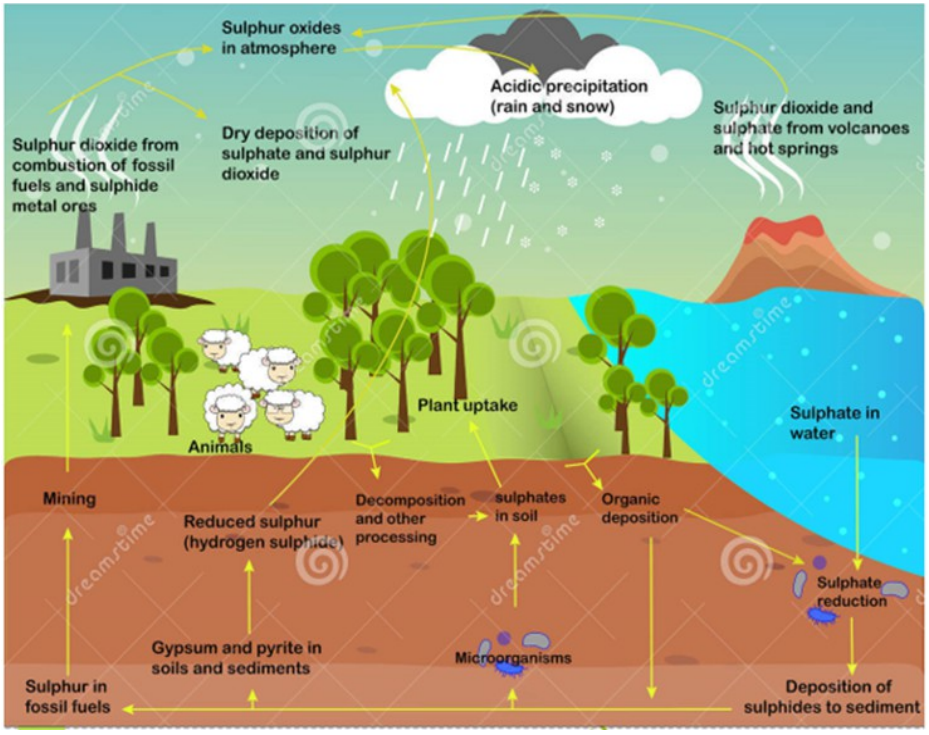
Industrialization has had a great impact on the sulfur balance in the last two centuries. Fossil fuel use and mining have greatly increased the amount of H2SO4 in the

atmosphere. Therefore, sulfur has become one of the main substances causing air pollution.

3.1.9.1. Asit Rain Problem

Rainwater is normally slightly acidic. The reason for this is the acids formed by the reaction of naturally occurring CO2 and naturally small amounts of sulfur and nitrogen oxides with water. In regions where a large amount of sulfur dioxide is added to the environment, the acid rate in rain water also increases. One of the main reasons for the emergence of acid rain as an international problem is the widespread practice of high chimney construction to purify the air of cities from SO2 in the 1960s. These chimneys, some of which are up to 300 meters in length, protected the settlements from SO2, but this time, SO2 emitted into the atmosphere began to rain down on large areas as acid.

Figure 11. Sulphur Cycle (URL-13)



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QUESTIONS

True / False Questions

1) (T / F) Primary consumers always make up the first trophic level in a food web.

2) (T / F) Ecological pyramids show the relative amount of energy or matter contained within each trophic level in a given food web.

3) (T / F) On average, about 50 percent of the energy available within one trophic level is transferred to the next trophic level.

4) (T / F) The more levels that exist between a producer and a given consumer, the larger the percentage of the original energy from producers is available to that consumer.

5) (T / F) Many animals are part of more than one food chain in an ecosystem because they eat or are eaten by several organisms.

6) (T / F) Decomposition describes the breakdown of organic wastes and dead organisms.

7) (T / F) Heterotrophic organisms cannot make their own nutrients, which is why they have to obtain them from the environment.

8) (T / F) Heterotrophic organisms can make their own nutrients.

9) (T / F) Inorganic matter does not come from living things and does not have carbon as its basic element.

10) (T / F) The community of organisms living in the forest depends upon each other and interacts with each other in a number of ways.

Multiple Choice Questions

11) What shows the many feeding relationships that are possible in an ecosystem?

a) Food web

b) Trophic level

c) Food cycle

d) Food chain

12) What is the process by which plants use sunlight to make sugar molecules?

a) Cellular respiration

b) Food chain

c) Photosynthesis

d) Carbon cycle

13) The movement of phosphorus from the environment to organisms and then back to the environment?

a) Water cycle

b) Phosphorus cycle

c) Carbon cycle

d) Nitrogen Cycle

14) Consumers who get their food by breaking down dead organisms?

a) Tertiary consumers

b) Secondary consumers

c) Primary consumers

d) Decomposers

15) Organisms that can fix atmospheric nitrogen into chemical compounds?

a) Pioneer species

b) Nitrogen fixing bacteria

c) Carbon bacteria

d) Primary species

16) Which of the following describes the process of biodegradation??

a) Plants using photosynthesis to create

b) Primary consumers eating plants

c) Omnivores eating plants and animals

d) Bacteria breaking down organic matter

17) In a food chain, primary producers are usually?

a) Amphibians

b) Bacteria

c) Mammals

d) Plants

18) In a food pyramid, how much energy is lost from trophic level to trophic level?

a) 20 %

b) 50 %

c) 70 %

d) 90 %

19) What product of photosynthesis supplies energy for life forms?

a) Carbohydrates

b) Carbon dioxide

c) Oxygen

d) Water

20) What is the original source of energy for nearly all living organisms on earth?.

a) Soil

b) Sun

c) Water

d) Plants

Correct answers: See annex "Answers"!

CHAPTER 4

Ecosystem Services

Gamze YÜCEL IŞILDAR & A. Çağlan GÜNAL

The foods we eat, the air we breathe, the water we drink and the climate that makes our planet habitable all come from nature.

Yet, these are exceptional times in which nature is sending us a message. Nature is showing that we are on the verge of a breakdown. It's time to wake up. To take notice. To reimagine our relationship with nature.

UNEP, World Environment Day, 2020

In spite of increasing public awareness and understanding the importance of the contribution of healthy ecosystems to human well-being in recent years; the degradation of ecosystems and loss of biodiversity still continue on a large scale. While people demanding more from the nature and overuse natural resources, destruction of ecosystems are increasing rapidly. In fact, ecosystems with high productivity are the guarantee of human safety with the services they provide. Healthy ecosystems are able to reduce risks and vulnerability where as poorly managed ecosystems may cause flood, decrease in crop quality, emergence of diseases like Covid 19 (Liu, 2005). Despite of this fact, knowledge of how ecosystems function, what are the types of ecosystems are, and how to manage them on a sustainable basis is lacking.

Mc Bride and Baldauf (2011) analyzed more than 1,000 ecologists and other environmental scientists on the 'nature of ecological literacy' and 'how it may be achieved'. Results of this study indicated that, "ecosystem services (ES)" is one of the six common dimensions showing participants' views for ecological literacy. ES framework allows the integration of multiple value realms; ecological, social, cultural and economic values, thus acknowledging the complexity of social-ecological systems in decision making (Martín-López et al, 2014). These values attributed to ecosystems, will affect people's relations with ecosystems, their demands/preferences and how to interfere/benefit from ecosystem services. Improved knowledge to realize ecosystems and their benefits in terms of ecosystem services enriched with socio-ecological sytem approach will provide better perceptions and more sustainable ecosystem valuation and management. The value might be expressed in many different ways; ethically, economically, esthetically or other qualitative criteria. It is important to reveal mutual

relationship with direct and indirect impacts, links between ecosystems and human wellbeing. Understanding the importance of the impacts of external pressures on ecosystems is a prerequisite for protection and conservation. People should understand the importance, necessity and value of ecosystem services so that they understand why they need to protect ecosystems and determine their priorities when deciding on land use or other similar projects in the balance of protection and use accordingly.

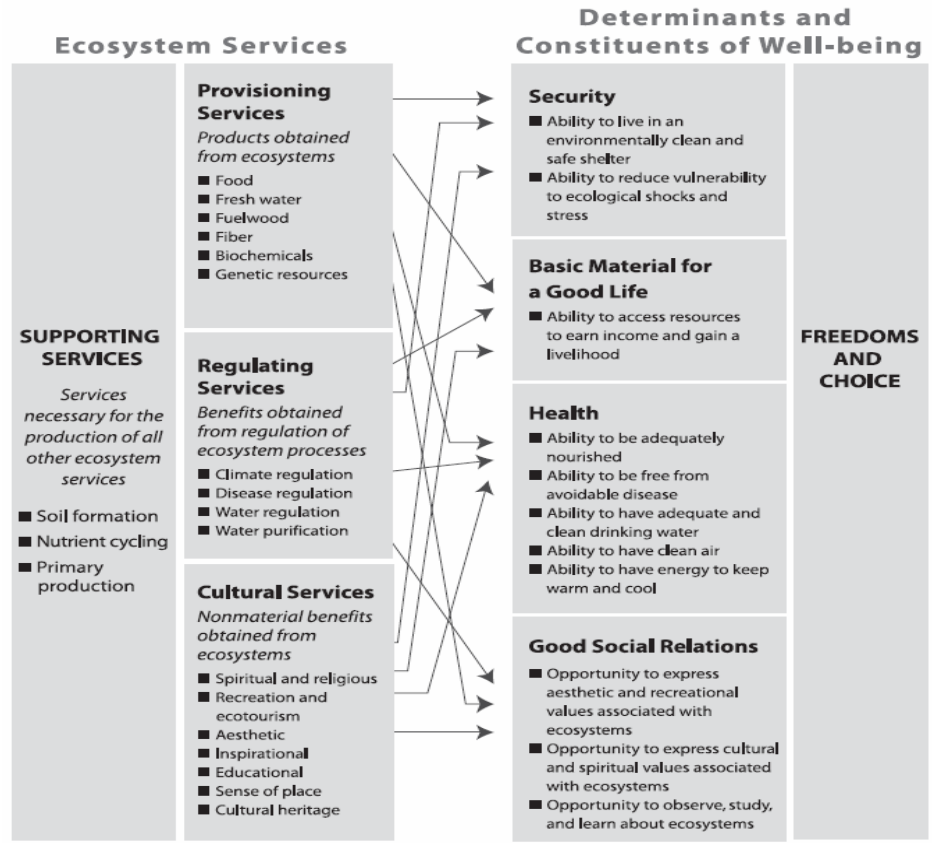
Along this line, the overall objective of this chapter is to improve the knowledge of **"ecosystem services"** (ES), their benefits and values to become **"ecoliterate citizens**". To achieve this aim, following questions will be explained in this chapter.

1) The interactions between different components of ecosystems and how they functions in relation to with each other and the role of biodiversity in terms of ES
2) Typology of ES common to EU
3) Anthropogenic impacts on ecosystems
4) Anthropogenic impacts on provision of ES
5) Impacts of spatial and temporal differences on demand from ES
6) Mapping and integrated assessment of ES for objective valuation
7) How to manage sustainably ES and biodiversity; effectiveness of "ecosystem service concept" in policy development.

4.1. Understanding Ecosystem Services

The '*ecosystem service'* is relatively new concept. Simply, ecosystem services are the direct and indirect contributions of ecosystems to human well-being (TEEB 2010). As explained in detail in Chapter 3, **e**cosystems are communities formed by the interaction between living (plants, animals, microbes) and non-living organisms (air, water, mineral soil). The structure and processes of the ecosystems underpin the capacity of an ecosystem to provide goods and services. These services include *provisioning services* such as clean water, food, raw materials; *regulating services* such as prevention and reduction of environmental risks such as flooding and erosion, carbon sequestration, biological control, pollination, etc. *habitat servic*es and *cultural services* such recreation, inspiration for culture and art, science and education.(Haines-Young, R. and M. Potschin, 2010). Ecosystem services and their links to human well-being are summarized in Figure 1.

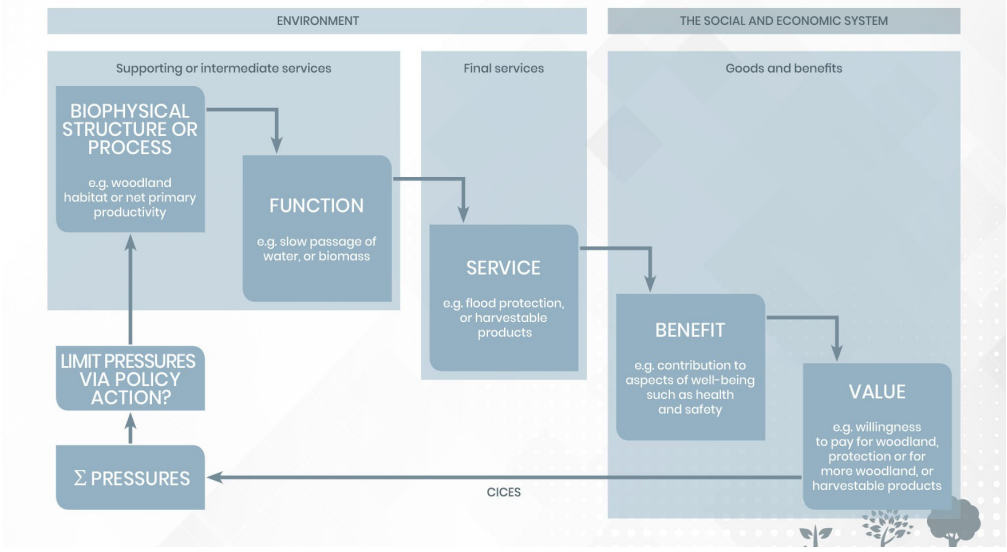
Figure 1. Ecosystem services and their links to human well-being



Source: Liu, 2005

To make the links between ecosystems and human wellbeing more clear and for better understanding of the relations, a theoretical model has been developed by Potschin and Haines-Young (2016); Burkhard and Maes (2018) to identify *intermediate* or *supporting* ecosystem services, *final* ecosystem services and goods and benefits. Ecosystem services are thought as an interface between human and nature. This model is described as "the pathway of causal interrelations between ecosystem at one end and the human well-being at another" (Fig. 2). The differences between endpoints and the steps between are aimed to be cleared more in this model.

Figure 2. The cascade model



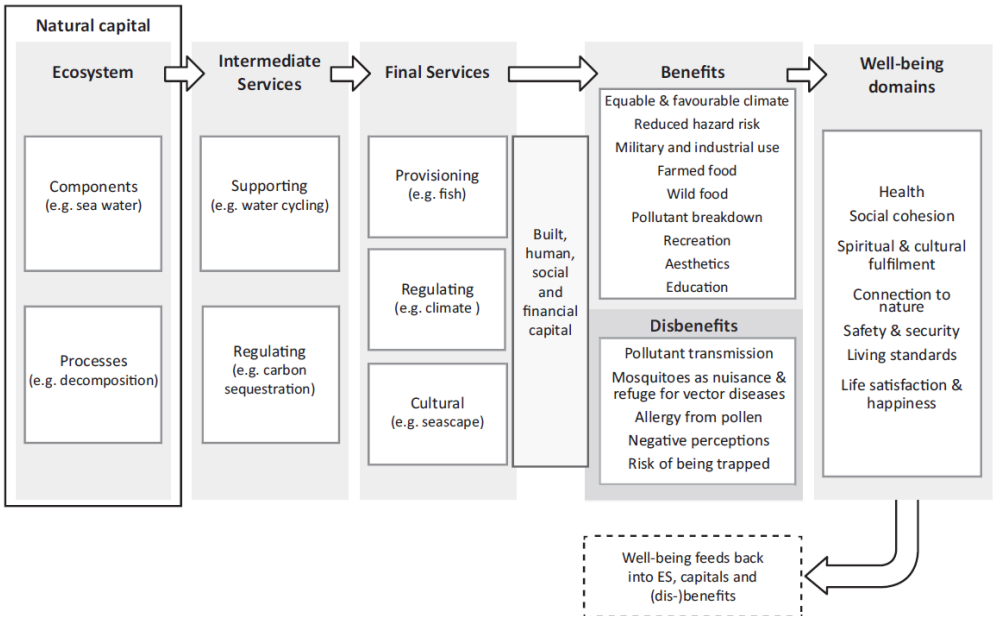
Source: Potschin and Haines-Young, 2016

The "ecosystem" given in this model is characterized by its biophysical structures and processes. Habitat type such as woodland, wetland, grassland etc. are meant by **biophysical structure**, similarly, dynamics and interactions forming the ecological system are meant by **processes** (e.g. primary production). The characteristics of the ecosystem that builds its capacity to deliver an ecosystem service is defined as **ecosystem functions**, in the cascade model. Those elements and features, which determines the ecosystem capacity to deliver services, are sometimes called'supporting' or 'intermediate' services. Directly contributing services to human well-being; what we actually can harvest (e.g. hey, timber) or gain from ecosystem (e.g. flood protection, beautiful landscape etc.) are 'final' ecosystem services as well as health and safety. (Kasparinskis, et al, 2018)

Cascade model might be criticised because of 'lacking links', especially not including disbenefits of ecosystem services to complete the picture. Along this line, Rendon et al. (2019) reported that, "The clarification of the linkages between ecosystem services and human well-being will provide holistic and informed decision-making through incorporating all relevant stakeholders especially health and social services; direct and indirect drivers of change. They proposed a framework that builds on the UK

National Ecosystem Assessment by accounting for the concept of *disbenefits* in addition to benefits and linking the classification of benefits and disbenefits to their effect on seven human well-being domains (Figure 3). This framework is beneficial to describe inter-dependencies between services and disbenefits, and also describe trade-offs* (explained at the end of chapter) with specific impact on human well-being at a various ratios and for different components.

Figure 3: Conceptual framework with disbenefit



Source: Rendon et al, 2019

Additionally, before finalization of this seciton, we should remember that, humans have reshaped ecosystems as never before. Therefore, to summarize human impacts on ecosystems will be beneficial to see the big picture (Table 1) before classificaiton of the ecosystem services.

Table 1. Pressures and indicators for ecosystem condition assessment

Pressures	Indicators for ecosystem condition assessment
Climate change	Changes in temperature, humidity, precipitation, fires, extreme events, droughts, floods, storms, sea (surface) temperature, sea level rise
Habitat change	Land take / sealing, land cover change, land abandonment, fragmentation, dams, river regulation.
Invasive alien species	Emergence or expansion of invasive alien species, diseases
Land/sea use or exploitation	Intensification, erosion, (over-) harvesting, deforestation, water extraction, degradation / desertification (over-) fishing, aquaculture, mining, irrigation
Pollution and nutrient enrichment	Air pollution, soil contamination, water quaity, fertiliser and pesticides application, acid deposition

Source: EU, 2016, Technical Report

4.2. Classification for Ecosystem Services

Measurement of the benefits and assessment of the ES is highly important. Additionally, what will be measured should be known precisely according to common typology of the ES. Several classifications are used for ecosystem services depending on different criteria such as ecosystem types and scale such as forests, marine areas, wetlands, etc; service flow such as cascade model; type of benefit (private or public) and values (intrinsic or enstrumental).

According to the European Commission Report (2016), there are 3 international classifications (MEA, TEEB and CICES) for ecosystem services. All three classifications include resources, regulatory and cultural services. It was stated by Haines-Young and Potschin (2018) "consistency is also needed when ES are to be defined and categorised; the revised version 5.1 of the Common International Classification of Ecosystem Services (CICES) provides clear guidance. Because it categorise ecosystem services using a five-level hierarchy, with each level being progressively more detailed and specific". Therefore, CICES built on the existing classifications (MA, TEEB) but focuses on the ecosystem service dimension will be given here. In the CICES system services are either provided by living organisms (biota) or by a combination of living organisms and abiotic processes.

Tables 2 and 3 summarizes CICES (V5.1) for biotic and abiotic ecosystem services respectively for upper three levels in the classification.

Table 2. CICES (V5.1) for biotic ecosystem services

BIOTIC ecosystem outputs		
Section	**Division**	**Group**
Provisioning (Biotic)	Biomass	Cultivated terrestrial plants for nutrition, materials or energy
Provisioning (Biotic)	Biomass	Cultivated aquatic plants for nutrition, materials or energy
Provisioning (Biotic)	Biomass	Reared animals for nutrition, materials or energy
Provisioning (Biotic)	Biomass	Reared aquatic animals for nutrition, materials or energy
Provisioning (Biotic)	Biomass	Wild plants (terrestrial and aquatic) for nutrition, materials or energy
Provisioning (Biotic)	Biomass	Wild animals (terrestrial and aquatic) for nutrition, materials or energy
Provisioning (Biotic)	Genetic material from all biota (including seed, spore or gamete production)	Genetic material from plants, algae or fungi
Provisioning (Biotic)	Genetic material from all biota (including seed, spore or gamete production)	Genetic material from animals
Provisioning (Biotic)	Other types of provisioning service from biotic sources	Other
Provisioning (Abiotic)	Water	Surface water used for nutrition, materials or energy
Provisioning (Abiotic)	Water	Ground water for used for nutrition, materials or energy
Provisioning (Abiotic)	Water	Other aqueous ecosystem outputs
Regulation & Maintenance (Biotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of wastes or toxic substances of anthropogenic origin by living processes
Regulation & Maintenance (Biotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of nuisances of anthropogenic origin
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Pest and disease control
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Regulation of soil quality
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Water conditions
Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Atmospheric composition and conditions
Regulation & Maintenance (Biotic)	Other types of regulation and maintenance service by living processes	Other
Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Physical and experiential interactions with natural environment
Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment
Cultural (Biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with natural environment
Cultural (Biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Other biotic characteristics that have a non-use value
Cultural (Biotic)	Other characteristics of living systems that have cultural significance	Other

Table 3. CICES (V5.1) for abiotic ecosystem services

ABIOTIC ecosystem outputs		
Section	**Division**	**Group**
Provisioning (Abiotic)	Water	Surface water used for nutrition, materials or energy
Provisioning (Abiotic)	Water	Ground water for used for nutrition, materials or energy
Provisioning (Abiotic)	Water	Other aqueous ecosystem outputs
Provisioning (Abiotic)	Non-aqueous natural abiotic ecosystem outputs	Mineral substances used for nutrition, materials or energy
Provisioning (Abiotic)	Non-aqueous natural abiotic ecosystem outputs	Non-mineral substances or ecosystem properties used for nutrition, materials or energy
Provisioning (Abiotic)	Non-aqueous natural abiotic ecosystem outputs	Other mineral or non-mineral substances or ecosystem properties used for nutrition, materials or energy
Regulation & Maintenance (Abiotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of waste, toxics and other nuisances by non-living processes
Regulation & Maintenance (Abiotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of nuisances of anthropogenic origin
Regulation & Maintenance (Abiotic)	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events
Regulation & Maintenance (Abiotic)	Regulation of physical, chemical, biological conditions	Maintenance of physical, chemical, abiotic conditions
Regulation & Maintenance (Abiotic)	Other type of regulation and maintenance service by abiotic processes	Other
Cultural (Abiotic)	Direct, in-situ and outdoor interactions with natural physical systems that depend on presence in the environmental setting	Physical and experiential interactions with natural abiotic components of the environment
Cultural (Abiotic)	Direct, in-situ and outdoor interactions with natural physical systems that depend on presence in the environmental setting	Intellectual and representative interactions with abiotic components of the natural environment
Cultural (Abiotic)	Indirect, remote, often indoor interactions with physical systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with the abiotic components of the natural environment
Cultural (Abiotic)	Indirect, remote, often indoor interactions with physical systems that do not require presence in the environmental setting	Other abiotic characteristics that have a non-use value
Cultural (Abiotic)	Other abiotic characteristics of nature that have cultural significance	Other

4.3. Ecosystem Services Mapping and Assessment

In spite of increasing evidence of the many benefits of 'nature's to people', especially for climate change mitigaiton and adaptation measures; ecosystem degradation and loss of biodiversity still continue on a large scale. Anthropocentric activities are the major cause of loss in biodiversity and modified wildlife at an unprecedented rate. (see Chapter 2). The Millenium Assessment found that more than 60% of ecosystem services are being degraded or transformed in a way that endangering future human well-being (De Groot, et al, 2018). Therefore it is increasingly becoming important to analyse and quantify the linkages between human activities and ecosystem services for better understanding of the potential implications of ecosystem changes thruough standardised, transparent, and eventually certified way. *Mapping* ecosystem services helps people to understand the full spectrum of ways in which the natural environment contributes to people's well being. Similarly, *ecosystem services assessment* is essential to make informed decisions for rational use and management of natural resources. In turn, this information will improve the environmental analysis and

review process and help avoid, minimize, and mitigate possible anthropogenic impacts. Appropriate and objective ES assessment is the most effective way and useful form of evaluation to provide development towards sustainable social-ecological systems.

In this respect, after the adoption of the EU Biodiversity Strategy 2020, ES mapping and assessment have gained priority on the agenda of all EU countries. The strategy intends to prevent the loss of biodiversity and destruction of ecosystem services and improving them as far as feasible in the EU by 2020.

Thus, to know where and how, for example, food, water, clean air, other materials and recreation are provided and how climate, nutrients, natural disasters, pests and diseases are regulated, appropriate methods, information and data are needed. Santos-Martín (2019) mentioned that; "information and data on actual ES demands, beneficiaries and potential mismatches with their supply location as well as ES quality and quantity are essential to make informed decisions for appropriate management of natural resources".

To this aim, a broad array of guidelines- over 80 tools- have been developed and applied to map and assess ecosystem services in line with Action 5 of the EU Biodiversity Strategy. Common main structure required to guide ecosystem assessment are;

(i) Mapping of ecosystems; Only if the ecosystem services are mapped and their spatial distribution is known, we will be able to understand this complex system

(ii) Describing the state of the ecosystem;

(iii) Quantification of the ecosystem services;

(iv) Gathering all these into an integrated ecosystem assessment. (Burkhard et al, 2018)

Although all these guidelines have common structure, it is not easy to decide which tool is the most appropriate to be used for which assessment step and under which circumstances. Harmonising the wide range of methods for mapping and assessing ecosystem services (ES) has been accepted as an important step in providing quantitative and comprehensive information on the status and trends of ecosystems and their services. (Vihervaara et al, 2019). The factors that could be taken into account in order to find the most suitable methodology among existing ES mapping and assessment approaches are related to the details of analyses needed, the purpose of the study and data and resources availability.

Mainly, three major dimensions of ES mapping and assessment could be classified as; biophysical, economic and socio-cultural dimensions. Biophysical units are used to quantify, in particular, the measurement of ecosystem structures, processes, functions and service flows like quantities of water abstracted from a lake, area of forest or stocks of carbon in the soil in **biophysical methods**. Hydrological and ecological models, production functions based on the analysis of structural and functional traits of ecosystems, or on biophysical modelling are used in this method. **Economic quantification** of ES attempts to measure the human welfare derived from the use or consumption of ES. ES values are expresses in terms of monetary units (e.g., market prices, replacement cost, hedonic pricing). Burkhard and Maes (2017) stated that, "economic quantification or valuation is one way to assess and communicate the

importance of ES to decision-makers and can be used in combination with other forms of information". Although ES assessments mostly focused on ecological and economic valuations until recently, as Pascual et al. stated (2017), "**socio-cultural dimension** has strongly gained in importance over the past 5 years, since value pluralism was again emphasised as an important goal in ecosystem service assessments". Socio-cultural dimension of ES assessment aims to identify values attributed by humanbeings to nature; intrinsic, extrinsic or instrumental values that is particularly suitable for capturing perceptions assigned by people to ES. It helps to increase our understanding of how important ES are to people (Walz *et al.* 2019). There may not be certain distinction between social pereference and monetary values assessments, methods to investigate social preference can be used to assign monetary values. In this situaiton experts from different disciplinary backgrounds take part and use variety of methods from different disciplinary backgrounds for ES assessments.

However, any evaluation of ES requires an integrated analysis, taking into account biophysical, socio-cultural and economic value dimensions together. That means, not only integration of various biophysical components, but also methods to map and assess social and economic values for different ES. Integrated modelling frameworks will be beneficial for end-users in ES assessment and enable decision-makers to assess quantified trade-offs associated with alternative management choices and to identify areas where investment in natural capital can enhance human development and conservation.

Along this line; integrated methodology of ES mapping and assessment will be discussed in this chapter. The MAES (initiative on Mapping and Assessment of Ecosystems and their Services) conceptual model that is central to the EU Biodiversity Strategy to 2020, based on the provision of ES, will be explained as an example to integrated assessment model.

European Commission's MAES approach provides a nine-steps including the identification of related questions or problems to be defined, characterization and mapping of ecosystem types, current situation of ecosystem and ecosystem services, their integration and dissemination of results.

The operational framework for integrated MAES approach is composed of nine consecutive steps as given in Figure 4.

Step 1: Question and identification of problem;

Step 2: Identification of ecosystem types;

Step 3: Mapping of ecosystem types;

Step 4: Characterisation of ecosystems and ES provided by ecosystems;

Step 5: Selecting indicators for ecosystem condition and ES;

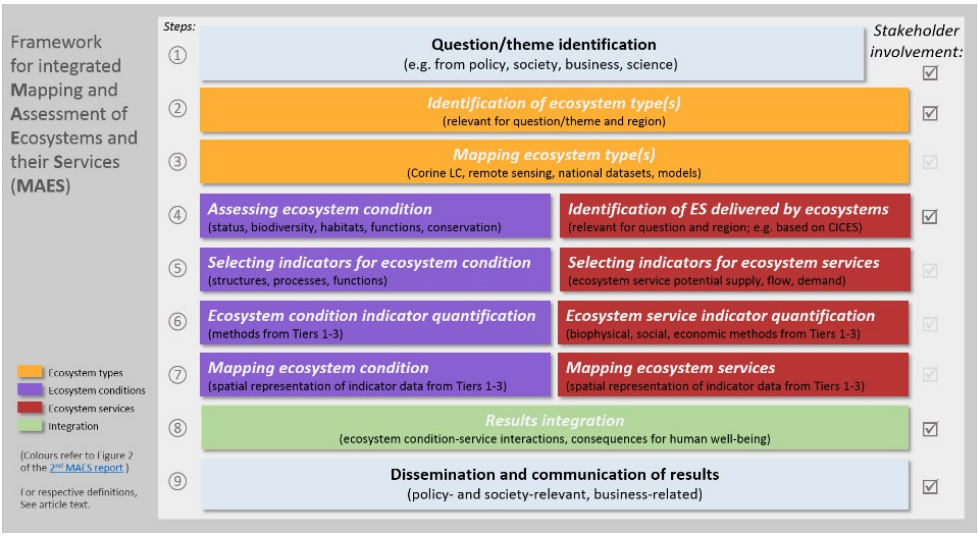
Step 6: State of ecosystems and ES indicator measurements;

Step 7: Mapping current state of ecosystems and ES;

Step 8: Integration of the results;

Step 9: Communicaiton and announcement of results.

Figure 4. Framework for integrated Mapping and Assessment of Ecosystems and their Services



Source: MAES

The presented framework provides a linear step-wise structure that facilitates the development of respective studies, starting from relevant questions to be answered and leading to the communication of integrated results. ES are truly transdisciplinary field of research and application and the involvement of stakeholders is mandatory if the assessment is to be successful. As authors (Burkhard et al, 2018) mentioned, "this method provides an easy-to-comprehend and applicable multitiered approach, considering different ES quantification and mapping methods (biophysical, social-cultural and economic) that can be applied according to specific needs, data and resources availability".

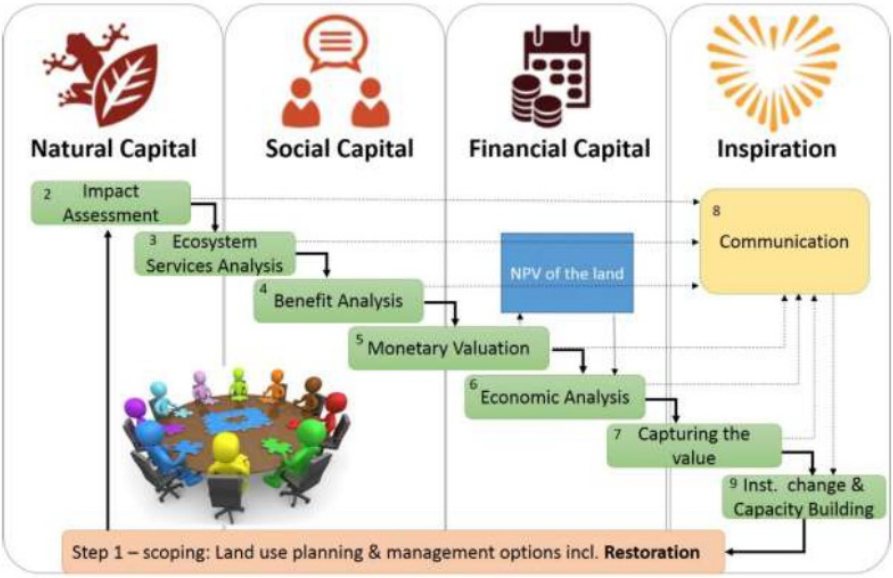
Since such a linear approach may not cover all aspects such as interrelations and feedbacks in complex social-ecological systems; another conceptual ecosystem assessment framework aimed at delivering a 'flexible methodology' to assist MAES, will be introduced in this chapter too. The distinctive character of this framework is to provide a flexible approach in terms of its application so that users can select, and integrate, only those activities most appropriate to their needs. The framework can provide guidance to practitioners as to the distinct elements and/or activities they will integrate, depending on their needs.

As can ce seen from Figue 5, the green box proposes different types of inter-relations among parts of the ecosystem assessment that are beneficial for specialists.

This will enable the characterisation of trade-offs, synergies and consequences for human well-being. Specialists can use the framework to identify where they need to integrate different elements. This 'flexible methodology' could be used to choose and apply convenient combinations of methods for ES mapping and evaluation under spesific conditions (e.g.time requirement, experience, specialization, avaiability of data, scale) and for specific contexts and purposes. By using such a framework, experts are supported to think through which activities are required to address the policy-relevant questions and to identify where integration will take place, ultimately leading to an assessment that meets the needs of policy-makers.

Brown et al. (2018) said that "it's essential when designing an ecosystem assessment to think about how and where the concepts of integration are going to be considered to deal with policy-relevant questions. While assessment processes aren't well documented or evaluated, anecdotal evidence suggests that integration through the governance structure (inclusion of stakeholders), combining of various data sources and therefore the use of appropriate tools allows for greater impact of the ecosystem assessment within decision-making".

Figure 5. The Integrated Ecosystem Service Assessment Framework



This method also figure out and includes the benefits of landscape restoration, nature conservation and sustainable land use. It contributes the understanding integrated direct and indirect effects on human wellbeing.

The framework consist of 9 steps as briefly explained below:

1) Scoping: Before starting an assessment, the scope, context and purpose of the assessment should be made clear, in close consultation with the most relevant stakeholders, to avoid collecting unnecessary data or forgetting important aspects.

2) Impact Assessment: This step involves assessing the direct impacts (positive and negative) of restoration, or other intervention in the landscape, on ecosystem structure and processes as well as the secondary effects in terms of changes in the functioning of the landscape (i.e. the (carrying) capacity of the landscape to provide services) compared to the baseline (e.g. loss of vegetation leading to erosion and loss of productive capacity).

3) Ecosystem Services analysis: Effect of restoration or other intervention on changes in actual, and potential, use of specific ecosystem services.

4) Benefit analysis: Changes in ES as analysed in Step 3 will have effect (positive or negative) on health, livelihood, cultural identity, and other wellbeing (social & human-capital) indicators (e.g. jobs, education, security, social-cohesion). In this step these benefits are quantified in non-monetary terms.

5) Monetary valuation: Once the effects of land use change (e.g. restoration) on ecosystem services (step 3) and benefits (step 4) are understood and preferably quantified, monetary effects could be analysed by tusing direct market values, indirect market values and non-market values to determine changes in Total Economic Value of the bundle of ES provided by the restoration activities.

6) Economic analysis: This step investigates the implications of ecosystem restoration for the local/regional/national economy in terms of economic indicators, e.g. employment, increased tax revenues, corporate profits, return to investors, etc. Also the change (usually increase) in value (NPV) of the land (see step 5) should be part of the economic analysis.

7) Capturing the value: Based on step 5 and 6, which together provide information on the return of financial capital, incentives (financial or otherwise) can be developed to invest in ecosystem restoration and/or sustainable management.

8) Communicating the value (and benefits) to generate awareness and support ('inspiration') for the measures needed to implement the incentives, communication activities can be employed after any of the steps (e.g. simply providing information on the return of ecosystem services (step 3) and their benefits (step 4) might be enough to move to step 9 (changing institutions and behaviour) without having to go through the more complicated and time-consuming efforts to calculate monetary (step 5) and economic (step 6) effects.

9) Capacity building and institutional change: To ensure implementation of the outcome of the assessment in long term policy, institutional and management changes at relevant scale levels (eg. ranging from local capacity building programs to national policies and institutions) are needed.

For a comprehensive assessment of the effects of restoration (or other interventions in the landscape) ideally all 9 steps should be included. Depending on the situation (available data, time and funding) and required level of detail this can be done in just a few months or may take several years (especially if it includes long-term

monitoring and establishing societal change). It should also be noted that there is some overlap between steps, and in practice some steps can, and should be performed simultaneously. Also, not all assessments will be able (or require) to perform all steps in the same detail depending on the aim and context of the assessment (De Groot et al, 2018).

Finally, it could be concluded that, above integrated and flexible ecological-economic and systems perspective to ecosystem services assessment is important to investigate the interplay between ecological and socio-economic systems. This will allow a deeper and all-inclusive understanding of the contribution of the ecosystems and the costs due to their uses.

Although ES mapping methods and technologies are improved, there are several challenges for map producers and map users because of complexity of the process and how to transfer mapping info into policies. Paloma et al (2018) classify seven mapping bottlenecks faced by the experts as:

i) interaction between map-maker and map-user;

ii) codification and ontologies;

iii) qualified personnel;

iv) data availability and map availability

v) selection of appropriate method;

vi) technical inadeqaucies;

vii) under estimation of mapping process/output

Humans are the inseperable part of web life which is complex, interconnected system. Each component plays an important role in this system. Even a small change or removal of any component, the entire system is affected, and this can produce positive or negative consequences.

4.4. The Role of "Ecosystem Service Concept" in Environmental Policy Development

Since ecosystem services represent integrated holistic view on human-nature relationships; deserves to be acknowledged as important framework for policy and decision making. ES have the potential to become a major tool for policy and decision making on global, national, regional and local scales. Results of the ES mapping and assessment might be leading documents for policy development in several areas; from sustainable management of natural resources, environmental protection and nature conservation, land use planning, climate protection, disaster risk reduction to environmental training and research activities. The ES concept can serve as a communication tool to engage the science–policy–society interface (Díaz et al. 2015, Everard 2015, Bull et al. 2016).

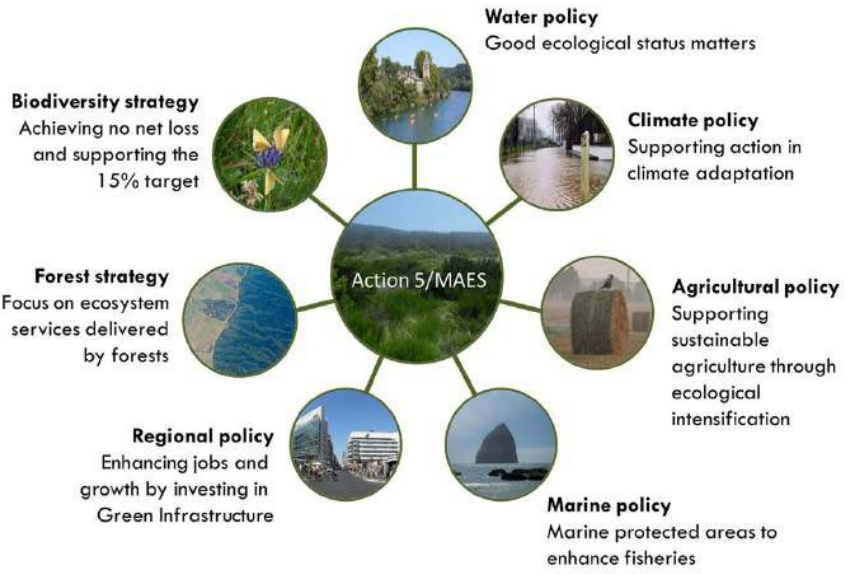
ES have potential to address conflicts, dilemmas and synergies between environmental, economic and social objectives. Such integrative approach requires

systematic thinking and understanding of the complex relations and feedback mechanisms in social-ecological systems for providing integrated measures (Liu et al., 2015).

As Maes et al. (2012) stated “policy makers have realised that ecosystem services or nature based solutions (e.g. using wetlands for water purification or flood prevention) might be more cost efficient than technical infrastructures”. Moreover, as Fürst et al. (2017) mentioned “ES concept can provide a comprehensive framework for trade-off analysis, addressing compromises between competing land uses and help to facilitate planning and development decisions across sectors, scales and administrative boundaries”.

Figure 6 indicates clearly; policy areas that can be benefited from ES and their assessment are not only biodiversity objectives as stated in Action 5 of the EU Biodiversity Strategy 2020, but also other environmental policies, including climate change, sustainable agriculture, water, marine, forestry as well as regional policies.

Figure 6. Applying of the EU Biodiversity Strategy 2020 Action 5 outputs in different policy sectors



Source: Maes et al., 2014

Ecosystem service mapping and assessment results can contribute to environmental policy in relation to assessment of risks and impacts to ecosystem and/or human health from different human activities as well as planning various mitigation or management measures.

4.5. Ecosystem Services for Pandemies

Biodiversity plays very important role and crucial for the sustainability of ES. The emergence of COVID-19 has accentuate with the loss of biodiversity, and the destruction of the system that supports human life. The more rich in biodiversity means, the more difficult for pathogens to spread out. Adversely, loss in biodiversity increase opportunity for zoonotic disesases; pathogens to pass between animals and people.

Anthropogenic impacts, including deforestation, extensive agriculture, encroachment on wildlife habitats, and climate change, have destroyed the sensitive balance of the ecosystems. As humanbeings, we increased our pressure on the ecosystems that serve us several benefits mentioned at the beginning of this chapter and have created conditions in wihich particular pathogens–including coronaviruses to spread. Zoonotic account for seventy-five percent of all emerging infectious diseases.

This can happen via various mechanisms as given by WWF, (2020)

- Increased breeding sites for disease vectors, such as irrigation channels and dams where mosquitoes proliferate
- Increased spread of host species
- Keeping wild species captive in close contact with each other, and with domestic animals
- Transfer of pathogens between different species
- Loss of predatory species
- Human-induced genetic changes in disease vectors or pathogens (such as the resistance of mosquitoes to pesticides or the use of drugs in intensive livestock farming leading to the appearance of bacteria resistant to antibiotics)
- Environmental contamination by infectious disease agents .

To prevent future outbreaks, threats to ecosystems and wildlife, including habitat loss, pollution and climate change should be taken into account. Because, change in land-use patterns especially deforestation and the alteration of natural habitats, are responsible for almost half of the zoonatic disesaes emerged.

COVID-19 allowed us to review our relationship with nature and warn us to adapt for new green deal and more environmentally responsible planet. Emergence of zoonotic diseasse is caused by impact of human activities. As the World population reaches to 9 billion, better understanding of the web of life in which we live and appreciate that it functions as a whole system is a must. After reviewing our relationship with nature, we must keep it at the forefront in decision making.

Useful Definitions

Specific concepts to examine how different ecosystem services are interconnected are:

Trade-offs are commonly defined as an increase in one ecosystem service resulting in a reduction in another. For example, felling a forest to cultivate crops contributes to and increases food provision but reduces other benefits coming from the forest's existence, such as carbon storage, air quality and flood regulation. Thus it is common to say that one ecosystem service is 'traded off' against others.

Synergies are a good example of ecosystem service interconnections. They occur where increases in one ecosystem service are coupled with increases in another. This happens in several situations, e.g. when the regulating service pollination contributes to increasing the provisioning service crop production. Another example is the synergy between soil erosion control and crop production. Usually erosion results in a loss of the more fertile soil, reducing yields. The control and mitigation of erosion phenomena means maintaining soil productivity and thus ensuring a better supply of crops (provision). Measures to prevent soil erosion might address additional synergies when, for example, they involve planting or protecting vegetation along river banks, which can in turn boost water purification (regulating) and might create a pleasant landscape for tourism (cultural).

An **ecosystem service bundle, or cluster,** is defined as a "set of ecosystem services that repeatedly occur together across space or time". A simple example is given by forests which provide timber (provision) carbon sequestration (regulation) and the possibility of pursuing outdoor activities (cultural). It will be interesting to find out how many ecosystem service bundles are present in the Alps.

So, understanding trade-offs and synergies among ecosystem services is the paramount aspect of decision making in territorial development and environmental management, in order to reduce the damaging effects of focusing on a few services at the expense of others.

Useful links:

https://www.es-partnership.org/

https://www.unenvironment.org/news-and-stories/video/how-nature-can-protect-us-pandemics

https://biodiversity.europa.eu/maes

https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=4900#PD

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QUESTIONS

True /False Questions

1) (T / F) The ecological valuation can NOT be expressed in terms of ethical values.

2) (T / F) Projected climate change threatens aquatic biodiversity and ecosystem services, partly by contributing to sea level rise.

3) (T / F) Both direct and indirect contributions of ecosystems to human well-being are considered as 'ecosystem services'.

4) (T / F)
Ecosystem services are products that humans provide for the ecosystems.

5) (T / F) Ecosystem services values can be expressed in terms of monetary units.

6) (T / F) After the adoption of the EU Biodiversity Strategy 2020, ecosystem services mapping and assessment have gained priority on the agenda of all EU countries.

7) (T / F) Evaluation of ecosystem services takes into account biophysical, socio-cultural and economic value dimensions separately.

8) (T / F) Trade-offs are commonly defined as an increase in one ecosystem service resulting in a reduction in another.

9) (T / F) Interaction between map-maker and map-user is one of the bottlenecks faced during mapping of ecosystem services.

10) (T / F) Inclusion of stakeholders are NOT essential when designing an ecosystem assessment.

Multiple Choice Questions

11) Food, genetic resources, and fuelwood are examples of:

a) Regulating services

b) Supporting services

c) Cultural services

d) Provisioning services

12) Recreation and ecotourism; sense of place are examples of:

a) Cultural services

b) Provisioning services

c) Supporting services

d) Regulating services

13) Examples of ecosystem services include:

a) Aesthetic beauty

b) Pollination of crops

c) Cycling of nutrients

d) All of the above

14) Which of the followings is NOT included in the “cascade model” of ecosystem services?

a) Biophysical structure

b) Benefits

c) Disbenefits

d)Function

15) Which of the followings is one of the disbenefits of ecosystem services?

a) Pollutant breakdown

b) Pollutant transmission

c) Allergy from pollen

d) All of the above

16) Which of the following is an example of how the service of an ecosystem might be compromised or threatened?

a) A river is polluted by the waste products of a nearby chemical plant

b) A wetland is drained to create farm land

c) A forest is cut down to provide lumber for housing

d) All of the above

17) Which of the followings in NOT true for ecosystem services assessment?

a) Necessary to make informed decisions for rational use

b) No need for certified assessment methods

c) Should be assessed in certified way

d) Should be assessed in transparent way

18) Which of the followings is NOT true for structuring guide for ecosystem assessment?

a) Mapping of ecosystems

b) Describing the state of the ecosystem

c) Quantification of the ecosystem services

d) Assess all of the above separately for ecosystem assessment

19) Socio-cultural dimension of ES assessment aims to:

a) Identify values attributed by human beings to nature

b) Measurement of ecosystem structures, processes

c) Capturing perceptions assigned by people to ecosystem services

d) Increasing understanding of how important ecosystem services are to people

20) How will increasing species diversity affect ecosystem services?

a) It increases the efficiency and productivity of an ecosystem

b) It increases only the efficiency and not productivity of an ecosystem

c) It do not increase the efficiency and productivity of an ecosystem

d) It only increase the productivity of an ecosystem

Correct answers: See annex "Answers"!

CHAPTER 5

Ecoliteracy

Anna KUJUMDZIEVA[8], Maya NUSTOROVA[9] & Trayana NEDEVA[10]

Introduction

In parallel with the formulation of the term ecoliteracy in ecology, another concept about ecoliteracy have emerged, with a definition that unquestionably differs from the traditional one. The idea of ecoliteracy as an approach that effects the formation of sustainable human communities and requires an essential reconstruction of the educational system, was introduced by Orr (1992). This idea is fundamental for his understandings for environmental/ecological literacy, and become quite popular during the mid-80s, along with the establishment of the World Commission on Environment and Development (WCED). This institution is formed in 1983 to make known the increasing concerns about the growing deterioration of the human and natural environment and its impact on economic and social development.

WCED (renamed the Brundtland Commission) issued a report, ”Our Common Future”, which was the first comprehensive survey on the Earth’s health, that described in details the responsibility for air pollution, desertification, and poverty. This report discussed as well the concept of sustainable development, formulating it as *“... development that meets the needs of the present without compromising the ability of future generations to meet their own needs”* (WCED, 1987). ”Our Common Future” report was used as a basis for Agenda 21,Chapter 36 that declared the responsibility to reorganize education within the vision for sustainable development (UNESCO, 1992). Consequently of these developments, UNESCO changed its International Environmental Education Program (1975-1995) to Educating for a Sustainable Future (UNESCO, 1997). Since the concept of sustainable development influenced and rearranged the environmental education process, the sustainable development itself was shaped as an educational field (i.e., education for sustainable development, ESD) (Bonnett, 2002; Gonzalez-Gaudiano, 2005; Stevenson, 2006).

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Five years after Orr's work on ecoliteracy, Capra (1997) imposed a new sense in the term ecoliteracy; defining it as an understanding of the principles of ecosystems organization and the application of those principles to create sustainable human communities and societies. (Cutter-Mackenzie & Smith, 2003). Namely the idea to use resources for the purpose of creation of sustainable human communities, demands and called for an essential reconstruction of the educational systems.

5.1. What is Ecoliteracy?

The term ecoliteracy represents understanding and internalization of sustainable ecological relationships in the nature and transfer of this sustainable lifestyle to daily life. This meaning is valid, although eco literacy does not have just one and unique definition.

The core subject of ecoliteracy is based on sustainability, which especially emphasizes that work and studies on sustainable development should design indicators and metrics in order to evaluate that ecoliteracy.

According to the literature review, there has not been found yet any ecoliteracy scale or alternative model. Therefore, there is a need for development of an ecoliteracy scale intended for use by adults, and to use this scale to test the alternative ecoliteracy model.

The basic elements in the alternative ecoliteracy model concept are focused on the common points of ecoliteracy: to have sustainable, affective, cognitive, behavioural roots. These roots refer to several subcomponents such as ecological intelligence, social intelligence, emotional intelligence, economy and green consumer behavior.

The designed ecoliteracy model that encompass these subcomponents according to the literature is shown in Figure 1. Following this model, economy, emotional and social intelligences are subcategories of ecological intelligence (1st stage of the model). Ecological intelligence on its turn is directly link to green consumer behaviors, at the 2nd stage of the model.

5.1.1. Ecological intelligence

Ecological intelligence is one of the main subsets of ecoliteracy. It is due to the fact that ecoliteracy concept is related to either holistic perspective or sustainability. The key mission of ecological intelligence is:

- ✓ To cultivate social and environmental responsibility and awareness
- ✓ To encourage critical thinking
- ✓ To follow cooperative learning
- ✓ To generate behavioral change in the long-term perspective.

Ecological intelligence is associated with those brain areas that are responsible for cognitive and affective reactions. Anatomically and physiologically, the both parts of learners' brains should be promoted.

Figure 1. Alternative model of eco literacy

1st Stage

2nd Stage

Legend: 1st stage: economy, emotional and social intelligences subcategories of ecological intelligence; 2nd stage - ecological intelligence link to green consumer behaviors.

Ecological intelligence respects the individual peculiarities. It does not overlook them, since individual experience influences the social community.

Another key feature of ecological intelligence is its holistic outlook, as there are many biotic and abiotic factors in the world to be minded. Therefore, each activity linked to consumption or not, can influence directly or indirectly the environment.

It is important people to be in charge for their concrete treatment of their environments and social communities. As the Individualism is characteristic for human capitalist society, humans (being social creatures) cannot isolate themselves from the social area because ecological intelligence is a social and collective process. In fact, the environmental asset is achieved through language communication and therefore environmentally responsible behavior also needs to involve responsible social and economic play.

5.1.2. Social intelligence

Social intelligence is the second key subset of ecoliteracy. Social intelligence pertains to social responsibilities of people regarding sustainability. For example, people have to suppose how a matter is produced or whether there is any environmental or social/human use in this production process.

To make better the social intelligence is a difficult task because of the process of migration. This process has two parts: migrants and hosts (cities/countries). The migrants are cheap labour sources for hosts. That is why they are named 'brown revolution'. If a migrants' population is placed in an urban area, it causes massive stresses on urban life. This is valid, especially to Asia, Sub-Saharan Africa, Latin America (FAO, 2015).

Another problem is the adaptation of the rural population to urban social life. This is not an easy process, there is a gap between anticipation and reality in terms of social and economic lives.

Despite these considerations, the brown revolution cannot be ceased (Economist, 2002) because of economic reasons. A compromised decision is it to be slowed down on the one hand, and the governments to support the rural population life with internal and external policies, as recommended by FAO 2015 Report.

The Economist (2002) proposes to rename the reinforcement of the rural population as 'green revolution' because the ecologic development of the rural area is related to the economy (FAO Report, 2003).

5.1.3. Economy

The last but not least subpart of ecoliteracy is economy. McCallum (2005) and Orr (2002) stated that the Western science in historical plan has adverse effect in understanding the natural environment: ecology and economy are viewed as two different and independent themes. At the same time, they are complementing to each other due to the fact that economy needs environmental and human resources in order to continue its development. Therefore, the economy should be based on sustainable development rather than on the exploitation of environmental and human resources (as the brown revolution is).

Thus, people should be able to understand that all their needs that are satisfied by buying foods, clothes, shelters are dependable on natural resources. That is why, people have to think about and sense their own effects on the environment and the need for its prevention. Therefore, the sense of environment is envisaged as emotional intelligence.

5.1.4. Emotional intelligence

Emotional intelligence is also an important subpart of ecoliteracy. In fact, Goleman, Bennett and Barlow (2012) amalgamate ecological, social and emotional intelligences under the term ecoliteracy. In respect to the emotional intelligence, one should be able to sense the putative negative impacts of ones' actions on society, natural environment and the other living organisms.

McBride et al. (2013) have also accepted this kind of relationship among the ecologic, affective and cognitive elements, under the ecoliteracy hat, calling these elements "head, heart, hands and spirit" connections.

Emotional intelligence is linked to human feelings. It is the emotive part of ecoliteracy. People have sense and emotions but sometimes they cannot be able to understand or express them. Regarding the environment, if people feel this environment (pain, hurt, anxiety, fear, empathy, etc.), they are linked with it. The main questions are whether human activities perturb lives of other living things; what are their feelings and whether they have empathy.

It is pointed out that special attention has to be paid to adult people, who are not very open to change, explore and express their feelings like children; For this reason a specific measures for adults should be developed to deal with their social and consumption problems.

5.1.5. Green consumer behaviour

In general, adult people use to spend and consume more products then they really need to do. This tendency is directly related to the growing consumerism, (Aracıoglu & Tatlıdil, 2009; Esposito, 2009). It is necessary to minimize the overuse the natural resources linked with consumerism effect. Here, the concept for ecologically friendly production appeared which stresses on ecological items. Nevertheless, that ecologically based products are more expensive, the producers will market them if the consumers tend to buy products that are harmonized with Nature. In this way, the industrial production will not act harmfully to the nature. The needs to be considered here are collective action and public awareness on the use of ecological products. These needs will be of great importance. Thus, the collective action of green consumers makes reference to ecoliteracy due to the environmentally responsible or green consumer behavior that is the visible/observable side of ecoliteracy (Kapogianni, 2015; McBride et al., 2013).

Ecoliteracy summarizes the following four components:

- ✓ To get the idea of how the Earth functions in the viewpoint of the basic ecological concepts (i.e. ecosystems, energetics, population ecology, community ecology, material cycles).
- ✓ To understand how humans fit the planet ecology, including awareness with the human threats to ecological integrity (i.e. global warming, ozone depletion, habitat destruction).
- ✓ To find possible solutions for these human threats of the Earth's ecological systems.

The basis, on which these first three components of ecoliteracy are constructed, is outlined in the following fourth component.

- ✓ *To express empathy and connection with the nature. Empathy is defined by different authors in a different way, as a "sense of wonder" (Rachel Carson), "biophilia" (Harvard's E.O. Wilson), and "love, respect, and admiration for the land" (Aldo Leopold). The scientists and the thinkers share almost*

undoubtedly the opinion that the nowadays life of the human species on the planet is, in the big picture, not sustainable. Since the humankind lives on a planet with physical and resource limits, sustainable human activities must be practiced as an awareness and response to the said limits.

The pathway for creation of a sustainable human enterprise, both locally and globally, demands taking smart solutions about a wide range of environmental issues. Intelligent, informed decisions about land-use, growth, energy-use, open space, pollution, and many other issues require ecologically literate citizens.

5.2. Need of ecoliteracy

The need of ecoliteracy is grounded on our understanding of the ecosystems of our planet and the ways, in which humans can more efficiently and sustainably live within those systems. The decisions and choices that individuals, communities and policy makers are taking often involve quite complex scientific, economic, and social factors. Unfortunately, the dialogue and literacy level among citizens (at all levels of the society) are characterized by misinformation and a lack of critical questioning. An example for this reality that is advancing at high pace, is the book reading. The book reading among all youth and adults is progressively declining. At the same time, research has shown that reading ability at children age declines as well. Declining literacy among youth has been attributed to "alienation and disempowerment due to traditional curricula, pedagogical practices and culturally irrelevant texts" (Okur-Berberoglu, 2018).

Thus ecoliteracy can be taught as an integrated environmental discipline that is both age-appropriate and standards-based, designed to make people's environmental culture fitting the 21st Century social, economic and environmental requirements. Ecoliteracy fosters a perspective essential to sustainable living: that the natural world supports and limits human needs and achievements (Fig. 2).

Ecoliteracy is not only awareness towards shifting to systems thinking. It goes beyond and applies this principle to all interrelated subject matters in a smart interdisciplinary format. Systems thinking is essential to develop attitude that can help tutors guide trainees towards healthy and active environmental awareness. In particular, this is regarded to the development of 'Earthfulness' - an orientation of people towards interconnectedness with all Earth processes and systems, that will enhance the movement of the entire society towards healthy relationships with our environment.

Modern research approaches and facilities allow scientists to collect comprehensive information about the health of our planet. Information pool of nowadays is enormous. To improve people's ability to filter this information and understand the complex natural systems that are being affected by human activities, there has been a growing importance of improving ecoliteracy. Ecoliteracy alone is insufficient to facilitate the desired change in our attitude towards the environment. It is not an easy task, since climate change continues to accelerate and biodiversity crises continues to get worse. However, it offers valuable knowledge that might contribute to people's efforts towards sustainable life and society. It main pillars are as follows:

- ✓ Through ecoliteracy, youths and adults mature to understand nature and their place in nature.
- ✓ The ecoliteracy background fosters links between humans and nature, and encourages them to move beyond the fear to explore, learn, and act on the knowledge, adopted from ecoliteracy.
- ✓ The life is joint and cooperative and the samples and species web, communities, and systems hold each other.
- ✓ The life demands to be multifarious. Diversity means that we can change.
- ✓ All living and non-living things are linked and the life is about interrelation. Communities represent ecosystems. Species have intrinsic links with each other in a network, although sometimes this means that they eat each other. That is a relationship too.
- ✓ All thinks begin with the sun, which feeds the plants that keep life on Earth.
- ✓ The life matter cycles. Every piece of sand and drop of water has been here forever, and it will always be here, although in a different form.
- ✓ Ecosystems do not have waste, because they are always food for another organism. The rest matter from one kind has to be utilize from another!
- ✓ People need nature to live. They need clean air, water, and soil. They need plants and other animals to work with people.

Figure 2. Essential Ecoliteracy concept.

(*adapted according to Nichols, 2010*)

5.2.1. The way to build ecoliteracy

As it was already mentioned, the recent understanding of ecoliteracy is based on an innovate amalgamation of emotional, social, and ecological intelligence. These elements are treated in perspective of care and concern, for understanding of natural systems and put up cognitive skills with empathy for all of life.

By linking these elements of intelligence together, ecoliteracy sets up the successes due to diminishing behavioral problems in order to rise academic achievement to foster

social and emotional learning. In this way, it introduces the knowledge, empathy, and action in order to practice a sustainable living.

Therefore, to achieve and foster socially and emotionally engaged ecoliteracy, the following practices were introduced which, of course are not the only way to do so. However, when such practices are involved, a strong way to become ecoliterate is succeeded and healthier relationships with other people and communities appeared.

These practices can be summarized as follows:

1. Development of empathy for all forms of life

Generally, all living organisms, including humans possess common needs for their life and survival - food, water, space, and conditions that support the dynamic of living equilibrium.

Assuming these basic and common needs, which are shared between all organisms, a shift from the admitted central role of humans as superior creatures to a more authentic one – (the view of humans as members of the natural world) is taking place. Thus, an expansion of the empathy towards the quality of life of other life forms is accepted.

Most people exhibit care and compassion toward other living beings and it is one of the important indicators: human brain is able to feel. This capacity has to be cared by creating lessons that emphasize the important roles that plants and animals play in sustaining the web of life.

Empathy also can be cultivated using contacts with other living things, by maintaining live plants and animals at home, performing field trips to nature areas, zoos, botanical gardens, and animal rescue centers; as well as participation infield projects such as habitat restoration.

Another way to evolve empathy for other forms of life is by understanding indigenous cultures. The traditional societies are intimately connected to plants, animals, the land, and the cycles of life. This manner of daily living has helped these societies to survive throughout the years. Understanding the relationship with their surroundings could be helpful to learn how a society lives when it values other forms of life.

2. Adopt sustainability like a community practice

The living organisms cannot survive in isolation. In fact, the web of relations within any living community defines its collective ability to survive and thrive. Learning about the remarkable modes, by which plants, animals, and other living things are interlinked, inspire people to understand the role of intrinsic links within living communities. This gives idea about the value in amplifying those relationships by thinking and acting cooperatively.

The development of sustainability is a community practice, but contains some features that are outside of the common statements for community activity. In fact, community practices are essential to building ecoliteracy because they examine how the community supports itself - the daily praxis value the common favor.

Another approach is based on projects that gathered data about the sources of energy and the used amount and then formulate the asking, "*How might we change the way we use energy so that we are more resilient and reduce the negative impacts on people, other living beings, and the planet?"* Such projects can give users the option to start building a community that values the common good and versatility.

3. Make the invisible visible

From historical point of view, as well as for some cultures still in existence today, the pathway from the decision and its realization was short and clear. For example, a family possessing and working on land, can have soon experience with flooding, soil erosion, a lack of shade, and a vast reduction of biodiversity.

However, the strong development of the global economy makes people sightless and they cannot have experience for the damages of our actions. Due to the economical fast growth for instance, the use of fossil fuels was strongly increased, and, it has been difficult (and is still difficult for many people) to understand that they are damaging with their activity the magnitude of the Earth's climate. Nevertheless, some places on the planet are starting to show different indications of climate change, but daily weather is not the same as climate collapse over time. Therefore, it is important to arrange the ways of living expressing real climate situation and making invisible changes visible.

There are a number of different strategies to achieve this effect. The excellent approach is web based tools, such as Google Earth, making possible a virtual walks and view the landscape in other regions and countries. In this way, special technological applications can be used such as Good Guide and Fooducate, which are selected from a great amount of research "packages". In this way, the easy-to-follow formats show the impact of certain household products on our health, the environment, and social justice.

That is why, using social networking websites, trainees can share with those of distant areas and learn directly what the others are testing and what is invisible to most trainees.

4. Expecting of possible consequences

A lot of the environmental crises, which happened today are with unexpected effect on human behavior. For instance, some death consequences were attempted and different technological ability to access, produce, and use fossil fuels were experienced. All these new technological abilities were considered as advance for our society. Today the public has understood the dependency of society on fossil fuels, and caused from their use pollution, suburban sprawl, international conflicts, and climate change. Of course, there are a couple of remarkable strategies for expecting unintended consequences. One strategy is based on the precaution principle, which can be applied to this basic concept: In case of an activity, which dangers to have a harmful effect on the environment or human health, safeguard actions should be taken in respect to the cause-and-effect links that has been scientifically validated.

Historically, to put barrier on new products, technologies, or practices, the people taking care about potential negative effects were anticipated to evidence scientifically that damage would result from them. Besides, the precaution principle, which is now in action in many countries, it requires the pressure of proof on the producers to show

harmlessness and accept responsibility in case harm exists. Another strategy is to switch on from problem solving to the analysis of its isolated components in order to adapt systems thinking to evaluate the links and relations between contained components.

The use of the systems thinking seemingly is better as to predict possible consequences for a little change of one part of the system that can potentially affect the entire system.

One easy method for looking at the problem systemically is by mapping it and all of its components and interconnections. It is then easier to grasp the complexity of the decisions and foresee possible implications.

Therefore, there is no matter how often the precautionary principle and systems thinking are applied, because in both strategies unanticipated consequences of the actions will be encountered.

Building flexibility for instance, by escaping from mono-crop agriculture or by setting up local, less centralized food systems or energy networks represents other important strategy for survival in these circumstances. Thus, turn to nature and find that the capacity of natural communities to rebound from unintended consequences is vital to survival.

5. Realize how nature sustains life

1. *The ecoliterate people admit that nature has sustained life everlasting; as a result, they have turned to nature as their tutor taught several crucial principles. Three of those principles are especially jussive to ecoliterate living. The ecoliterate people have studied from the nature that all living organisms are elements of a convoluted, associated web of life and that those elements occupation a particular place depend upon their interaction for survival. Tutors can foster an understanding of the diverse web of relationships within a location by having trainees study that location as a system.*

2. *The ecoliterate people are aware that all systems in nature exist and are structured at different levels of scale. Organisms are members of systems, and these systems are positioned within another ones progressing from the micro to the macro-level. Each level is important since it supports the rest to sustain life. When trainees begin to understand the complex net of relationships that sustain an ecosystem, they can better understand that for survival, and help a system to respond to disturbances are needed strengthen relationships.*

3. *Ecoliterate people practice together a way of life that satisfies the needs of the present generation. Meanwhile, that life style supports nature's essential ability to sustain life into the future. They have learned from nature that as members of a healthy ecosystem, they have not to mishandle the resources they need in order to survive. They have learned as well from nature to take only what they need at a time they need it and to tune their behavior in both times of prosperity and difficulties. This requires that trainees learn to think in perspective making decisions about how to live.*

5.2.2. Guidelines to ecoliteracy education

The above mentioned 5 practices build on social and emotional learning skills. To understand ecosystems' principles of organization, which have evolved over billions of years, one needs to learn the basic principles of ecology—the language of nature. The most useful framework for understanding ecology today is the theory of living systems, which is still emerging and whose roots include organismic biology, Gestalt psychology, general system theory, and complexity theory (or nonlinear dynamics).

What is a living system? Living systems are what we see when are walking out into nature. All living creatures – from bacteria to big mammals comprise a living system. Each living system is composed by parts - the parts of the living systems are themselves living systems. Under the definition of living systems, the communities of organisms, including both ecosystems and human social systems such as families, schools, and other, are living systems.

How to educate in Ecoliteracy

From historical point of view, environmental education definition and development reflect the changes in the environment and the associated with this change' problems.

The UN General Assembly recognized the importance of environment education and subsequently ecological literacy, and in 1987 endorsed the development of educational programmes that consider to fit the local economic, environmental, and societal realities (UNESCO, 2005).

In the view point of these realities, the following goals the environmental education were specified (Gevorgyan & Adanalian, 2009):

1. To promote of knowledge about the environment and its conditions;
2. To deliver criteria, standards and recommendations necessary for adequate decision-making in respect to natural environment preservation and inclusive solutions to economic, social and ecological issues;
3. To establish possibilities for environment preservation along economic progress;
4. To intensify the importance of ecological traditions and eco-friendly means of economy management in order to foster environmental management.
5. To authorise and prepare current and future generations to use a balanced and cohesive approach to the main dimensions of sustainable development (economic, social, environmental).

Environmental education is based on the premise that both the natural and human built environments, locally and globally, are interdependent and include interactions between biological, economic, social, and cultural forces (UNESCO, 1980).

Environmental sustainability depends on the natural environment and how it endures and remains diverse and productive, also the state of air, water, and the climate.

Ecoliteracy focuses on the various interactions between different elements in the environment and human activity. It is essential to the achievement of a self-sustaining community with preserving the resources for future generations. Ecoliteracy is the most important part of education at all levels. Ecoliteracy is an essential element of pro-environmental behavior, since it is defined as capability to distinguish and interpret the environmental systems health and to implement appropriate initiatives to keep, restore, or expand their health, (Disinger & Roth, 1992). This is true on both individual and community levels (Esposito, 2009).

Ecologically literate people have knowledge of ecological principles, concerns for a healthy natural environment and skills to engage in environmentally responsible behaviours. They are responsible and lifelong learners. In other to accomplish these characteristics, they try to become inquirers, reflective learners, intelligently self-directed, morally responsible and ecologically responsible people (Puk, 2002). With these characteristics, an ecologically literate individual understands environmental realities by specifically identifying their cause and effect relationship and provides for the shift to an ecological paradigm by affecting other people. This shift to an ecological paradigm is a part of the transition to sustainability. This means that not only meeting basic needs but also creating a vibrant society becomes very important (Ecological Literacy, 2011).

The basic principles of the formation of an environmentally literate person are as follows:

- ✓ Mandatory and prioritized environmental knowledge in the education system;
- ✓ Consistency and continuity of education in the field of ecology;
- ✓ Education focus on solving practical problems in preserving and restoring the natural environment, resource-saving nature management;
- ✓ Generality and complexity;
- ✓ Focus on the development of people with respect to the environment, understanding of personal responsibility for its conservation, restoration and augmentation;
- ✓ Publicity of the development and implementation of environmental education and awareness programmes;
- ✓ Continuity of domestic and world experience in the formation of environmental education of the population;
- ✓ Interregional and international cooperation for formation of an environmentally educated person.

The education of ecologically literate youth in school settings is strongly influences by their surroundings - ecologically literate families, teachers, friends. Therefore, it is also necessary to give education to families and teachers on ecoliteracy (Yıldırım & Hablemitoğlu, 2013). The main recommendations for achieving ecoliteracy, as specified

by McBride (2011) are realized through different channels - from traditional education to scientific communication, to financial motivation. These recommendations are discussed in Table 1:

Table 1. Eight recommendations for achieving ecoliteracy

Channels	Recommendation	Conditions for realization
	Education	
Formal / Traditional	1. To update ecology standards and assessments	Standards should: - Reflect the now-a-days vision of ecoliteracy - Be useful for instruction - Be grounded in educational theory and research - Be linked to assessment tools
	2. To update ecology curricula and instructional materials	- New or complementary standardized textbooks and curricula based on the above standards and equipped with appropriate assessments - Their content should focus on the connections between learners and their local ecosystems
Participatory / Interactive	3. To involve students in real scientific engagement	- Teaching for ecoliteracy must promote learning ecology by doing ecology
	4. To include informal learning options	- Nature centers - Museums - Other non-school educational settings (including the internet)
Through Mass Media	5. To implement mass media campaigns	- Need for coordinated and prolonged campaigns of electronic and print media
	Communication	
by Scientists	6. To offer training	- Training of ecologists as

	and support for engaged ecologists	skilled communicators (both as teachers and collaborators) to become effective promoters of ecoliteracy,
	7. To recognize and remunerate ecologists for participating	- Ecologists' efforts to promote ecoliteracy must be recognized and rewarded along their ecological science contributions.
	Motivation	
Financial	8. To provide monetary incentive to motivate or prevent certain actions	- Government remuneration for "green" activities and/or penalty for "non-green" activities as a tool for promoting ecoliteracy

Adapted according to McBride, 2011

David Orr in his book "Ecological Literacy" (2005) wrote: *"Our efforts to build a sustainable world cannot succeed unless future generations learn how to partner with natural systems to our mutual benefit. In other words, children must become* "ecologically literate." It aims, says David Orr in his foreword, *"toward a deeper transformation of the substance, process, and scope of education at all levels—familial, geographic, ecological and political."*

An exemplary approach to effective ecoliteracy teaching and learning is described by McBride (2011), and comprises the following milestones:

Use ecological inquiries and investigations (original and/or adapted):

- ✓ Teachers use inquiries to assist you in the development of educational activities that correspond to the educational requirements of a curriculum.
- ✓ *Examples*:
  - A trainer, graduated in soil ecology inquires trainees about the effects of soil drought on plant growth.
  - A trainer, graduated in wildlife biology educates trainees about predation avoidance strategies through inquiries about adaptation through camouflage and warning coloration
  - A trainer, graduated in plant ecology inquires trainees about seed type and dispersal mechanisms of plants, thus teaching them in plant adaptation strategies.

Apply ecological research:

- ✓ teachers determine the framework of different research activities, such as practicaltasks, case studies, observation studies, and the trainees, on their turn, design and perform them.
- ✓ *Examples*:
    - A graduate trainee whose research activities are related to fire ecology work with worked students from high school biology classes and collaborate as well with the local municipal authorities to design and conduct experiments on the putative negative effects of a burn in the said local area.
    - A graduate trainee in forestry worked with elementary school classes to follow the leafing and flowering of species in their schoolyards to predict and monitor the processes.

Demonstrate outdoor ecological research:

- ✓ Graduate fellows worked with teachers and students to create physical structures on school grounds, in collaboration with other experts from the university and community, including non-profit environmental organizations, artists, landscape architects, and carpenters. These serve as continuing resources for teaching and learning about ecology.
- ✓ *Examples*:
    - One school developed a native plant garden
    - Another school built an interpretive nature trail.

Basic competency of the ecoliterate

Understanding the relationship between living things and their environment means to understand how nature works. These relationships may be cleared through the following basic competencies:

- ✓ Evaluate the impacts of human actions and technologies
- ✓ Learn in the community
- ✓ Explore traditional ecological knowledge
- ✓ Mind the reduction of energy and resources uses
- ✓ Increase and maintain biodiversity
- ✓ Explore, observe and investigate local communities culture
- ✓ Explore how people are nature dependent
- ✓ Focus on environmental issues that are personally appropriate.
- ✓ Express concern, empathy, and respect to other living things
- ✓ When learning about the environment, followed different points of view

- ✓ Mentor, teach, inspire others about environmental issues
- ✓ Rank the significance about a particular area through multiple visits to it
- ✓ Plan events to engage others for active participation in environmental such
- ✓ Participate in community events and actions that promote sustainability
- ✓ Explore interactions within the community and the wider society
- ✓ Work on environmental solutions that contribute to equity, justice, inclusiveness, and respect for all people
- ✓ Further citizen science by contributing local data

Ecoliteracy in action

If you have a premises with trainees that foster a sense of wonder for the natural world and encourage children to explore that world, on personal or institutional projects. This place would support joy in the relationship with the rest of Nature. In addition, trainees are encouraged to have an ongoing relationship with natural places.

Together, all trainees (adults and children) would learn that they rely on nature and also, that they are an active part of it. This would provide a foundation so that children could inquire, learn and grow as life-long citizens of the planet. Ecoliteracy must be taught in a way that trainees yearn to ask questions and find answers and learn about their place in the world.

The training system concept

The efficient training in ecoliteracy requires exploitation of variety of teaching strategies grounded on the principles to fit students' level of development and based on brain-based research. The aim of these teaching strategies is to provide that knowledge, skills and attitudes that are vital for sustainable living. It is approved practice that students learn better if the teaching strategies applied by teachers unify indoor and outdoor environments, *i.e.* include both indoor studies and outdoor activities. This combination allows students to practice hands-out activities, to have time for reflection and decision making, to develop interdisciplinary projects, etc.

These training strategies are implemented through different training approaches that fit students diversity. These are the following.

Place-based Learning

The principle of this training mode (invented a century ago and named experiential learning) is to engage students in their own environments. The main advantages of this strategy are that it encourages students' imaginations and stimulates environmental management and civic responsibilities.

The key feature of place-based learning is to start with simple questions: "What is my place? Where do I belong to? What is the history of my place? Where is the position of my place within the rest of the world?"

To be successful, a place-based programme must consider students as participants in the social life of their communities. Consequently, this programme has to envisage activities such as:

- ✓ Perform outdoor learning: take the students into the community and natural environment; integrate what they have learned back in the classroom lessons.
- ✓ Make students map their surrounding community to create visual representation of their place within the larger systems to which they belong., and to to learn key ecological and cultural principles.
- ✓ Emphasize on students' contributions to environmental quality and to community well-being; stimulate them to solving real problems on the basis what they have learned.
- ✓ Stimulate students' active role in shaping their own social, physical, and economic environments while collaborating with local citizens and institutions (organizations, agencies, governmental authorities, businesses).
- ✓ Encourage students to regard their community as an ecosystem and to understand the relationships and processes necessary to support the ecosystem health.

There are lots of benefits of place-based learning proved by thorough research activities. Some of the most promising are related to: higher test results, better grades, improved indoor behavior, better problem-solving skills, improved thinking skills.

Project-based Learning

Project-based learning approach is a valuable strategy, since it is based on challenging questions which answers demand complex thinking and skills. Project-based learning is by rule interdisciplinary and quite complex. Projects may be of different durations but require students to explore different resources and tools, among which the the Web, each other collaboration, the community, external experts, written resources, etc.

In project-based learning, the teacher's role is to be a facilitator rather than an expert to learning. The main benefits of project-based learning are focused on:

- ✓ Increased critical thinking skills and problem-solving capabilities
- ✓ Fostered positive attitudes toward different study subjects and better performance with applied problems.
- ✓ Better attitudes toward learning and better work habits

To promote ecoliteracy, project-based learning experiences such as habitat restoration and modeling the evolution of agriculture are very appropriate

Socratic Inquiry

Based on Socrats philosophy that questions, not answers stimulate learning, this strategy exploits the idea of encouraging students to question their assumptions, values, and preconceptions. This process help students not only to clarify their misconceptions but to clarify their thoughts related to this matter.

Engaging students in Socratic discussions helps them to enter deeply in the discussed topic and to apply to it critical thinking,while improving their listening skills, articulating capabilities and ideas presentation. Socratic discussions contribute as well to develop in students sense of tolerance to diverse opinions.

In this strategy the role of the teacher shifts from instructor to facilitator of discussion.

In respect to ecoliteracy, applying Socratic inquiry students discuss and debate issues such as animal welfare, workers' rights, the right to know what is in genetically modified plants, etc.

Experiential Learning

Experiential learning regards learning as an active process. Experiential learning encourages involvement in the real world and defines the teacher's role as a facilitator of learning to the students as active recipients. The philosophy of this learning strategy is that the process of learning is a continuous one, in which center is the experience of the learners.

The students participating in experiential learning, follow what is known as "the learning cycle", a process that comprises exploration, concept formation and concept application. This cycle repeats each time students test an idea.

Experiential learning is crucial for sustainability. Only through direct contact with nature students develop in-depth understanding of fundamental ecological principles.

Interdisciplinary Learning

Interdisciplinary learning is focused on making relation among traditional disciplines such as math, science, history, languages. Here, the teaching and learning are dedicated to problems, which solving demands knowledge and skills from various subjects. In this way, an expanded and more complex understanding of the studied topics is realized.

Interdisciplinary learning avoids gaining isolated skills. On the contrary, it allows students to face a problem from different entry points as they use various sources of information and stand points. It also allows teachers to invent adequate methods of assessment.

The benefits of interdisciplinary teaching are that it:

- ✓ Promotes students' motivation for learning
- ✓ Stimulates students' active engagement
- ✓ Help students to recognize the value of what they are learning
- ✓ Encourages students' interaction with each other, with teachers and community members.

Interdisciplinary teaching and learning is the best approach for adopting the principles of sustainable living.

Learning Outcomes

Learning Outcomes reflect the cognitive and practical abilities of trainees. These are statements that describe the knowledge, skills, autonomy and responsibility trainees should acquire by the end of a training course, particular assignment, or programme. They also help trainees to understand why it is worth to gain those knowledge, skills and attitudes and how they can use them for personal development.

Learning Outcomes are focused on the specific subjects' context and potential applications of the knowledge and skills acquired. In this way, Learning Outcomes assist trainees to relate learning from various contexts to practice and to the assessment and evaluation of this knowledge.

Learning Outcomes emphasize the knowledge application in real life situations, and its integration in abroad sense.

Based on the Learning Outcomes as an important qualification descriptor, the overall objective of a course of study of ecoliteracy is to provide the trainees a solid foundation for environmental literacy (EQF, 2018). This means capability for detailed understanding of environmental problems with the purpose to enable their analysis, synthesis, assessment, and decision making at a citizen's level.

Ecoliteracy in the curricula

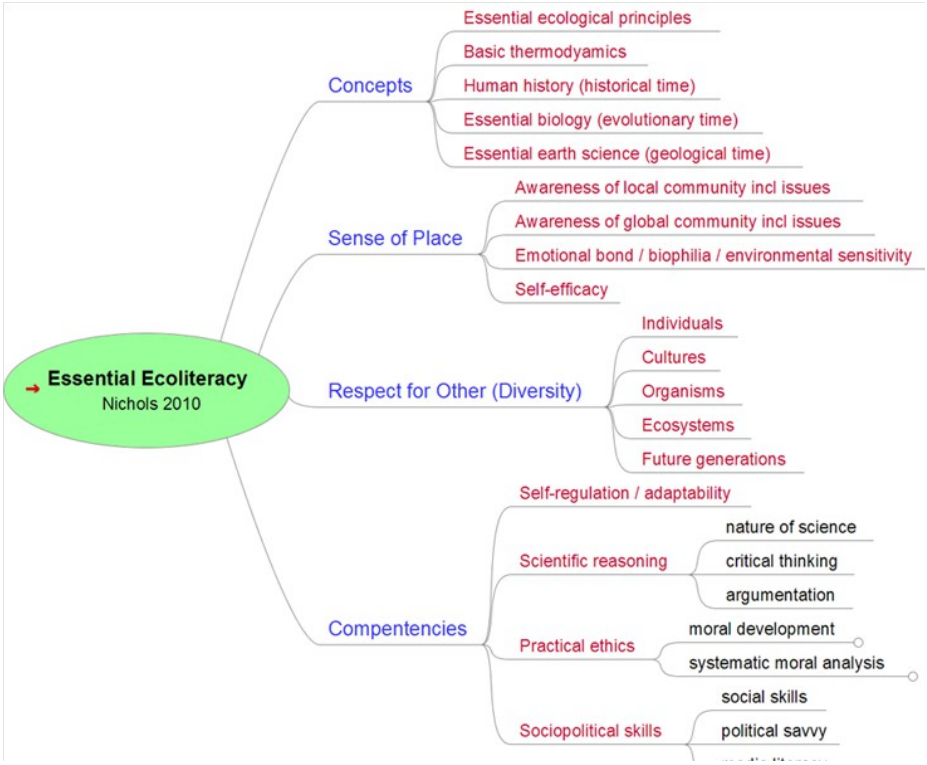
Nowadays, ecoliteracy is a central platform of education at all levels. The principles of ecoliteracy might be used to rethink and restructure not only the learning process but as well the learning content and the way it is organized. The ecoliteracy curriculum has to respect the following considerations:

- ✓ To impose transformations in the society in terms of assumptions and worldviews through education.
- ✓ To help students to understand the way in whicfunctioning of the ecosystems and the role of humans as their essential element to support their health as an inseparable part of humans one.
- ✓ To be interconnected and use holistic approach in studying life's basic pattern of organisation, thus making students pro-active and creative about their future.
- ✓ To support environmental responsibility to be implemented and practiced everywhere.

- ✓ To encourage students to observe and 'read' nature to experience the sense of wonder that knowing nature can bring.
- ✓ To stimulate students to develop a sense of place and build knowledge of the local environment, as well as to develop a sense of responsibility to others.
- ✓ To cultivate the feeling of involvement in students, a sense of being able to make a difference.
- ✓ To teach students to think for the future, to develop foresight and think long-term.

Summarizing the ecoliteracy main features and the needs of it as a multifaceted approach for establishment of sustainable ecological relationships in the nature and arrangement of their transfer to everyday life, the following related components of ecoliteracy can be summarized (Fig. 3).

Fig. 3. Essential ecoliteracy related elements



Source: Nickols, 2010

5.3. Ecological literacy and the transition to sustainability

5.3.1. Environmental Sustainability

Sustainability provides the conservation, protection, and regeneration of resources affecting the future of human health. Sustainability means to protect our planet and natural environment, reducing carbon emissions, renewable fuel sources, human and ecological health, while not compromising our way of life.

In Ecology, sustainability means how ecosystems remain diverse and productive. Healthy forests and oceans are example of sustainable ecosystems. In more general terms, sustainability is the stability of all the systems and processes.

The term Sustainable Development was invented by the Bruntland Commission established by the United Nations in 1983 with the purpose to reflect about the ways to protect the human environment and natural resources and avoid deterioration of economic and social development (Gro Harlem Brundtland was the former Prime Minister of Norway and was chosen due to her strong background in the sciences and public health) (UN, 1987). According to Bruntland Commission, Sustainable development is defined as development that *"meets the needs of the present without compromising the ability of future generations to meet their own needs"*.

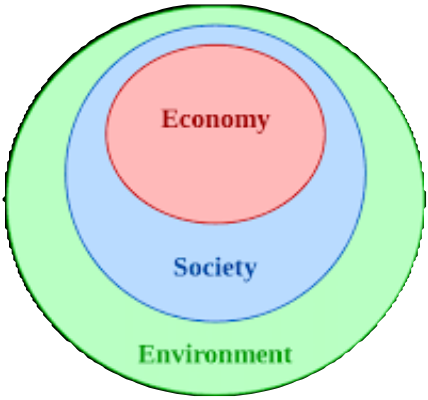
Ecological sustainability is a part of the relationship between humans and their natural and social environments. Also termed human ecology, the sustainable development domain is broadened with the of human health one. Fundamental human needs such as quality of air, water and food are also the ecological foundations for sustainable development. In accordance with IISD Annual Report, 2011, *addressing public health risk through investments in ecosystem services can be a powerful and transformative force for sustainable development, which, in this sense, extends to all species*.

Adopted by the 189 United Nations member states, the goals of sustainability were advanced to help achieve the following sustainable development standards by 2015 (UN, 2005):

1. To eradicate extreme poverty and hunger
2. To achieve universal primary education
3. To promote gender equality and empower women
4. To reduce child mortality
5. To improve maternal health
6. To combat HIV/AIDS, malaria, and other diseases
7. To ensure environmental sustainability (one of the targets in this goal focuses on increasing sustainable access to safe drinking water and basic sanitation)
8. To develop a global partnership for development

People need to have the knowledge of ecological principles, concerns for a healthy natural environment and skills to engage in environmentally responsible behaviours. In this context, Ecoliteracy is the ability to use ecological understanding, thinking and habits for health living. In the 21st century, Sustainable Development is considered as the capacity of the biosphere and human civilization to coexist, as well as the ways to maintain a homeostasis balanced environment. For many scientists, sustainability includes three interconnected domains or pillars: environment, economic and social. These pillars and their interrelations according to Fritjof Capra, are based on the principles of Systems Thinking (Capra, 2015) (Fig.4).

Figure 4. The three pillars of sustainability

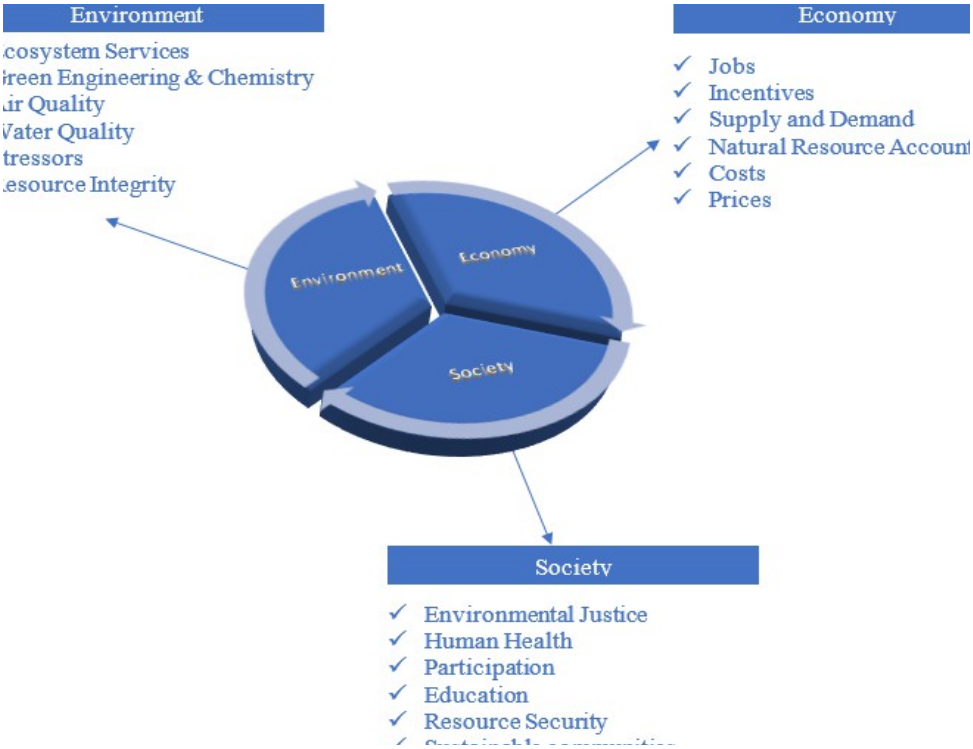


source: en.wikipedia.org

The scheme represents the relationship between the three sustainability pillars. In it, both economic and social pillars are controlled by environmental limits (Scott, 2009). Some sustainability experts illustrate a fourth pillar of sustainability - future generations, which emphasizes the long-term thinking associated with sustainability (Waite, 2013).

The major sustainability criteria, as offered by United States Environmental Protection Agency (US EPA) cover the environment, economic and social aspects, and encompass several broad topics to each of them (Fig. 5).

Figure 5. Major criteria related to the three pillars of sustainability.



Pillar: ENVIRONMENT

Broad topic	Activities	Examples
Ecosystem Services	✓ To protect, sustain, and restore the health of critical natural habitats and ecosystems	✓ Innovative nutrient management techniques (Green Infrastructure)
Green Engineering & Chemistry	✓ To design chemical products and processes to eliminate toxics, reuse / recycle chemicals, reduce total lifecycle costs	✓ Lifecycle Assessments in products design

Quality of Air	✓ To Manage and maintain air-quality standards and decrease the risk from toxic air pollutants	✓ Investigate potential strategies for greenhouse gas emissions reduction
Quality of Water	✓ To reduce exposure to contaminants in water systems and infrastructure ✓ To optimize aging systems ✓ To explore next generation treatment approaches & technologies	✓ Innovative technologies for water reuse and treatment
Stress factors	✓ To reduce the effects of pollutants, greenhouse gas emissions, GMOs on the ecosystem and vulnerable populations	✓ Fate of GMOs in soil
Resource Integrity	✓ To reduce adverse effects by minimizing waste generation ✓ To prevent accidental release and future clean-up	✓ Innovative technologies and processes to prevent environmental impact

Pillar: ECONOMY

Broad topic	Activities	Examples
Jobs	✓ To reinforce and maintain current and future jobs	✓ Introduction of innovative technologies and practices that provide multiple benefits to society and the

		environment
Motivations	✓ To promote human motivation ✓ To encourage sustainable practices	✓ Collaborative approaches for management of urban stormwater
Supply and Demand	✓ To promote fully informed market practices to endorse environmental health and social prosperity	✓ Full lifecycle cost and benefit accounting techniques
Natural Resource Accounting	✓ To improve understanding and quantitative evaluation of ecosystem services in cost benefit analysis	✓ Sustainability Assessments
Costs	✓ To positively impact costs of processes, services, and products throughout the full lifecycle	✓ Encouragement for development of waste-free processes
Prices	✓ To promote prices that reduce risk for new technologies	✓ Fast launch of innovative technologies and approaches to the market

Pillar: SOCIETY

Broad topic	Activities	Examples
Environmental Justice	✓ To protect communities health over-loaded by pollution by empowering them to improve their health and environment	✓ Established partnerships with local and state organisations to achieve healthy and sustainable communities
Human Health	✓ To protect, sustain,	✓ Established model

	and improve human health	that predicts developmental toxicology
Participation	✓ To use transparent processes that engage relevant stakeholders	✓ Developed database of reduced-risk pesticides for commonly used products; ✓ Greater public understanding about sustainability
Education	✓ To enhance the education about sustainability of the general public, stakeholders, and potentially affected groups	✓ Provided opportunities for students and communities to learn about sustainability
Resource Security	✓ To protect, maintain, and restore access to water, food, land, and energy for current and future generations	✓ Study impact of pollutants on natural waterways
Sustainable Communities	✓ To encourage the development, of communities that promote sustainable living	✓ Landscape with native plant species ✓ Green buildings

adapted from: www2.epa.gov

The main characteristics of the three main pillars of Sustainable Development can be outlined as follows:

- ✓ **Environmental Sustainability**:

  Environmental sustainability means to make eco-friendly products, to fight pollutions and climate change, to explore practices that ensure the natural resources to remain intact, so the components of the environment not to be degraded. The definitions of sustainable manufacture, products, and practices are outline in Fig. 6.

According to Pettinger (2018), environmental sustainability is concerned as well with the protection and maintenance of environmental resources for the future generations. Environmental Sustainability tackles issues such as:

- *Long-term health of the ecosystem*: to protect food supplies, farmland stock.
- *Renewable resources*: to diversify the energy sources.
- *Protection of biodiversity and ecological structure*: specific plant species are required for the production of some medicines; this limits future technological innovations.
- *Prevent the global warning due to human activities*: to implement policies that ensure the environment is not destroyed.
- *Intergenerational decision making*: to make decisions, considering the consequences for the future generations. For instance, burning coal provides a short-term benefit because of the cheaper energy; meanwhile, the extra pollution inflicts cost on future generations.

Figure 6. Environment Sustainability Practices

Source:

https://www.pngitem.com/pimgs/m/56-569962_environmental-sustainability-practices-hd-png-download.png

Thus, the environmental sustainability targets are focused on (Fig. 7):

- Shift to renewable resources through restricting the consumption of non-renewable resources;
- Protect ecosystems health through avoiding the irreparable damages of the ecosystems;
- Avoid excess pollution through controlling the earth's atmosphere pollution
- Make intergenerational decisions through taking economic decisions on the basis of future consequences in long-term vision;
- Aim welfare not sole economic benefits through implementing economic measures that value social wellbeing.

Figure 7. Environmental sustainability targets

- ✓ **Social Sustainability**:

  Social sustainability means the ability of society to work towards common goals through satisfaction of individual needs, for instance demands for health and well-being, nutrition, shelter, education, culture, etc. Social impact may encompass a variety of activities to be reached: from making safe working environment to development and implementation of ecology-awareness programmes.

  The social sustainability targets combining planet, people and profit for common benefits, are focused on (Fig. 8):

  - Facilities and infrastructure: accessible transportation and street layout, provision of enough physical and community space, formation of places of distinct character;

  - Social and cultural activities: community facilities, well-being; feeling of safety;

  - Expression and influence: confidence to influence and improve the surrounding environment.

Figure 8. Main targets of social sustainability

- ✓ **Economic Sustainability**:

  Economic sustainability means that development towards social and environmental sustainability is financially attainable. Hence, economic sustainability refers to the way an economy functions in a sustainable manner, shielding social and environmental elements. Economic sustainability is grounded on important economic outcomes. For instance, reducing the carbon emission results in cost saving.

  Economic sustainability is realized through smart economic growth, Research and development spending, cost savings, long range planning, leading to social and environmental benefits like fare taxation, business ethics, employment, trade, energy efficiency, carbon credits, etc.

Sustainable vs. unsustainable

Sustainability requires that human activities use nature's resources at a rate at which they can be replenished naturally. An unsustainable situation occurs when natural capital (the total nature's resources) is used up faster than it can be replenished. Theoretically, the long-term result of this unsustainable situation is the inability to sustain human life (*Russell & Fran, 2019*). Sustainable *vs*. unsustainable situations in respect to the state of the environment as a result of resources consumption is presented in Table 2.

Education for sustainable development systems

A promising direction towards sustainable environmental development is to design systems that are flexible and reversible (*Zhang & Babovic, 2012; Fawcett et al., 2012).* Education for sustainable development is such a flexible and reversible system that integrates key sustainable development issues into teaching and learning. Among the key development issues, instruction about climate change, disaster risk reduction, biodiversity and sustainable consumption may be listed. This system requires participatory teaching and learning methods that motivate and empower learners to change their behaviours and take action for sustainable development. Therefore, education for sustainable development promotes competencies like critical thinking, imagining future scenarios and making decisions in a collaborative way *(UNESCO, 1997; Marope, Chakroun, & Holmes, 2015).*

Table 2. Sustainable/unsustainable situations

Consumption of natural resources	State of environment	Sustainability
More than nature's ability to replenish	Environmental degradation	Environmentally unsustainable

Equal to nature's ability to replenish	Environmental equilibrium	Steady state economy
Less than nature's ability to replenish	Environmental renewal	Environmentally sustainable

Source: https://en.wikipedia.org/

To be realized efficiently, the education for sustainable development process needed relevant environmental curricula and programmes, which development was guided by the Tbilisi Declaration (Tbilisi Declaration,1978). This is a document that outlined a number of objectives and principles to be followed for the development of environmental curricula and programmes. The goals and principles specified in the Tbilisi Declaration illustrated that environmental education had to promote the notion that students be given an understanding of the natural world and to become critical thinkers, active participants and balance and acknowledge how economic and social needs influence ecological relationships in their own communities. It also focussed on environmental issues from regional and global perspectives so that students received insights into environmental issues in other regions of the world, which in turn would work to foster empathy, responsibility, and cooperation in addressing restoration and improvements in the environment (Locke, Russo, & Montoya, 2013).

Klien and Merritt (1994) linked the goals and principles of environmental education to constructivists learning theories and found many similarities, suggesting that students and teachers have to be actively engaged in creating knowledge of the environment through real-life situation/experiences instead of passively learning pre-determined facts. To achieve local significance, lessons need to discuss and resolve real-life problems; the lessons must be learner-centred and the learning process interactively organized within a group of learners. Additionally, the assessment has to be performed in a way that really measures student progress (Locke et al., 2013).

Dillon and Scoullos (2003) emphasised on the fact that involvement of learners in the learning process is essential when study the environment and that environmental education is most effective when it is based on the pragmatic social constructivist approach. They suggest that environmental programs are more effective when students actively participate in activities perceived to be useful and culturally acceptable.

Each environmental issue is associated to a certain historical context and geographic location. This requires the teachers and students to examine it not only in the context of the forces and lifestyles that have contributed to the issue but the human and physical geography of the zone that have shaped it as an environmental problem (Montoya & Russo, 2006). That is why, lessons focus must be redirected from content to experiential learning, this will allow students to learn not only the subject theory but to launch personal and group conclusions through practical activities. Thus, both teachers and students through focusing on real-life situations in a local environment (UNESCO, 2005) will meet the guiding principles of ecological education for sustainable development. UNESCO in its 2005 document on reorienting teacher education to address sustainability stated that even though sustainable education needed

to be based on local needs and conditions it recognized that a focus on the problematic of local communities often had global consequences (Locke et al., 2013).

One of the main steps to be taken in solving environmental problems and creating a sustainable future is the understanding of ecoliteracy. Roth (1991) defines three levels of ecoliteracy:

- ✓ The first level - to recognize basic environmental terms and provide definitions of their meanings;
- ✓ The second level - the ability to use environmental knowledge and concepts to formulate positions on particular environmental questions;
- ✓ The third level - the ability to gather and evaluate information, select alternatives and take action on different environmental issues.

Defined in this way, ecoliteracy means not only the ability to identify, classify, and name different aspects of the environment but it includes as well the ability to take action and participate in the decision-making process of environmental problems and issues (Locke et al., 2013). Ecoliteracy requires a degree of awareness of the physical environment. However, it has gone beyond the simple identification of plant and animal species to gain understandings and knowledge of the ecological relationships and interactions, and the long-term impact of human activity on the environment (Capra, 1999; Orr, 1994; Smith-Sebasto, 1997).

Starting from pre-school, individuals must be educated in development of ecoliteracy at each stage of the education system. One of the most important topics that contribute to the development of ecoliteracy is environmental education (Watling & Zachary, 2013). Yıldırım and Hablemitoğlu (2013) focus on explaining how ecoliteracy affects creating a sustainable environment, and propose the "*Eco-sociological model*" of U. Bronfenbrenner (1986), adapted by Stanger (2011) as an education model for ecoliteracy at schools. Discussing ecological systems is important for the youth to understand easily positive and negative effects of the changes occurring at each level of the ecosystem on environment and human life and to be ecologically literate by making correct ecological connections.

5.3.2. Improving sustainability through education management

The environmental education has a significant importance in creation of beliefs, understanding, and human ecological behavior. Environmental education is dedicated to keep sustainability through definite impact of education on the environment. It is important to understand the effectiveness of Learning Management System (LMS) to ecoliteracy. Applying analysis, design, development, implementation, and evaluation criteria the student in ecoliteracy is evaluated in respect to ther Learning Outcome descriptors: knowledge, skills and autonomy & responsibility. The observation indicated that the Learning Management System by using Lewinshon criteria can improve the ecoliteracy capability, especially in the attitude of preserving for the environment.

Following the LMS framework, the ecological concept is adapted to the above mentioned descriptors in a lesson plan, then indicators that are appropriate are applied in learning. The obtained results indicated that learning by using ecoliteracy can increase awareness in protecting the environment. Also, the learning environment can be worked out as a ground for sustainable learning, thus enhancing the learning pedagogies. The ecoliteracy learning rises a programme character through knowledge and skills in learning environments.

Thus, an environmental education-based learning encourages a spirit of environmental awareness by preserving culture.

Addressing environmental damages through ecoliteracy education, a perception of environmental care increases and opportunity for ecoliteracy is created Using the LMS for management ecoliteracy education can give the following results:

- ✓ Ecoliteracy learning can facilitate awareness to protect the environment
- ✓ Eco-literacy learning maintains environmental awareness in the pedagogy of continuing education in daily life
- ✓ Eco-literacy learning can be treated as a motivation for learning environments
- ✓ Learning using eco-literacy proposes information about students knowledge in respond to environmental problems: they are invited to analyze the problem; after that to give answers, and as a result - they know to present. Finally, the students are trained to think logically in reply to a problem.

Eco literacy in learning includes two important aspects:

i) the aspect for the modern worldview;

ii) the aspect of complex ecological integration.

Their decision give sustainability of environmental problems.

- ✓ Development of eco-literacy for improvement of environmental education. Ecoliteracy learning builds environmental education based on aspects of knowledge and skills;
- ✓ Learning ecoliteracy by promoting biodiversity resilience for protection of ecosystems and measures for better agility to environmental damage caused by global warming and including such themes in ecological learning material;
- ✓ Ecoliteracy learning in merging with traditional learning can facilitate enthusiasm in environment protection;
- ✓ Learning with ecoliteracy leased with National Environmental Programmes (NEP) enhances knowledge and worries in environmental matters, but in respect to the common environmental problems is not enough;
- ✓ Ecoliteracy learning operates a medium value category. The assessment of the aspects of addressing environmental problems gets high marks;
- ✓ Learning including ecoliteracy issues can facilitate ecoliteracy.

- ✓ Learning eco-literacy with ethnographical aspects rises awareness in preventing the environment by promoting culture;
- ✓ Ecoliteracy learning using illustrations presenting differencing pictures can enhance student cognitively.

Based on the results of use of Lewinshon's criteria-based Learning Management System to train in ecoliteracy of students in senior high schools on Biology are as follows:

- ✓ The students' ability to understand ecology in life to study the environment significantly rises, and students are trained to maintain the environment.
- ✓ Biology learning using the development of a Learning Management System can improve the learning outcome based knowledge and skills of students in ecoliteracy.
- ✓ The learning process - the teacher should always try to choose and use methods and media that can improve the ability of students' ecoliteracy so that biology subjects can provide meaning and are not considered merely rote learning.

5.3.3. Strategies of sustainable ecoliteracy development

Countries around the world continue to advance economically, and they put a strain on the ability of the natural environment to absorb the high level of pollutants that are created as a part of this economic growth. Therefore, it is necessary to search and find solutions so that the world economies and the public well-being are growing in paralel. In the world of economics, the amount of environmental quality must be considered as limited in supply and therefore must be treated as a scarce resource. This resource has to be protected. A common way to analyse possible outcomes of policy decisions on the scarce resource is to do a cost-benefit analysis. This type of analysis contrasts different options of resource allocation and, based on an evaluation of the expected courses of action and the consequences of these actions, elicits the optimal way to do so in the light of different policy goals (*Barbier, Markandya, & Pearce,1990).*

The World Conservation Strategy

The World Conservation Strategy is published almost 30 years ago. Since the last decade of XX century, it has become one of the most inspiring developments that apply a goal-oriented programme for political change concerning ecological sustainability. It promotes among the wide audience the principles of sustainable development and treats the environmental concerns introduced by economic development decisions in a wide-public friendly way. The World Conservation Strategy marked a fundamental shift in the policy for global conservation movement. The focus was shift from prevention to cure, in support to the expanding trend for inclusion of preservation and maintenance in the development aims, key to an ecologically sustainable society. In particular, the

wildlife conservation efforts to protect more strains degrading the natural environment are a subject of concern *(McCormick, 1986).* According to *Smith (1995),* there are three chief conservation objectives:

1. To maintain essential biogeochemical cycles and life-support systems;
2. To preserve genetic diversity
3. To launch a sustainable use of species and ecosystems.

For example, sustainable agriculture comprises methods of farming that are environment harmless and that guarantee the agricultural production does not impose damage to Nature and humans. It involves preventing adverse effects to water, soil, biodiversity, available or processed resources, as well as to people working or living in those and neighbouring areas. The main elements of sustainable agriculture include permaculture, agroforestry, mixed farming, multiple cropping, and crop rotation (Falk, 2013). It comprises agricultural methods that do not undermine the environment, and smart farming technologies that enhance environmental quality. The concept of sustainable agriculture is further extended, covering rather the conservation or improvement of natural resources, than those that have been depleted or polluted (*Networld - Project, 1998).*

Integration of ecoliteracy in education initiatives strategy

The general scope of this strategy is to make ecoliteracy a bridge across different subject areas in science, art, and humanities. For its realization, a joint approach for building ecoliteracy is proposed that combine indoor (class rooms) instructions with outdoor experiences. The later to be gained through observations and interactions in both natural and urban environments, supported by informal learning settings. It means that both groups of players – trainees and tutors need access to learning environments outside the traditional training premises. In addition, formal and informal educators need knowledge, skills and the training to teach trainees outdoors and to interrelate the inside and outside experiences gained to academic standards. Thus, educators need support to match trainees' indoor learning with the experiential comprehension of the environment.

Because of these reasons, the strategy foresees concentration of the efforts to build ecoliteracy in the following directions:

- ✓ Consideration of the pleura of backgrounds, languages, and life experiences of trainees;
- ✓ Provision of learning experiences that are culturally relevant and presented via culturally competent instruction;
- ✓ Requirements for diversity in workforce and its leadership qualities;
- ✓ Provision of subject content and training approaches that meet the needs of, and are relevant to, variety of students' populations;
- ✓ Establishment of effective communication between educators and traineess who come from different backgrounds.

Following the main concept of this strategy, ecoliteracy must be a hallmark of all the domains where the trainees learn, and must be supported by professional learning for all educators in these domains. The variety of learning settings covers the spectrum from classical classrooms, to informal learning environments, and environment-focused institutions within the communities where trainees live. This broad set of training institutions will allow the trainees to study the actual environment in various forms, and hence, to build better understanding of the environment as a specific subject matter. This approach stimulates the gathering together of all educational settings experience to assist all trainees to become environmentally literate.

The successful integration of ecoliteracy into curricula and guiding materials requires the implementation of the following main steps:

- ✓ Assurance of enhanced access of educators to relevant instruction materials that concern environmental topics and in the same time meet academic standards.
- ✓ Development of key performance indicators and criteria to assist educators in determination of the quality of environmental curricula and guiding materials applying the common for all studied subjects' standards.
- ✓ Stimulation the exchange of information and materials between formal and informal educational representatives.
- ✓ Incorporation of the environmental principles into future curriculum frameworks to increase awareness and understanding of these principles among educators through professional communication.
- ✓ Assurance that guiding materials developers produce materials that contain environment-focused content.
- ✓ Use of different tools (formative assessments, model lessons, etc.) that support environmental literacy in the digital resource repositories that provide resources for educators of unified standards.
- ✓ Emphasis on the importance of the outdoor environment as a teaching resource.
- ✓ Provision of guidance for and promotion of the outdoor teaching of multiple subjects.

Another important element of this strategy is to make professional learning more accessible to educators through:

- ✓ Improved access to professional learning opportunities that enhance formal and informal educators' abilities to teach environmental literacy.
- ✓ Incorporate ecoliteracy into all phases of professional learning for formal educators.
- ✓ Provide training to nonteaching administrators to effectively bring and educate students outdoors.

- ✓ Work with colleges and universities that offer teacher preparation programmes to implement changes and incorporate ecoliteracy into the standards for the teaching profession, so that educators are better prepared to provide to their students ecoliteracy.
- ✓ Leverage the use of different resource directories, social media, etc. to increase educators' awareness of the ecoliteracy resources that are available to them.
- ✓ Leverage existing professional learning infrastructure to improve professional learning opportunities that bring together educators from various learning domains to collaborate and share lessons learned.

The integration of ecoliteracy in the systems for knowledge assessment is the final step of its successful amalgamation with the other study subjects. It can be achieved through:

- ✓ Establishment of ecoliteracy learning outcomes: knowledge of environmental processes and systems; skills for comprehending and facing environmental issues; positive attitudes toward the environment; individual and social responsibility, etc.
- ✓ Integrate the assessment of learning in ecoliteracy with the officially recognized national assessments systems.
- ✓ Develop evaluation tools for assessing ecoliteracy that are integrated with the national assessment systems. The portfolio approach is a god choice to begin with.
- ✓ Perform survey with a module of questions among future trainees to understand their environmental attitudes, motivations, and actions.

Promotion of partnership and cooperation amongst key stakeholders of environmental education strategy

Realizing the vision of environmental literacy for all students requires collaboration between Informal and formal educators should work as critical partners, with each contributing important skills and expertise.

Building partnership and collaboration will also help educators access high-quality professional learning opportunities and instructional resources, share best practices, and determine the best ways to integrate environmental concepts with current and future standards. A collaborative approach will better engage, and facilitate the sharing of expertise among these different partners to create high-quality and culturally relevant experiences for students in all domains.

To build successful collaboration and partnerships, it is necessary to:

- ✓ Enlarge the collaborative work in support of ecoiteracy;
- ✓ Strengthen the capacity of organizations that support outdoor
- ✓ Strengthen the partnerships with other key organizations, to support the greening of education premises.

- ✓ Improve the effectiveness of collaboration among state institutions involved in supporting ecoliteracy.
- ✓ Support internal Collaboration among nonteaching staff to embed ecoliteracy within the educational standards, curriculum frameworks, and assessments:

Mobilize the public influence strategy

The essence of this strategy is to prioritize environmental literacy as a fundamental element of 21st century education. To create awareness of strategies for advancing environmental literacy foresee:

- ✓ Disseminate and promote ecoliteracy principles and advantages;
- ✓ Communicate the importance of ecoliteracy;
- ✓ Encourage and support education committees to integrate environmental literacy programmes and education experiences outdoor.
- ✓ develop and undertake an awareness campaign for teachers and administrators that promotes ecoliteracy guiding materials.
- ✓ Communicate to curriculum developers that ecoliteracy is a priority for inclusion in textbooks and instructional materials.

Regulation frameworks of ecoliteracy

To expand the reach to ecoliteracy of all trainees and training settings requires new approaches in terms of changes in the existing national statutes and related to them policies that can complement and support the efforts for ecoliteracy promotion. Among the possible changes the following can be listed:

- ✓ Integrating ecoliteracy into high school graduation requirements, and development of environmental learning outcomes;
- ✓ Assurance that ecoliteracy content is included in educator preparation and support resources;
- ✓ Demands for implementation of ecoliteracy in all new school construction and modernization projects.

Sustainable Funding Strategy

A comprehensive, coordinated, and cohesive funding strategy is needed that identifies funding streams (existing and new, public and private) and coordinates fundraising to ensure consistent funding for key priorities. This funding strategy will mainstream the funding streams to increase the stability of activities focused on achieving ecoliteracy.

Funding sources, especially for learning experiences outdoor, are a priority trainees to have better access to outdoor learning experiences. The main recommendation in this context are as follows:

- Organization and Planning of Funding Efforts
- Encouragement Funding at Local level
- Organization of a Funding Network and Partnerships
- Develop Funding Sources to Support Development of Green initiatives
- Support Funding for Professional Development for the Science Standards

Summarized, environmental literacy can be presented as a combination of: environmental education - environmental thinking - environmental awareness - environmental culture, multiplied by the psychological and pedagogical features of students and pedagogical technologists. As was mentioned above, David Orr (1992) has created a theory of ecoliteracy, a mode by which we better learn the ecology of the Earth and live in a sustainable manner. Adding biophilia and ecojustice to Orr's ecoliteracy, and recognizing the value of experience-in-learning, the values of environmental education will be incorporated within the educational reform (Mitchell & Mueller, 2010).

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Questions

True /False Questions

1) (T / F) The key mission of ecological intelligence is to cultivate social and environmental responsibility and awareness, encourage critical thinking, follow cooperative learning, generate behavioral change in the long-term perspective.
2) (T / F) Social intelligence refers to social responsibilities of people regarding environment..
3) (T / F) The need of ecoliteracy is not grounded on the emerging tendencies for decline in literacy among youths.
4) (T / F) Ecologically literate people have knowledge of ecological principles.
5) (T / F) The effective ecoliteracy teaching and learning explores ecological inquiries and investigations.
6) (T / F) Ecoliteracy training approaches that fit students' diversity include face-to-face tuition, only.
7) (T / F) In Ecology, sustainability means how ecosystems exclude human activities.
8) (T / F) Environmental sustainability means to fight pollutions and climate change
9) (T / F) The man scope of the Integration of ecoliteracy in education initiatives strategy is: 'Ecoliteracy is a hallmark only of the domain ecology'.
10) (T / F) Environmental sustainability targets are sole economic benefits.

Multiple Choice Questions

11) The basic elements in the alternative ecoliteracy model concept are focused on:

a) Human intelligence, social intelligence, emotional intelligence, economy and green consumer behavior

b) Ecological intelligence, individual intelligence, emotional intelligence, economy and green consumer behavior

c) Ecological intelligence, social intelligence, emotional intelligence, economy and green consumer behavior

d) Ecological intelligence, social intelligence, emotional intelligence, economic intelligence

12) Which of the following statements **IS NOT** a component of ecoliteracy:

a) To understand how the Earth functions in the viewpoint of the basic ecological concern.

b) To understand how humans are threatening ecological integrity.

c) To express empathy and connection with the nature.

d) To record human threats of the Earth's ecological systems

13) The way to build ecoliteracy comprises (**tick the incorrect**!):

a) Development of empathy for all forms of life.

b) Adopt sustainability like a community practice.

c) Support the invisible.

d) Realize how nature sustains life.

14) The goals of environmental education are (**tick the incorrect**!):

a) To restrict the future generations to use a balanced and cohesive approach to economic, social, and environment dimensions of sustainable development.

b) To promote of knowledge about the environment and its conditions.

c) To establish possibilities for environment preservation along economic progress.

d) To intensify the importance of ecological traditions.

15) The main channels to achieve ecoliteracy include:

a) Informal education, mass media, communication by scientists, and financial restrictions.

b) Informal education, interactive education, communication by scientists, and financial restrictions

c) Formal education, interactive education, mass media, communication by scientists, and financial motivation.

d) Non-formal education, interactive education, mass media, communication by society, and financial motivation.

16) The efficient training in ecoliteracy requires (**tick the incorrect**!):

a) Exploitation of variety of teaching strategies.

b) Only a classical class room

c) Exploitation of the principles to fit students' level of development.

d) Performance of brain-based research.

17) Which of the following statements **IS NOT** correct?

a) Learning Outcomes reflect the cognitive and practical abilities of trainees.

b) Learning Outcomes are statements that describe the knowledge, skills, autonomy and responsibility trainees should acquire by the end of a training.

c) Learning Outcomes are not qualification descriptors

d) Learning Outcomes are focused on the specific subjects' context and potential applications of the knowledge and skills acquired.

18) The three pillars of sustainability are (**tick the incorrect**!):

a) Economy, society, environment.

b) Individuals, economy, nature.

c) Individuals, environment, Earth.

d) Economy, well-being, health.

19) Ecoliteracy education management can give the following results (**tick the incorrect**!):

19.a) Ecoliteracy learning can facilitate awareness to protect the environment.

19.b) Learning using eco-literacy offers information about students' knowledge in Nature damages.

19.c) Ecoliteracy learning can be treated as a motivation for learning environments.

19.d) Ecoliteracy learning maintains environmental awareness.

20) The main recommendations of the Sustainable Funding Strategy include:

a) and planning of funding efforts; encouragement funding at local level; organization of a funding network and partnerships

b) Restricting funding efforts; encouragement funding at local level; organization of a funding network and partnerships

c) Organization Organization and planning of funding efforts; restricting funding at local level; organization of a funding network and partnerships

d) Organization and planning of funding efforts; encouragement funding at local level; restricting funding networks and partnerships

Correct answers: See annex "Answers"!

CHAPTER 6

Social Ecological System Approach

Rainer Paslack[11] **& Jürgen W. Simon**[12]

"In nature, everything is interaction."

Alexander von Humboldt

Introduction

Chapter 4 highlighted the paramount importance of ecosystem services (ES) in protecting the various ecosystems from degradation and loss of biodiversity, in so far as they constitute an interface between human and nature. With the help of these "services", an attempt is made to stop the negative anthropogenic effects on the ecology of the planet or to compensate for such effects that have already occurred. Conversely, the "profit" of mankind from the valuable resources of nature is to be preserved and, within certain limits, even increased - without, however, endangering the existence of nature (and thus also humanity) or permanently disturbing its essential functions.

In the present chapter, these ES goals are taken up again by providing them, or rather the interrelationships between humans and nature, with a theoretical foundation based on fundamental insights of general systems theory, or more precisely: on the basic assumptions of the theory of complex and dynamic systems, which are relevant for both human social systems and natural ecosystems. At the same time, this chapter also aims to introduce the reader to "systemic thinking". After all, the system-theoretical terms should not be understandable from the outset to anyone who is not already professionally familiar with them, so that misunderstandings or perplexity can often arise here. Therefore, in the following, not only the theory of "social-ecological systems" will be presented, but also the particularities that distinguish especially complex and dynamic systems from other (non-systemic) entities - such as simple things (stones, tools, etc.) - will be briefly discussed. In connection with this, it should also become clear with which specific epistemological and methodological problems

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each system theory has to struggle with, which it undertakes to determine and coherently model the individual components of a system (or even several systems coupled with each other) and their interactions.

This is because systems theory not only models and analyzes the dynamics of individual (isolated) systems in exchange with their environment, but also the complex interplay of several systems that are interdependent with each other's environment by examining the internal effects of each of the systems on the other: in doing so, system theory considers the interrelationships between the various systems as if they were the interactions between the components of a single "supersystem", but without ignoring the respective characteristics of the two "components" (the subsystems).

Within the framework of this trans- or inter-systemic approach, the "theory of social-ecological systems", which is decisive for our context, has emerged in recent decades, in which human systems (societies) and ecosystems (nature) are interlinked. The SES approach is an "integrative approach", which, so to speak, investigates and models the causal interconnection of systems of different types.

A "social-ecological system" (SES)can roughly be understood as follows: A "social-ecological system" is a system "that includes societal (human) and ecological (biophysical) subsystems in mutual interactions" (Harrington et al. 2010: 2773). In such an "adaptive system", geophysical and biotic factors on the one hand and social and cultural factors on the other interact in such a way that the SES as a whole is able to exist resiliently and sustainably: Everything here is in an "eternal cycle" in which, at least in terms of material, nothing is lost in principle, because the released matter is immediately fed back into the cycle. The dynamics of this system is driven by the energy of the sun and the earth's interior (even if it first has to be released from fossil deposits). And everything here is interaction: both within the ecosphere and the human sphere, and between these two spheres: man influences nature and nature influences man, so that man only appears to be able to control nature, but in reality is only ever in an exchange with nature. There is no escape from nature, but also nature does not remain untouched by the activities of man - if one wants to compare man and nature at all, because this distinction is only due to a perspective that classifies and evaluates everything non-human from the point of view of man ("anthropocentrism"). Now, although science is not "value-neutral" either, insofar as it is always carried and driven by human interests, science at least strives for an objective view (a "view from nowhere"), whereby it overcomes the one-sidedness of a merely subjective view insofar as it critically evaluates and tries to avoid it. For this reason alone, we need science if we want to understand the interactions between the eco- and human spheres in as unprejudiced a way as possible. And here it is the research approaches of the various SES theories (and the empirical studies based on them) that bring us closer to an understanding of social-ecological interrelationships in a way that is appropriate to the complexity of these interrelationships.

In the following, however, the aim is not to trace the history of the SES approach in all its numerous variants, but rather to present those theoretical ideas and findings relevant to practice that are indispensable for strengthening "public awareness" with regard to the sustainable conservation or renewal of natural resources and living

conditions. This chapter is divided into two major sections: "Theoretical Framework" (6.1.) and "Systematic Indicators" (6.2.).

Subchapter 6.1. (author: Rainer Paslack) pursues the following objectives or questions:

- What are the reasons why we should consider the world as a comprehensive social-ecological system?
- What are the most important characteristics of complex dynamic systems in society and nature?
- What does the theory of "social-ecological systems" achieve?

Subchapter 6.2. (author: Jürgen Simon) is dedicated to the following goals or questions:

- Which indicators ("key tools") does SES research use?
- In which way can these indicators support the monitoring of Social-Ecological Systems (SES)?

6.1. Theoretical framework

6.1.1. The problematic relationship between human and ecosystems

We all live in an extremely complex and dynamic world. No one can any longer grasp the multitude and variety of components and their complex interplay, which together produce what we call "our reality". In the course of the modern **globalization** of the world in economy, politics and culture, the earth has been covered with a huge and unmanageable network of traffic connections, on which countless people and goods as well as data are transported day and night. And although there are numerous international agreements that attempt to order and regulate this "jungle", this process is on the whole rather "wild", since in the mostly neo-liberal economic systems, especially in the western world, the transnationally active companies act primarily according to business efficiency and return criteria and seize every opportunity that presents itself to develop further profitable products and to open up new markets wherever this is possible and appears opportune.

In particular, agriculture, which must feed a growing human population or meet the increasing demands for prosperity, is expanding more and more over all areas of land that can be used at all. Neither the "invisible hand" of the market, which does not actually exist, nor the community of states is apparently in a position to intervene here in a regulatory capacity and counteract the general proliferation. The economic globalization of the earth is thus proceeding largely blindly, i.e. in the form of a self-organizing process in which countless actors with their often competing interests are involved. Of course, every single company and every single state pursues its own goals with care, i.e. systematically, rationally and in a planned manner; there is also a legal framework that has to be adhered to almost everywhere (admittedly, there are also "tax

havens" that grant economic entities a great deal of freedom). Yet, seen as a whole, the many ventures of the countless actors compete in a confusing way; and it is not uncommon for global economic interdependencies in particular to be so opaque that movements are set in motion, especially in the financial markets, that elude all control and can easily lead to chaotic situations. International tourism, for example, which is also industrially organized, also contributes to this global process. Not only states and companies, but also each and every one of us is therefore involved in the ongoing globalization and its "side effects" on society and nature, which are inestimable in detail. It is part of the nature of complex systems, in which many different things always happen at the same time and discrepancies, incompatibilities, but also linkages (temporary alliances) and overlaps can occur, so that risky developments or undesirable trends ultimately arise, which are sometimes noticed only late and are even more difficult to control.

This process is also accompanied by a growing **technization** of all areas of life and even the last corners of our globe, which does not stop at even the most remote "reserves" of nature: The unchecked hunger of human civilization for more and more and better consumer goods as well as for a more and more closely meshed and efficient infrastructure, for roads and canals, for factory and residential complexes, for further energy sources and raw materials does not only lead to an increasing exploitation of nature, but also to a growing demand for energy and raw materials("land grabbing") and the development of new water and raw material resources, but also to closer and more intensive interactions between man and nature. The negative consequences of this development are well known: Soil sealing and water pollution, loss of species and climate change are only the largest items on the negative side of the balance sheet within human-environment relations. In the meantime, both the "limits of growth" and the environmental costs are becoming increasingly visible. In particular, rising environmental costs could soon put an end to our desire for further prosperity and economic wealth and even bring entire economies to their knees. For this reason, there is a growing willingness to change our behaviour towards nature and in particular to "redirect" our economy by, for example, making technological use of renewable energies (sun, wind and water power), feeding used raw materials back into the economic cycle ("recycling") or substituting or saving natural raw materials with artificial materials. The reduction of pollutant emissions (such as CO2, methane and fine aerosols), which are downright "climate killers" and can also have a serious impact on health, plays a particularly important role in this context. Furthermore, in many places, nature is being given areas of retreat and "recreation" (e.g. in the floodplain forests and rainforest zones, in the moors and other wet biotopes), agriculture and forestry are being converted to "ecological cultivation" and the extraction and use of the increasingly scarce natural resources are being subjected to strict consumption and sustainability management. But so far a start has been made here at best - and the time until a possible environmental and climate collapse is becoming ever shorter (especially since nobody knows where the "tipping points" are where the climate irreversibly tips over into a new "regime").

Of particular importance in all this is **environmental management**, which operates at the interface between humans and nature. Of course, the socio-cultural systems of the past have never been disconnected from the ecological systems of nature,

so that man-made "environmental crises" have occasionally occurred in the past: For example, deforestation for the construction of houses, ships and mines or for the firewood needed for heating and cooking in larger settlements or for the operation of smelting furnaces; the extensive and intensive grazing of meadows and savannahs, excessive hunting of game or excessive exploitation of fishing grounds, the diversion of streams for the operation of water mills or the pollution of waters by tanneries and dye works or for paper production have already caused serious environmental damage or pollution relatively early in human history. For this reason, the first tentative measures, e.g. for water, soil and forest protection, can be traced back to the Sumerians and ancient Egyptians as well as to ancient India and China and even to the pre-Columbian cultures of ancient America.

But the environmental problems that had to be overcome at that time, which resulted from a precarious interplay between human demands for use and nature's limited capacity for self-regeneration, were nothing compared to the problems we face today, since the existence of man (and with him numerous plant and animal species) is clearly at stake. Now, environmental management that takes all relevant factors into account is becoming indispensable, even essential for survival. But this is easier demanded than put into practice! As already mentioned above with regard to economic globalisation and a generally unregulated technization of all areas of life, we do not even have control over our own socio-economic systems in which we interact, communicate, produce and trade with each other. For not only have the movements on the markets for goods, services and finance become increasingly inscrutable due to their intransparent structures and global interdependencies, but the political and intercultural conditions are also so confused, sometimes unstable and polarised that we have cause for concern here too. Therefore, for many contemporaries, an intact nature seems to be the (utopian) counter-image to the confused and precarious conditions within the "world society" of competing states and social as well as religious-fundamental movements and groups. But this is deceptive: for in nature, too, everything is in a constant state of flux, and in the history of the earth there have already been repeated cases of enormous "natural disasters" (such as "big extinctions" of many species). And in general, the diversity of species and climatic conditions that we can observe on Earth today are the result of a natural evolution that has dragged on for billions of years. And even within a single biotope, there is not only sheer harmony and peaceful cooperation (in the sense of sociability or symbiosis), but above all an all-round struggle for survival over scarce food resources, which repeatedly leads to unstable situations and the resilience (resistance) of the biotope to its limits: New advantageous mutations give one species a survival advantage over another species, or the immigration of alien species releases unsuspecte forces of selection that can lead to the displacement or even extinction of endemic species. But it is true: sometimes biotopes or special ecosystems remain relatively stable over a long period of time by repeatedly succeeding in dampening any fluctuations that may occur (e.g. fluctuations in the composition or internal dynamics of the system).

And a comparable mastery of dangerous fluctuations is of course also sought in human social systems: above all through the formation of value and legal systems and the establishment of executive institutions (such as the administration or police), in order both to establish and to control and maintain "law and order". Cooperative,

administrative and work-sharing processes play a decisive role here, as do clear assignments of social roles with specific rights and duties, as well as political power relations. And for all of this to work, citizens need to have confidence in the legitimacy and non-corruption of governance; but also in the justice of legislation and the adequacy of law enforcement. As long as the majority of the population has this basic trust in the state institutions, the social system will be able to function smoothly for the most part and will endure (otherwise there is a risk of uprisings or even revolutionary upheavals).

In nature this is quite different: For, apart from certain "friendly" convivial relationships within animal societies (e.g. in the case of great apes) or the rigorous division of labour within bee or ant colonies, in nature it is predominantly "physical superiority" that dominates, so that violence and "natural intelligence" set the tone here. In short: here the "law of eating and being eaten" determines the biological process. And only within groups of animals from a certain stage of development (as with mammals and birds) are cooperative behaviour, care and even helpfulness observable, since here the individuals are dependent on each other for their survival and well-being. Thus, a preliminary stage is already reached at which "social learning" to a rudimentary extent is already possible. This development finally takes its most pronounced form in humans. For in human social systems the propensity to violence (aggressiveness) is usually "channelled" through the acceptance of moral rules of the game (values and norms) and through ritualised forms of behaviour and thus kept within limits. Ideally, this peaceful organization of all human concerns can encompass the whole of humanity - but we are still a long way from this, as the armed conflicts in several regions of the world show. It is therefore one of the greatest and most difficult tasks of every human community and society to keep the inner potential for violence of every human being, which is an inherited part of biological evolution, as low as possible, for example through education and the threat of legal punishment, or to redirect it to harmless areas of behaviour (such as sport, but also state-regulated competition for market advantages, career opportunities, etc.). However, since this is only ever possible within a society, it usually maintains an army that can defend it against external enemies in case of emergency.

But why all these long remarks on the structure and functioning of *social* systems, when this article is about social-*ecological* systems? The reason is that this kind of system modelling is not only about ecology, but also about sociology and other social and cultural sciences - yes, it must be! It is important for us to point out the characteristic differences in the nature of natural ecosystems and cultural human systems. In SES theories, knowledge of these differences is usually presupposed - with the consequence that the interaction of these different types of systems is only incompletely understood and often even causes misunderstandings. However, the quality and strength of "systemic thinking" can also be seen in the extent to which the special characteristics of different types of systems have become conscious. For only then can the inter-systemic relationships be adequately understood. The epistemological prerequisites for the description and understanding of human social systems are in part very different from those for the analysis of ecosystems - and in some respects even opposite to them. A *complete* SES theory must therefore try to do justice to both types of systems. At the very least, however, it is advantageous to be aware of the different modes of operation of both types of systems. Failure to do so can easily lead to certain misjudgements from which even science is not spared: A famous example is the so-

called "naturalistic fallacy", which is based on the fact that one derives from the observation that in nature obviously always the stronger one survives, the idea that there is or should be also in human society a "right of the stronger one" (which leads to the well-known "Social Darwinist" ideologies). Generally applies: Both the resolute fighting position against the "dangerous nature" and the attempt to raise the allegedly so "harmonious nature" to the model for human behaviour, as well as also the idea that nature is only a "stock" of economically usable materials and energies from which one can make use of as one likes, are only expressions of a deficient attitude of consciousness that lacks the ability to differentiate. In particular, opinions have always been divided on the question of whether and, if so, what we can learn from nature. To mention just two of the frequently asked questions: is there a universal "natural law"? Are there "natural foods" so that genetically modified foods are to be rejected? An appropriate answer can also be found in a system theory that is suitable for the different food groups.

Let us ask, for example, whether the laws prevailing in nature (such as those of "natural selection") can provide a model for the organization of human communities by adopting them for stabilizing social dynamics and for containing the above-mentioned "tendency to aggression", which is apparently innate in humans. Let us ask, then, whether authoritarian state regimes are better able to contain the propensity to violence of their citizens by controlling them with police and intelligence measures than democratic communities which, in the legal "suppression" of interpersonal and political violence, depend on the free consent of their citizens in order to be legitimate? And are such dictatorship-like states therefore more stable than democracies? Answer: From a systems theory perspective, this question cannot be answered in the affirmative, since authoritarian regimes always lead to the mobilization of internal resistance after a certain period of time and then to insurrections; even in the case of natural disasters (e.g. Even in the case of natural disasters (like earthquakes and floods) they often react more ponderously; and finally, economic emergencies based on central economic planning can be rather difficult to cope with, since individual action is usually given too little leeway (at least this applies to extreme forms of inwardly repressive rule). Therefore, "free societies", in which great importance is attached to the democratic and civil liberties of the individual, cannot necessarily be considered more unstable or crisis-prone than authoritarian states or collectivist communities. Liberal societies are generally characterised by a high degree of innovativeness (inventiveness) and a not inconsiderable ability to adapt (flexibility) in times of crisis.

If we now look at modern civil societies of the democratic-legal state type, it is striking that they consist of a "mixture" of self-organising (informal) processes on the one hand and of politico-legally regulated (i.e., from the perspective of the individual, "externally organised") processes on the other. This is of course due to the fact that humans can take up a "reflexive distance" to themselves, i.e. they can reflect on their actions and will and take responsibility or accountability towards other persons. On the other hand, we do not find such a "mixture" or overlap in ecological systems in nature (as long as we do not intervene in them from the outside): natural ecosystems are rather consistently self-organized - for here there are no "controlling instances" that would counteract the "blind" natural processes: i.e. no cooperative planning or evaluation of measures implemented in order to correct their results or to optimize the instruments

and methods of action. Only human beings seem to be able to evaluate the consequences of their actions and to learn from them in a sustainable way (even to foresee such consequences within limits), to stimulate and promote new technological developments and to reorganize the forms of their collective action again and again, if this seems necessary or useful. None of this is possible in nature.[13] Nevertheless, we will see later on that there are also certain "margins" and "degrees of freedom" in natural ecosystems which contribute to the resilience and stability of the system; only that this has nothing to do with "free decisions".

And the ability of humans to learn from failures (bad planning) is also absolutely necessary, because in complex social contexts (for example, in the case of a comprehensive reform of the tax or health system or an attempt to reorient economic processes) it is often not possible, or only to a limited extent, to foresee the potential effects of innovative action. And even the assessment of the long-term consequences of habitual actions can be extremely difficult - as the example of the continued "overexploitation" of natural resources impressively shows, where in the early phases of industrialisation mankind abundantly "naively" assumed that the planet's raw material and energy reserves were inexhaustible. This attitude has now changed fundamentally. However, some politicians and economic experts still behave as if they believed they

13 An area of arable land does not develop by itself, but is the result of a planned reclamation of wilderness, because it first has to be wrested from nature. Of course, many (perhaps even all) living creatures also structure their environment according to their "interests" and habits (think, for example, of beaver castles or termite mounds, which can greatly change and shape the existing landscape; or coral reefs and guano bird colonies), but below the primate level, all these activities take place on the basis of an innate instinct program, because the non-human creatures cannot choose an alternative for their behavior. Which is why one rightly tends to distinguish between merely instinctive or reflex-reactive behaviour and human action: because only action is intentional and purposeful, and there are usually alternatives for action between which a "free choice" is made. Obviously, only man is capable of acting in a fully purposeful and reasoned way, setting priorities and making plans with the help of his imagination. This is the source of man's special responsibility for his actions and omissions: Only man can demand justification for his actions. It is true that higher "intelligent" animals can occasionally "trick" their fellow species by apparently deliberately deceiving them, e.g. about the location of a hidden prey, but we would not hold them accountable or assign blame to them for this. Only from humans one could expect a "bad conscience" here, if they have violated an existing moral or legal norm. Some people might reply that their dog knows very well when ithave done something "bad". However, it is more likely that the dog merely realises that his owner is angry with him and he must therefore fear his anger. - But the fact that man alone is a "moral", i.e. responsible being, does not mean that other living beings need not be granted any "ethical value" whatsoever: that a fox, for example, cannot be guilty of "chicken theft" does not justify that man may treat it as if it were some "thing", since the fox is a sentient being that is capable of suffering, so that here there is a ban on inflicting suffering on man. He may indeed defend his chicken possessions against the fox, but without causing avoidable suffering to the animal. Above all, however, a predator must be granted an unconditional right to life, since this too has a morally relevant "intrinsic life value". Animal protection not only serves the preservation of the species, but also insists on the well-being of every single individual of every sentient animal species. The preservation of biodiversity on this planet should therefore not only be done out of self-interest, but also out of ethical respect for all living things. In this respect, nature conservation is also an "ethical duty". (The reader will find more detailed explanations in Paslack 2012, p. 65 ff).

could make a deal with nature - as they are used to doing on the international diplomatic scene. But you can't make "offers" to nature, for example to gain time before an important "tipping point" is reached, after which climate change and all its associated consequences (such as species extinction, rising sea levels, expansion of desert zones) will take their inevitable course.[14]That is precisely the problem: nature simply always follows its own unchangeable laws and is not open to discussion. Whatever cumulative or systemic feedback effects occur here (for example, in the case of progressive ocean acidification or the increasing release of methane from the Siberian permafrost soils due to a "positive feedback" between rising temperatures and methane emissions), it simply *happens* because the laws of nature *require* it to happen just that way (not only *can* it, so that there could be a kind of "bargaining space"). So while "positive legislation" in human societies repeatedly permits legal adjustments in the form of amendments to the law, the laws of nature apply absolutely and irrevocably. The only thing that humans can do in such a situation is to respect the prevailing laws of nature either by exercising restraint, by treating natural resources carefully and sustainably (for example, by reforestation or by allowing fish stocks time to recover), or by technological means, for example by tapping new (non-fossil) energy sources (for example, through wind power and photovoltaic systems) or by using the latest technologies. structuring the products of his economic activity from the outset in such a way that they can be reused ("recycled") in order to reduce the consumption of new raw materials as far as possible. In other words: Man can only ever act in accordance with the laws of nature by *obeying* them or using them technologically, but not *against* them.

This may be a truism, but it leads to considerable consequences for any system management at the interface between man and nature. For while we can only ever change the behaviour of ecosystems in a planned manner to the extent that this is possible within the framework of the applicable laws of nature (or the genetics based on them), we can change the rules and patterns of our own behaviour to a far greater extent because, unlike most other living beings, we are not (or only rudimentarily) bound by instinct programmes in our actions, so that we can rethink the appropriateness of our behaviour and institutions and can also fundamentally transform them at will.Precisely such a rethinking of our modes of action and the performance of our institutions seems to be necessary at present to answer the central question of the management of social-ecological systems: How can we gain "control" in the development of the human-nature relationship so that this relationship does not lead to social-ecological chaos? To do this, we obviously not only have to understand how ecosystems function, but we also have to

14 Environmental politicians are therefore moving in a terrain that confronts them with unusual tasks, because there is an exchange with nature, but no dialogue. And although man can fight for his life (for example in the case of an earthquake or a flood disaster), he cannot fight against nature, because nature itself is neither against nor for man, but simply happens. Nor does nature know any "catastrophes", but only restructurings of a lesser or greater extent. What we can learn from nature, therefore, are not rules for our coexistence, but only model solutions for technical questions regarding feasibility, effectiveness and efficiency. And finally, we can also learn something from nature about the biological foundations of our own species: e.g. about those "archaic" psychological mechanisms that shape and control our spontaneous behavioural reactions (reflexes). Above all, however, our knowledge of nature can help us not to damage or disturb those natural conditions and natural processes that are indispensable for our survival.

create at least enough order in our "own house" so that an orderly and promising approach to social-ecological management becomes possible at all! Consequently, we must not only identify and learn to control the "critical points" within the dynamics of ecological systems, but also the "neuralgic points" within human societies. A reordering of the relationship between man and nature thus requires a reordering of the world social conditions, which above all concerns the orientation of the global economy. Otherwise, all the fine theories of social-ecological systems that have already been developed will remain largely a waste of time.

What does this finding mean for the tasks and procedures of a management that attempts to harmonize the social structures, economic interests and technical operations of human societies with the structures, processes and laws of the ecosystems that are important for our survival and well-being? Such management will itself have to take on a systemic character. And it will ultimately have to treat the interplay between human social and ecological systems as a *single large system*, in which the human and ecological systems, each with their own dynamics, form "subsystems", as it were, which do not operate independently of one another, but rather touch and constantly influence one another at countless points. Therefore, it was obvious to develop a theory of so-called "social-ecological systems", in particular to be able to depict the interplay of ecology and economy (but also of other areas of human practice) in models, and to gain knowledge from these models that would allow us to estimate and evaluate every conscious intervention in the natural environment, but also every other effect on it. This is an extremely difficult undertaking, which places high demands, especially on the methodological approach: in order to be able to create a factually appropriate model that is instructive for practical purposes, it is necessary, for example, to determine all relevant components of the system, all constants and variables, and to develop indicators with the help of which we can monitor the ongoing changes in a socio-ecological system (and thus the success or failure of our environmental measures). This is a huge task for theory and modelling, which cannot be solved in one fell swoop, but only gradually, by gathering experience and feeding it back into the model so that it gradually takes on a meaningful and practically useful form.

6.1.2. Basic properties of complex dynamic systems

The following presentation goes into detail mainly because its intention is to sensitize the reader to "systemic thinking". The reader should be familiarized with the basic concepts, but also with the pitfalls and difficulties of their application. Therefore only a little foreknowledge is assumed. Gradually it should become clear what it means to see reality as one system or as a network of many (sub-) systems. As is well known, it can easily happen that one cannot see "the forest for the trees". However, in the system analysis it is precisely the "forest" that matters, because forest trees behave differently than single trees. But it is not true that any tree would ever stand alone: there is always a soil rich in water and bacteria on which it stands, and there is always an atmosphere, often covered with clouds, and a sun that gives light, with which every tree interacts (even if the tree does not, of course, react to the distant sun itself, but can only use its light energy photosynthetically for its metabolism).

In general, "systems" can be defined as controlled structural populations of more or less many components, in which the relations between the components are more important than the components themselves. In this book, however, only *dynamic* systems are dealt with (not, for example, systems of thought, not systems of concepts or classification). And the systems discussed here are particularly *complex*, i.e. internally networked in many ways, with their components interacting or "communicating" with each other in different ways. Also, the components here are by no means all the same, but often very different. Therefore, only those systems which form a *holistic* structure-process-connection are discussed here. In addition, the systems considered here are all *self-organized* and *self-sustaining*, i.e. not planned or "constructed" like machines. Moreover, they are capable of *evolution* in that they can change their internal structures, their rules of operation and also their size (their spatial extension, but also their temporal duration). Finally, the systems of interest here are (at least to a large extent) *"functionally closed"*, which stabilizes their order and makes them to a certain extent resistant to disturbances from their environment. The systems we are dealing with in this book are probably even the most complex dynamical systems we know of. Accordingly, it is challenging and difficult to understand these systems theoretically and to manage them successfully in practice.

If we are talking about a "social-ecological system" (SES)[15], then we are obviously dealing with an extremely complex dynamic system - or more precisely: with a whole network of different systems, all of which are interdependent and whose internal and interdependent interactions lead to results that cannot be predicted, or only within limits. Especially since we are not used to thinking in terms of complex ("circular-causal" and non-linear) process sequences and, moreover, to taking into account the immense amounts of data that are generated when observing these processes: if we have this data at all, because they first have to be obtained laboriously and in a methodically reliable way. And even if we had all conceivable empirical data available, even then we would still have to find out which of them are important and in what respect. This also means asking the right questions and having the methodological (especially mathematical) tools at our disposal to order and evaluate the data material appropriately. In short: In order to obtain a meaningful result, we must also be able to *interpret* the collected data, because only then will it become informative and worth knowing. And it goes without saying that the creation of a comprehensive model can only be achieved in an *interdisciplinary* manner, i.e. only through the cooperation of numerous social, cultural and natural science disciplines. A single academic discipline would simply be overtaxed here.

15 In the German-speaking world, the term "socio-ecological system" is also commonly used (in analogy to the descriptions of socio-cultural, socio-economic or socio-technical systems). Instead of speaking in the singular of only one "socio-ecological system", one can also speak in the plural of many "socio-ecological systems", if one takes certain "ecological complexes" (or systemic units) out of the "ecosystem earth" and thematizes them for the analysis. Thus there are not only countless local ecosystems but also many regional ecosystems, which all together make up the global ecosystem of our planet. The methodological problem of how individual social-ecological systems can be "tailored" or separated from each other will be discussed further below.

In the following the essential characteristics of complex and dynamic systems are described.[16]Because these characteristics are also of central importance for the "social-ecological system" discussed below.

6.1.2.1. Self-organisation, "environmental openness" and "operational coherence

Systems of the social and environmental type are essentially self-organising, as already indicated in the introduction (7.1.1.). What is meant by this is that such systems both build up their internal structures themselves and also themselves (autonomously) determine the rules according to which this structure is built up and reproduced (structure maintenance). In contrast to "trivial" machines (e.g. automata), there is no constructor here who determines the structure and processing (functioning) of the system from the outside, nor is there an internal central instance that would control this "self-generation" and self-regulation, but instead a complex interaction of all system elements or structural components from which the form and functioning of the system "emerge" spontaneously (i.e. undirected and unplanned) - which, however, usually does not happen at once, but over numerous steps (evolutionarily). And, of course, this process can only ever take place within the framework of the applicable laws of nature, whereby (as we will see later) the "mastery" of the laws of thermodynamics plays a special role. But for such systems to determine their structure and behaviour themselves, on the one hand, and to be able to develop further by continuously adapting to changing environmental conditions, on the other hand, they must be *"evolutionarily open"*. For this purpose, the individual system elements must not be too "rigid" (inelastic) linked, so that "evolutionary leeway" can open up in the network of their interactions. We are therefore also dealing here with "self-adaptive systems".[17]

If one speaks of a "system", then one must also speak of the "environment", since both terms form a pair: namely of *its* environment, because complex (e.g. living) systems are not simply located in an "environment", but maintain very specific exchange relationships with it, with the consequence that not everything that happens "outside" is (at least not directly) relevant to a particular system: Only that which the system "needs" for its maintenance is of interest and segregated from the environment. This means that such a system is "sensitive" (receptive and reactive) in a particular way to a particular "segment" of the overall reality: and this "segment" then forms the specific "environment" of the system. Thus, for example, social human systems with their various subsystems (such as economy, law and culture) are usually only "interested" in specific aspects of their environment: for the economic subsystem of society, for example, objects in nature (deposits, water resources, cultivable creatures,

16 The description of the basic properties of complex dynamic systems is essentially based on preliminary work of one of the two authors of this chapter: see especially Paslack (1991), Paslack (2012) and especially Paslack (2019).

17 The term "self" here, by the way, does not refer to some ominous "self" to which all processes are related (as we assume in the case of the psyche, insofar as at least all conscious processes here refer to an "ego-self"); rather, in a term like "self-organized", the "self" means only as much as "spontaneously" or "by itself" occurring.

etc.) that can be exploited economically (and with which money can be made) are of particular interest.

This "selective access" to the environment, which provides the system with its special environment, is now meaningful and understandable from the point of view of the system, but with it the overall reality has by no means disappeared, but has only been faded out on the basis of a certain "systemic perspective", i.e. has been pushed into the general "world background" (horizon of being). For, what is taking place here is merely a respective system-related "reduction of world complexity" (as the German sociologist Niklas Luhmann has called it), which the system has carried out for its own purposes in order not to have to pay attention to everything at once, i.e., to have to "intrasystemically process" the entire diversity of being, which would inevitably lead to an operative overload of the system. This selective restriction of the "gaze" is, however, not free of certain risks, since it can also easily make one "blind" to processes in one's environment, which may well be of considerable relevance for one's survival and well-being! And it is precisely this situation that humanity is currently in, having operated at the expense of nature for too long and now having to realize that its interventions in nature have led to contamination and degradation on the one hand and (in connection with this) to cumulative developments (such as a "critical" accumulation of carbon in the atmosphere and rising temperatures) on the other. These developments could also be easily overlooked for a while because they were outside of the focus of the economy, settlement planning, water regulation and transport.

Although care has always been taken to ensure that "small-scale" and "medium-term" (i.e. in relation to the planning project currently underway) the available natural resources are used as sensibly and efficiently as possible, the more complex, i.e. "long-range" and "long-term" feedback effects within the self-dynamic balance of nature could or would not be taken into account. In psychology one would probably speak here of a certain "operational blindness" or short-sightedness. But still, nature with its huge net of interacting ecosystems is completely there! So if nature is to continue to form a viable environment for us in the future, we must find a way to overcome the "home-made" (human-systemic) limitations of our environmental perception at least as far as is necessary for the future viability of humanity. This is not least also a commandment of intergenerational justice, insofar as also our more distant descendants have a right to a living environment that allows them a bearable, even pleasant life in exchange with a nature that is as intact as possible.

But how could we, despite our "systemic glasses", achieve this extended "environmental openness" towards nature? Fortunately, there is a special "functional system" among the subsystems of modern society, which is now very strongly differentiated and possesses reserves of knowledge that allow us to look beyond our predominantly economic interests in the utilization of nature: science. Even though science (like any other function-specific social system) is bound to very specific "functional imperatives" (knowledge and cognition) and "methodological standards" (e.g. experimental rules and statistical relevance criteria) as well as to "discursive ideals" (only the best rational argument counts), it is nevertheless in principle capable of acquiring all knowledge about nature that is possible for man and making it available for other social purposes. For this, however, society must consistently orient itself as a "knowledge society" that subjects all its planned or even unintended interactions with

nature to a rational examination according to scientific criteria. And in this process not only the findings of the natural sciences would be discussed, but the methods and knowledge stocks of the social and cultural sciences would also have to be included, since human interests in the use of nature should continue to exist. All relevant scientific disciplines, including, for example, the engineering sciences or psychology and medicine, must therefore be involved in developing a comprehensive and practicable model for the processes in social-ecological systems.

In all this, the aesthetic aspects of our experience of nature should not be ignored either, which cannot be easily integrated into a scientific model, but which have a significant influence on our general relationship with nature: an intact nature, that is always also a "beautiful nature" in which we feel comfortable and can gather new strength. So this aesthetic and emotional interest in nature must also be taken into account when we take measures to care for the environment and protect it. The conservation of natural resources and landscapes as well as the preservation of biodiversity must therefore always include the aesthetic (and perhaps even spiritual) needs of human beings, because as a cultural being we do not only do business, science and engineering.[18]

If we now summarize the aspect of the "environmental openness" of complex systems with the aspect of their self-organization and internal self-regulation (according to autonomous rules), the following picture emerges: All social and ecological systems will, on the one hand, be dominated by their own rules, which is why they can be regarded as **"operationally closed systems"**, but on the other hand they also represent

18 In religion and in the fine arts (but also in poetry), man's relationship to nature has always been of great importance: But while art (starting with antiquity) has almost always virtually celebrated the beauties of nature and at times even took nature as its model, the high religions (Judaism, Christianity and Islam) in particular have often attached a rather dubious value to nature (which often included the low esteem for the human body and "sinful" sexuality): for example, when the Bible speaks of man's "subjugation" of nature - an imperative that modern technological civilization has been all too happy to follow. But there are also indications here that nature should be cherished and cared for like a "good shepherd", since it too (besides soul and spirit) is a "creation" of God and therefore worth preserving. Altogether the relationship of religion to nature (and this already in myth) is marked by a high ambivalence. In contrast to this, artists have often felt that their own creativity is often twinned with the creative nature. But it was precisely this that sometimes made them suspicious of religion: did the artists want to be "equal to God", i.e. to become divine themselves? A reproach that many theologians and believers, however, also made to research and technology. This "hybris" accusation used to mainly concern efforts to "create life" (such as the golem or the Frankenstein monster). At present, the suspicion is more directed against certain developments in the area of “Artificial Intelligence”, genetic engineering (e.g. kloning), the possible creation of cyborgs (man-machine hybrids) and "synthetic biology" - precisely because life and spirit are divine creations that should not be artificially simulated or manipulated. For today it is rather the case that religion rather appreciates the value of nature - and a spiritual connection with it - (provided that this connection to nature does not drift into esoteric realms). And there has always been in all religions also a nature-mystical side branch or undercurrent that tried to read the "Book of Nature" in a contemplative way as a revelation text. There have also always been pantheists who insisted on the identity (equality of essence) of nature and God (such as Giordano Bruno or Spinoza). In any case, in art, religion and mysticism there are always efforts to emphasize and invoke the unity of (divine) spirit and nature - and thus to see man's relationship to nature not only as an economic or technical relationship.

"open systems" in so far as they absorb and release energy and matter: thus the social system continuously draws raw materials for food and production from the ecological system for internal processing or consumption, but at some point returns them to nature and its material cycles - be it in the form of waste heat or material waste. It is then also said that the social system relieves itself of everything it no longer needs and that, if it remains, it could even disrupt the internal order of the social system: physically speaking, this is an export (or externalization) of **"entropy"**, i.e. of "disorder".[19] And, of course, ecosystems (just as individual living beings already do) also are **"open systems"** that exchange matter and energy with their environment. It is thus a characteristic of operationally closed and at the same time energetically and materially open systems that they can only establish, stabilize and maintain their internal order by selectively taking from their environment what they need for their continued existence on the one hand, and on the other hand by returning to the environment everything that could impair their internal functions.

6.1.2.2. Resilience and robustness

But social systems can also, within limits, adapt to new challenges from the natural environment by redistributing and using their available resources differently or by partially replacing (substituting) needed environmental resources that have become scarce; indeed, they can sometimes even change their own rules and priorities, develop themselves further or restructure their internal processes. In other words, social systems often seem to be surprisingly flexible in their behaviour when shortages or turbulence occur in their environment that cause them difficulties or even threaten their existence. This is what makes them resilient or resistant in precarious situations.

Flexible and, within limits, resilient are also the ecological systems in which restructuring can also occur, perhaps accompanied by the death of many individuals of a species or even the extinction of entire species, but which need not result in the complete destruction of the system.[20] In this case, however, it is not decisions on priorities and measures, as in the case of human social systems, that play a role, but above all processes of population size reduction or a remixing of the species living in

19 Thermodynamic aspects (such as the effects of entropy) therefore also play an important role in some SES approaches. For example, the SOHO concept of Kay and Boyle (2008) explicitly uses terms such as "energetic dissipation", "non-equilibrium" and "exergy" (meaning the quality of the available energy): "The proponents of the [SOHO-] framework argue that as systems move further from equilibrium, exergy increases, more dissipative opportunities become available, and more organization emerges. Flows from ecosystems provide exergy both supporting and constraining human society. The flow of structurally utilizable energy in systems far from equilibrium even enables the (innovative) self-organization of these systems." This systems-theoretical knowledge does not, of course, relieve us of the need to empirically demonstrate the self-organizing structural changes in each individual system. For each system has its own (specific) "inner boundary conditions" under which it operates and evolves.

20 "Resilience can be described as the ability of a system to maintain its identity" (Cumming/Collier 2005). As long as a system is able to sufficiently "resist" major disruptions, it maintains its identity so that it remains recognisable.

them, as well as the random occurrence of favourable genetic mutations that give some species a selection advantage over their competitors. Nevertheless, such transformation processes are always risky in all open systems, so that they may not succeed in keeping themselves alive despite all efforts to adapt.[21] If, for example, humanity, which not only lives in its self-created social and cultural systems but is also part of the Earth's ecology as a biological species, should die out, then nature will of course continue to exist (geologically speaking alone): only that biological evolution would then continue without us. In order to prevent this, which is precisely why it is so important to understand the socio-ecological interactions better and better and thus also to increase our chances of successfully adapting to a changed environment. And of course it would be best if the economic and social costs of such adaptation were to be kept as low as possible or if serious environmental changes (such as major climate change) were not to occur in the first place.

The **adaptive resilience** of biological or ecological systems often goes hand in hand with **robustness**, which is the evolutionary stability of a particular property of the system in the event of disturbances or under conditions of uncertainty. The more robust a system is to external disturbances, the more it is able to maintain its original identity. For the analysis of SES and especially for the predictability of their behaviour, the identification of the "robust factors" is crucial, as they limit the scope of possible variability.

This all outlines the essential goal of social-ecological modelling: namely to identify emerging major environmental problems as early as possible and to estimate their scope (monitoring and warning function), to identify their causes (causal analysis and explanatory function) and to provide indications for efficient countermeasures (recommendation function).However, even among scientists it is not always clear which measures are the most suitable, so that fundamental controversies about the right approach often arise: Is it, for example, more sensible to "help" endangered forests by "cleaning up" them and reforesting them with more climate-robust trees from other parts of the world, or would it be better to simply leave the forests alone for a while so that they can recover by themselves and adapt to changing climatic conditions? The various social-ecological models provide quite different answers to these and similar questions, depending on the premises on which they are based.

In order to achieve all this, a special way of thinking is required: "systemic thinking", i.e. thinking in terms of understanding the interactions between recursively interlinked components that together form a "whole" in whicheverything is connected with everything else. However, "systemic thinking" is not self-evident, but must be learned and practiced. But to do this is not easy, because in general we think "linearly", i.e. in simple causal chains that develop in different directions and branch out like trees. Here we quickly lose the overview. "Non-linear" or feedback "circle-causal" relationships, as they are typical for complex networked systems, usually exceeds our understanding, especially since in everyday life we usually get along with simple cause-

21 Expressions such as "risky" or "successful" can always only be understood metaphorically in the case of natural processes, because nature knows neither risks nor success or failure, as it has no self-confidence or intentionality. However, it is extremely difficult to avoid such "anthropomorphic" metaphors entirely when talking about nature.

and-effect relationships. However, this also applies to exponential growth processes in which the quantity of a certain factor doubles in a given period of time (which is why many people find it difficult to understand the exponential development rate of a pandemic such as that of Covid 19). In addition, we are used to thinking and planning in the short term, which is why the long-term consequences of our actions usually remain hidden from us. Everyday thinking, but also the thinking of many politicians and business leaders, takes place predominantly on small temporal and spatial scales, so that far-reaching (especially global) consequences are hardly ever considered. In a sense, we almost always behave opportunistically (by giving preference to the nearest advantage) and "future-blind" when it comes to developments beyond our short or medium-term horizon of action ("in the long run"). In a strongly networked and at the same time "systemically closed" world (such as ours), however, such thinking can easily "take revenge" by suddenly confronting us with unexpected and perhaps even irreversible consequences of our actions (especially in the case of deep interventions in the balance of nature).

6.1.2.3. Limited predictability of complex system processes

It is precisely for this reason that we need to learn how to deal with complexity, exponentiality, procedural feedback, non-linearity and circular causality. And fortunately, we have a number of mathematical methods at our disposal for this purpose, with the help of which networked and recursive processes can be modelled in principle. Nevertheless, the predictive power of such processes is also subject to certain methodological limitations, precisely because these processes are so complex that even unlikely “bifurcations” and "feed backs", even "chaotic" or "fractal effects" can occur due to unpredictable process fluctuations. Therefore, measures that are intended to intervene in the balance of nature in a positive way must always be designed in such a way that even possible undesirable effects that were not anticipated remain controllable by allowing them to be revised ("retrievability").

The relative **unpredictability** of the course of system processes does not mean, however, that in many cases it is not possible to produce reasonably reliable forecasts and trend estimates (at least in the medium term): the more data we can collect on natural processes and evaluate them with suitable models and algorithms (in the sense of a "big data analysis"), the more promising the success of measures that are implemented cautiously and accompanied by monitoring as closely as possible. There is therefore less and less reason for a pessimistic or "fatalistic" attitude with regard to our positive control options for precarious developments in ecosystems. A recurrent problem is rather a lack of political and administrative will (governance) to implement the necessary environmental measures "sensitively" and consistently, as such implementation is often hindered by economic interests and conflicts. In addition, ecosystems do not respect national boundaries (just think of the global climate system) and therefore require international and transnational agreements, which are sometimes only reached with great effort (of which the difficult negotiation processes, for example, on a worldwide limitation of carbon emissions at international "climate summits" provide an eloquent example).

With regard to the fundamentally inadequate predictability of the future behaviour of complex systems (which of course includes the social human systems), we can state that every measure that intervenes in complex systems always has a certain "experimental character", since not all possible consequences can be clearly predicted: what is beneficial and advantageous in one place (e.g. improving the yield of a crop) can sometimes have quite negative consequences in another part of the ecological system (e.g. climate). And since these are "real experiments" and not laboratory experiments, the success of which is fundamentally threatened by contingency (random events), environmental managers must proceed with due caution and step-by-step (successively and cyclically) to ensure that the effects can be "retrieved"; for example, continuous monitoring is indispensable for this. Complex dynamic systems are not "trivial machines" whose functioning is well-known and which are relatively easy to master technically, but their behaviour is more like that of "autopoietic living beings" (H. Maturana and F. Varela 1980), where certain "degrees of freedom" are always given.[22] What every fruit grower knows, for example, when he sees how the same fruit trees can often react extremely differently to only slight changes in environmental conditions (e.g. slight variations in the ambient temperature or in the amount of fertiliser used, or depending on the type of pruning, etc.) This "sensitivity" of systems (be they single plants or complex ecosystems) to small fluctuations in important parameters is characteristic of the behaviour of "open" systems (even if the famous "butterfly effect" does not occur as often as was once thought).

6.1.2.4. Complexity, balance and stability

Under no circumstances - and even this is difficult for everyday consciousness to understand - should "complexity" (in the sense of a highly sensitive interaction between the system components) be confused with "complicatedness" (the number of system components): even an apparently simple physical system such as a double pendulum can prove surprisingly complex, i.e. highly variable, in its behaviour. And even in ecosystems, especially when their stability threatens to get out of hand, the number of possible "development paths" that these systems can take in an evolutionary way is sometimes unmanageable. But again, "stability" should not be confused with "equilibrium"[23], since ecosystems (and even individual organisms) owe their stability at best to a "floating equilibrium": indeed, it is even said that they organize and stabilize themselves (thermodynamically speaking) "far from equilibrium" by continuously "redirecting" (channeling) the entropy (the tendency to disorder) in their interior in such a way that it has the opposite effect: namely, to build and maintain structures; the "entropic energy flow" through the system is "managed" by the system according to its own operational rules in such a way that the maximization of entropy is achieved

22 Autopoiesis" means the "self-production" and self-reproduction of all physiological processes and their products within the operationally closed metabolism of a living being. This is because living systems are always organised in such a way that the whole of the system and all its components produce and maintain themselves recursively and reciprocally. This leads to a certain "production cycle" of all biochemical components of the organism, as can already be observed in a single-celled organism. Of course, "regulators" (genes and other biochemical "attractors" and "order parameters") on different hierarchical levels also play a role here (cf. Matura/Varela 1980).

precisely by the fact that the energy flow produces flow-optimized structures in its path (just like the well-known honeycomb-shaped convection cells in "Bénard convection" in thin layers of liquid). At first glance this seems paradoxical because it contradicts our everyday intuition, but (physically speaking) it is a completely logical and causally determined process.

In other words, the stable structure and regular behaviour of self-organising systems are subject to an "imbalance thermodynamics" (Ilya Prigogine) or a "steady state equilibrium" (Ludwig v. Bertalanffy), although phases of instability can always occur. But it is precisely these temporary unstable phases that can also increase the "resilience" of the system, its resistance and adaptability to external disturbances, so that they ultimately even form the "motor of evolution". Thus, when one repeatedly hears talk of a "balance of nature", one should actually more accurately speak of an inherent or intrinsic "stability of natural ecosystems", the maintenance of which ecosystems succeed in maintaining precisely because they process "far from (thermodynamic) equilibrium". Actually balanced or absolutely stable systems (following the model of classical mechanics), on the other hand, would be too rigid and inflexible to adapt to changing environmental conditions and would therefore easily perish. It is just that this adaptive and evolutionary advantage of structurally and behaviorally flexible systems also implies that their development cannot be exactly predicted when influenced from outside - which is a disadvantage for environmental management.

6.1.2.5. Hierarchy and heterarchy, emergence and scale differences

We have already said above that in nature there is no "control centre", no instance dominating all processes. Such a central power does not exist, at least not in modern democratic society: although there is the legislative and executive power of government, there is the judiciary and the administration, there is the police and the military, but in addition to these political and administrative institutions with their "separation of powers", there are also the economic enterprises, which act relatively autonomously within the framework of legislation, and the "free market" of goods and services, which no one is able to dominate (as long as no monopolies are created) and whose development is therefore often "chaotic". And many cultural institutions (such as religions, research, the media and numerous art institutions) also lead a relative life of their own, which, although often dependent on state or corporate financing, nevertheless follows its own rules and interests. Of course, all these institutions and actors "observe" and influence each other in an incessant game of "action and reaction", innovation and provocation, etc., but overall they form a "fluid mix" within which no one has absolute control or sets the tone. But after all, in democratically constituted social systems there is not only certain scope for self-organization and self-regulation, but almost

23 Such confusion of terms is often observed in the debate about the right balance between ecology and economy: For example, the term "sustainability" is often used to refer only to long-lasting effects or measures (in this sense, however, environmental damage could also be "lasting"), whereas "sustainable development" is characterized by the fact that a certain resource (e.g. wood or energy) is managed in such a way that (a) it can be renewed again and again (e.g. by recycling materials already used or by reforestation, i.e. the regrowth of forest wood), or if this (b) involves the use of a resource that is basically not exhaustible (such as solar or wind energy).

everywhere there is also a considerable degree of "foreign organization" through regulations, norms, state laws as well as public morality, perhaps even a kind of "guiding culture" that asserts itself in many areas.

It is quite different in non-human nature: Here, everything is self-organized from the outset due to evolutionary processes, i.e., completely unconsciously and haphazardly created solely by "accidental" physical and (bio)chemical interactions. This does not mean, however, that ecological structures of order ("order regimes") have not also arisen in nature, through which the continuation of evolutionary processes is considerably restricted in its possibilities: The respective "state of evolution" (i.e. what is already there) that has already been reached restricts the possible paths along which an ecosystem can change. This *structural robustness* or resistance of the ecosystem must then be taken into account when humans attempt to steer the ecosystem's "course" in a different direction. All natural systems have an inherent "structural conservatism" that makes it rather unlikely that innovations (of mutations or "evolutionary thrusts") will prevail (except perhaps in "supercritical" situations where the whole is at stake). The "natural order" of ecosystems (or of nature as a whole) includes not only "model solutions" (such as the flying apparatus of birds and insects) but also hierarchical structures, i.e. macro levels of order to which micro levels are subordinate. This already begins with the individual organism, which is differentiated into countless levels of regulation, whereby the central nervous system (of mammals, for example) forms only the topmost point of this hierarchical architecture.

Nevertheless, the lower levels (e.g. the cellular level) always have a certain "degree of freedom", especially in the processing of information (e.g. regarding the available amount of water or the mineral and energy supply), so that the metabolism of the living being is not always "decided" only "from above". For example, it could be that the "dirigate" of the superordinate (macrostructural) patterns in the reactive processing of unusual information, which triggers a kind of "stress" in the organism, depends to a certain degree on the variability of locally effective *heterarchical* structures in order to find an appropriate "answer". In multi-layered systems there is always a lot possible.[24] Among the unusual information that can be processed heterarchically are, for example, such "negative" (life-threatening) information that occurs, for example, in the case of an inadequate supply of vital substances, forcing the organism to take "economy measures" or internal redistribution; however, this can also involve the "perception" of damage (e.g. through parasite infestation), to which the organism must also be able to react flexibly. As far as the range of possible adaptation reactions is concerned, it is unlikely that it is always possible to make exact predictions - precisely because the dominance of established hierarchical reaction patterns can also

24 For a long time it was believed that genes determine everything that can happen in an organism. However, it is now known that other cellular processes also have a considerable influence on the way genes work (for example through the folding of DNA), which can lead to feedback between different levels of regulation. In addition, so-called "epigenetic" mechanisms have also been discovered which, especially in stress situations, mark (methylate) the DNA in a certain way so that the expression of certain genes is increased or decreased. This epigenetic modification of gene expression can even be inherited over several generations before it disappears again.

be "broken" by heterarchical processes, so that growth and behaviour move in an unexpected direction.

And systems-theoretical modelling is confronted with yet another somewhat puzzling phenomenon: that of **emergence**. This means that the special properties of *systems* cannot simply be derived from the properties of the system *components*. "Emergent properties" already emerge at the lower stages of nature's development: for example, the flow properties of water (i.e. a "loose" accumulation of many water molecules) cannot be derived from the properties of hydrogen or oxygen.[25] This applies even more to complex ecosystems that are subject to certain laws that are not determined by any of the physical, chemical or biological components involved. Therefore, only empirical analysis of the concrete behaviour of the ecosystem can help here. Only then do the "superimposed features" of the system (relative to the component properties) become apparent. The "emergent" system properties cannot be read from the system elements themselves, but only from their interaction, i.e. the interactions between them: they are thus relational properties (but again not of individual relations, but of the entire relational structure). Although a certain interaction relation presupposes that the "relations" are suitable for the relation (therefore, grazing animals, for example, interact with each other differently than with plants, for example), the character of a relation depends on the environment of all other relations: Thus, interactions always take place in the context of all circumstances and influences to which they are exposed, but also have an effect on these circumstances and influencing factors.

In other words, systems always form entireties that are "more" and different than just the totality of their parts (their elements), so we have to look at them from a "holistic perspective". This approach poses certain methodological problems, however, in that an analysis always requires the "isolation" of a certain system variable in order to observe how its variability affects the behaviour of various other system variables. Only

25 The fact that organismic systems, for example, are capable of unexpectedly assuming new properties is shown in animals equipped with a brain: here mental properties such as consciousness, sensory perception and emotions suddenly appear, which require a material basis (a central nervous system as a subsystem of the organism), but which cannot be seen by neuronal processes from the outside, since they are only revealed in the inner subjective experience of a psyche. Nobody is yet able to say how the brain arrives at its psychic functions and experiences, but this riddle (the so-called "body-soul problem") is not yet a reason to assume the existence of an autonomous psyche, i.e. independent of the brain, as is usually postulated by religions. After all, the example of the emergence of mental characteristics in the realm of higher beings shows that one must always expect surprises in complex systems. Even the question whether "life" is also an emergent phenomenon has so far not been answered convincingly by anyone. For what we find empirically when we approach nature from the outside as observers, these are always only material or energetic phenomena, i.e. physical or chemical entities and processes. Do living beings as such (i.e. already at the pre-mental stage) possess specific properties that cannot be understood from their biochemistry? Properties such as self-activity or self-determination or even "self-interest"? Do living beings only *behave as* if they were pursuing "purposes", or are "teleological mechanisms" actually effective in them? These are all unanswered questions: How vitality and subjectivity can arise within certain organisms, this eludes (perhaps even in principle) any purely materialistic understanding of nature. At best, we understand the correlations and conditional dependencies (e.g. between neuronal circuits and certain experiences of consciousness), but not the *causality* that connects objective events with subjective sensations.

then, when certain "macro-structural" mechanisms and patterns of rules within the system context have been successfully elucidated, only then can more complex internal (intrasystemic) and external (environmental) interactions be considered quasi "holistically".

Now, the components of an ecosystem are often themselves complexly structured - as in the case of organisms, which themselves embody systems - which means that these components often have a wider range of behavioural options than one would expect. From this spectrum, however, under the dominance of the macro rules of the system, only those component properties can manifest themselves that the system permits or that the components need in order to survive within the ecosystem (or within the ecosystem-environment-interaction-network): the more rigid the system-environment conditions are, the fewer degrees of freedom remain for the vital components to ensure their existence. The "surplus" of behavioural complexity does not disappear, however, but remains "latent".[26] If now the ecosystem as a whole should get into a "critical" situation, in which its stability is threatened (e.g. when a "tipping point" in climate development is reached), then a certain "loosening" of the hitherto close interactions between the system components will sometimes occur, so that their manifest behavioural scope will increase (but, of course, also the pressure on them to adapt): it may now become important that the components (organisms) have behavioural reserves whose survival value or "evolutionary fitness" they can test in a "trial and error" process; and genetic mutations, too, now have an increased chance to prove their advantageousness for survival within the ecosystem. This is one of those stress situations in which "heterarchic impulses" are able to partially or temporarily overcome the dominance of hierarchical ecosystem structures: Fluctuations in the structure and behaviour of the subsystems (the organisms) can under certain circumstances even lead to a change in the macrostructures of the ecosystem, for example by a certain species gaining a hitherto impossible preponderance over the other species of the ecosystem, thereby changing the character of the ecosystem as a whole.[27]

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26 The astonishing adaptation strategies of birds, for example, which have become accustomed to life in the city by tapping into new food sources (e.g. inspecting garbage cans or picking the aluminium caps of milk bottles or cracking open nuts from passing cars), show what possibilities, especially learning capacities, can be hidden in more intelligent animals. As a result, our settlements have become new ecosystems not only for us humans, but also for non-human "opportunists".

27 In the field of humane social systems this is not infrequently the case. If, for example, a company gets into an economic imbalance, so that its continued existence in the market becomes questionable, then sometimes the (formal) management structures that have been firmly established up to now are loosened, in that the creative imagination of the employees suddenly takes on greater significance even at the lower levels of the company's hierarchy: the "informal relationships" between employees are now more important and the normally low level of "bottom-up" feedback is becoming more numerous and significant, making the corporate system as a whole more "informationally transparent" and the decision-making process more open. In addition, however, there is often an increase in "external organisation", in that the management calls in an external consultancy firm to explore the company for internal restructuring possibilities (e.g. savings and redistribution).

In the case of "social-ecological systems", we are now dealing with the special case that man, on the basis of his intellectual capacity, can even conquer a certain amount of freedom from the restrictive natural conditions by using his innate "surplus" of cognitive powers to devise technologies with the help of which he can apparently transform or exploit his natural environment at will. While this creative surplus of human thought and action (e.g. being able to do higher mathematics) is only a random result of biological evolution but, once it is there, it can provide man with a tremendous potential to eventually expand into all available habitats on Earth, i.e. to subject all natural resources to his interests. It is precisely this that has made humans the most successful species on the planet - and a threat to them.[28]

What makes the prediction or management of ecosystem development even more difficult are the *different* time scales on which ecosystem processes take place (with the consequence that, for example, the effective regeneration of forest stands or animal populations takes different amounts of time); also cumulative processes (which can occur particularly in the case of contamination and are often difficult to slow down); finally also periodic fluctuations (for example in the sizes of a predator and prey population) or climatic rhythms (e.g. in the El Nino phenomenon). Despite their regularity, even these can only be predicted and modelled within limits in terms of their impact. But at least they provide a framework within which the "order of nature" can be understood in principle.[29] However, knowledge of the universal laws of nature alone is not sufficient to understand the specific behaviour patterns of complex ecosystems: The peculiar "rules of the game" that determine the structure and functioning of the various ecosystems do not exceed the framework of natural laws anywhere, but they cannot be directly reduced to physics and chemistry. And this is perhaps the most important lesson that can be learned from the analysis of ecosystems.

6.1.3. Different approaches to modelling social-ecological systems

Modelling the relationships between humans and nature in a *single*comprehensive "social-ecological system" is in some ways much closer to reality than a systems-theoretical modelling that compares human social systems with ecological systems. This is because such a contrast, which corresponds to the traditional opposition "culture vs.

28 What may be considered an "evolutionary success", however, is not easy to determine: Are not, for example, the soil bacteria or numerous species of insects, some of which have been colonizing the Earth for many millions of years, to be regarded as at least as successful (if not more successful) as humans, who have only been appearing for a relatively short time? What really is "success" is ultimately determined by the length of time spent on this planet. Also, "more complex in structure" does not always mean "ecologically fitter": for it is precisely its enormous biological complexity that could soon be the undoing of mankind and make it a "threatened species".

29 One should always keep in mind that the periodic (i.e. regularly recurring) processes in ecosystems should be regarded as properties of evolutionary, disruption-prone and flexible systems that are more variable than the periodic processes in "conservative systems": as in the case of the solar system, for example, where the planets and moons follow their orbits extremely closely, so that solar and lunar eclipses, for example, can be predicted very accurately.

nature". It is true that (as Niklas Luhmann, for example, has said) the communicative processes of a society can be described as an operationally closed system, relative to which nature as an ecological overall system ("Gaia") only forms the environment of the society; but on the one hand, intra-societal communication is not little concerned with the exchange relationships with nature, and on the other hand, people, the social actors, are not only citizens of socio-cultural communities, but always also natural beings. Seen in this way, namely from an anthropological point of view, nature is present to us not only as an environment, but at the same time also as an "in-world"; which is already visible in the fact that we all have a body, i.e. we are biological organisms and must therefore be nourished, protected and cared for in order to be able to exist at all.[30] From a biological point of view we are only "higher animals" with special mental and linguistic abilities, but at the same time we are also equipped with "natural needs" which we can only satisfy materially. The way we deal with our own bodies or with the bodies of other people may be culturally shaped or "transformed", but our bodies still remain thoroughly organic bodies, i.e. "natural things", which we use in physical work (despite all the support of all kinds of technology) or with or on which we use violence (in war, corporal punishment or when committing violent crimes). Last but not least, we need food, clothing and shelter for our physical survival and well-being; as well as the services of medicine when we fall ill, or of physical hygiene and health prevention in order not to fall ill in the first place. In fact, our body, our naturalness, is the very centre of social life - and this also applies to the execution of our communications, which, even when communication technologies are used, ultimately remain body-bound.[31] Our biological nature asserts itself everywhere: in work and sexuality, in sports, games and dance, in procreation and motherhood.

In other words, cultural human systems have always been intimately intertwined with ecological natural systems, because we ourselves "embody" ecologically integrated natural beings. Therefore, it is right, because it is appropriate to the matter, that the theory of "social-ecological systems" considers human cultural activities from the outset as integrated into the more comprehensive ecological system of the earth (even if, for methodological or pragmatic reasons, it often only considers local or regional sections of this global ecosystem). Although the global ecosystem may be substructurable (i.e. subsystemically differentiable) into human-cultural system formations on the one hand and "purely natural" ecosystems on the other, which then interact with each other, there is actually only *one* "universal" socio-ecological system: Planet Earth as a whole. And what is to say about its environment? Well, this is all that which is already mentioned in

30 We become aware of how ambiguous and vague the system-environment relationship is when, for example, someone speaks of "his" environment, whereby he usually means his residential environment or social milieu. Here the speaker functions, so to speak, as the "reference system" to which everything else around him refers. And indeed, every single living being already forms a complex organismic system for which everything else belongs to its environment. So there are - strictly speaking - as many environments as there are reference systems, i.e. innumerable.

31 The fact that almost everything in society is permeated by the physical, even carried by it, is something we become particularly painfully aware of in "Corona times", since we have to practice "physical distance" among ourselves and the physical closeness of our fellow human beings increasingly begins to be lacking; conversely, the possibly infected body of the other person can also become a threat.

a well-known children's song: "Sun, Moon and Stars". However, not everything that makes up "space" is equally relevant to the Earth's ecosystem: most important here is probably the Sun, which gives light to the Earth; then there is the Moon, which is involved in regulating the tides, for example; finally, there is also cosmic radiation from electrically charged particles, which fortunately is largely reflected by the Earth's magnetic field or deflected towards the poles, where the fascinating northern lights often appear.[32]

Here it is also evident that almost all systems (especially those in the natural world) are ultimately *theoreticalconstructions*: What we actually perceive in nature are always only conspicuous interactions, dependencies, correlations, causal relationships, etc., but in order to be able to "see" systems in this confusion, we must construct system models whose boundaries to their environment are often blurred or fluid: In the case of an isolated desert oasis, it is still relatively easy to understand it as a system delimited towards the desert; but even in the case of the Wadden Sea or an atoll, such a delimitation towards the open sea is not so easy to achieve; and certainly not in the case of the tropical rainforest, which frays everywhere at its edges, so that it is not possible to say exactly where it actually begins and where it ends.[33] And from how many trees and at what distance between the trees does the ecosystem of a *forest* actually begin? Of course, the scientific demarcation of an ecosystem from its environment is not arbitrary or random, but always based on certain criteria (i.e. according to certain empirical indicators, general definitions and pragmatic aspects), but ultimately we have to draw a more or less clear line somewhere in order to arrive at a "system" whose behaviour we can then analyse. Whether we have made our system delimitation correctly (or whether it is too wide or too narrow), this is basically only revealed in practice, i.e. by the success of our model-based predictions about its development or also by the success of our interventions in the system, if everything develops exactly as we intended. And after all, the appropriateness of a particular system model is not only about the correct spatial delimitation of the system, but also about having captured all relevant factors (all

32 As far as the rest of the solar system and the space of fixed stars is concerned: their existence is mainly based on the ecological development of the earth in a historical perspective - for example, when a large meteor hits the earth (which has already led to some "great extinctions" in the past of the earth: such as the extinction of the dinosaurs at the end of the Cretaceous period about 65 million years ago). However, compared to the considerable influence of the Earth's own volcanism and the ice ages, some of which were caused by the Earth's orbit, the other influences of the farther reaches of space on the Earth's history can be described as marginal or subtle. All in all, it can be said that the "spaceship Earth" forms a largely closed system that is hardly or only rarely affected by the extrasolar rest of the universe.

33 A system-environment delimitation is still most clearly successful where we are dealing with structures which we have also constructed ourselves as realities "bottom up": e.g. in companies, social groups or political institutions which are based on a clear and arbitrary demarcation between internal organisation ("internal milieu") and external environment ("external milieu"). Such functionally unambiguous demarcations are actually only found in nature where a living being has self-organised a cell membrane (as in the case of a unicellular organism) or an outer skin (as in humans) so that it *actively* demarcates itself from its environment in order to become "autonomous" (even if not self-sufficient). However, we do not find such a self-organized "membrane" in ecosystems.

parameters and variables) so that we can arrive at a complete picture of the presumed system context.[34] As is common practice in (natural) science, the criterion of success has replaced the criterion of truth: Nobody can say what nature itself is like, so we rely on the plausibility of our theoretical premises and on the success of our experimental expectations and computer-aided modelling.[35]The climate models of the IPCC (the "International Panel of Climate Change") are a good example of this. However, this already applied to the early future scenarios in the reports of the "Club of Rome".

If one thinks the theory of social-ecological systems to its conclusion, then the original system-environment relationship is transformed into a comprehensive *world relationship* in which man can or should regard himself as a culturally acting subject and at the same time as an "object" (more precisely: as a component) of nature: he is more of a player within nature than its master and transformer (although he naturally already tries to transform and exploit nature according to his interests). At any case, he should not be an opponent of nature, cause lastly (like everything else) he is subject to its laws. And this also applies to his mental and moral becoming, which in the end always has to be oriented and proven by empirical facts: for sensual beings like us, for example, even ethics cannot avoid making our physical neediness, our vulnerability and mortality an essential starting point for all moral considerations. And this also includes our moral relationship with non-human "fellow creatures", the animals and perhaps even the plants, in so far as these too are entitled to our respect because of their physical sensitivity to pain. Thus, a social-ecological consideration of the overall reality will also have to take into account the animal- and nature-ethical dimension, which means that philosophy also belongs in the "interdisciplinary setting" of SES-theory. To deal with nature that always contains an ethical component - even if it is only a matter of conserving natural resources. In the context of a *world*, everything is basically equally important and of equal value - but nothing is indifferent or superfluous.[36]

In other words, man is only a single link in the extremely ramified "chain of beings" - and can neither break away from nor rise above it (even if some religions and ideologies would like to tell us so). The history of mankind is therefore only a single moment within the planetary "big history", which also takes into account the geological aspects (e.g. plate tectonics and rock formation) and the development of the climate in order to reconstruct the gradual development of mankind from a "global perspective". Thus, even if the representatives of social-ecological systems theory occasionally

34 This can be quite difficult, considering that, for example, most soil bacteria are not yet known. Nor do we yet understand all the mechanisms that drive the flow systems in the atmosphere or in the oceans. And the terrestrial and marine food chains have by no means been fully explored.

35 If, for example, a laboratory experiment delivers a good result that confirms the theoretical assumptions, one does not say "It's true", but more modestly "It works".

36 Even then, if one takes a consistently "anthropocentric" stand towards nature, that is, if one judges all nature beings according to their value for man, without attributing to them a special intrinsic value, even then the direct (primary) "duties against themselves" (as Immanuel Kant says) require the observance of the indirect (or secondary) "duties against nature", since the destruction of nature also includes the destruction of man. Moreover, cruelty to animals that are sensitive to pain is also detrimental to "general morality" (Kant).

compare the human cultural sphere with the natural sphere in their modelling, since humans with their special needs like to face nature, this does not change the fact that the social-ecological approach is a fundamentally global systems approach (despite all local or regional differentiations in certain practical issues).

As is to be expected, there are numerous definitions of Social-Ecological Systems (SES), of which only the perhaps most complex one is mentioned here, especially since it includes many of the aspects of such systems discussed above: According to this definition, SES embody "complex adaptive systems with key characteristics such as: (1) integrated biogeophysical and socio-cultural processes, (2) self-organization, (3) nonlinear and unpredictable dynamics, (4) feedback between social and ecological processes, (5) changing behavior in space (spatial thresholds) and time (time thresholds), (6) legacy behavioral effects with outcomes at very different time scales, (7) emergent properties, and (8) the impossibility to etrapolate the information from one SES to another" (Delgado-Serrano et al. 2015).[37]

Since the 1990s, numerous SES approaches have been developed which will not be presented in detail here, although they highlight and analyse very different aspects of SES. G. S. Cumming (2014), who himself is one of the earliest and most important representatives of the SES approach, has proposed a classification of the different SES frameworks into five categories, which may be helpful to get a certain overview. It distinguishes "(1) hypothesis-oriented frameworks; (2) assessment-oriented frameworks; (3) action-oriented frameworks; (4) problem-oriented frameworks; and (5) theory-oriented frameworks".

Together with Cumming, we should be particularly interested in the "theory-oriented frameworks", which according to Cumming should satisfy seven "assessment criteria". Due to their importance, these criteria will be cited here in full (Cumming 2014):

1. Social-ecological core: a framework may have its origins in either the social or the ecological sciences, but it needs to provide a clear way of linking social and ecological systems and to be strong in both disciplines. Frameworks that deal primarily with economies and claim to be interdisciplinary because they mention ecosystem goods and services, or frameworks created for ecosystems which indirectly include anthropogenic drivers of habitat change, do not fit this criterion. It also excludes conceptual frameworks which offer general ways of thinking about the world, such as integral theory, but do not make specific claims about social-ecological relationships.
2. Empirical support and translation modes: frameworks that claim to be scientific, no matter how elegant, should be supported by rigorous empirical studies. Analyses, results, and conclusions should be framed in a way that is repeatable, at least in principle, and different scientists should ideally reach the same conclusions independently. The criterion of empirical support also includes Popper's falsification criterion; it should be possible in principle to find counter-examples or to disprove empirical claims. Likewise, frameworks should include

37 Or from a slightly different perspective: "Ecosystems and social systems are characterized by bottom-up and top-down controls and thresholds, multiple scales and nonlinar dynamics. (Cumming/Allen 2017: 1712) One therefore needs both: the "view from below" and the "view from above", because in complex systems hierarchical and heterarchical structures always play together, so that "self-organization" in the sense of an interaction "between process and structure" occurs.

translation modes that allow theory to be connected to empirical observations, and vice versa. Theory should provide a way of distinguishing between significant and irrelevant observations; and, conversely, observation should provide a way of distinguishing between significant and irrelevant theories. This is not possible if the predictions of a theory cannot be framed in terms of testable hypotheses.

3. Mechanisms: frameworks should offer insights into causality. They should ideally be based on first principles, or at least on accepted observations, and should offer clear statements of cause and effect. Frameworks for SESs should also offer explanations for the complex behaviors observed in real-world SESs. System descriptions alone, whether of system elements or system behaviors, do not provide a complete framework.

4. Spatiotemporal dynamics: frameworks should deal with the dynamic aspects of SESs and the nature of change through time, as well as with the spatial nature of SES and spatial variation.

5. Disciplinary context: frameworks should relate to previous frameworks and, ideally, should be able to explain their weaknesses and/or incorporate their strengths. In a discipline such as physics, for example, the theory of relativity builds on and expands Newtonian physics rather than discarding or ignoring it. In my subjective view, the study of SESs has suffered from an excess of isolated development of frameworks with too little synthesis between frameworks and too much ignorance of preceding ideas.

6. Interdisciplinarity and transdisciplinarity: this builds on the preceding criterion of disciplinary context, but more broadly. Frameworks for SESs should be able to cope with, and offer connections between, complementary perspectives and different epistemologies.

7. Direction: frameworks should provide direction for the study of SESs by suggesting or guiding new empirical studies which will advance our theoretical understanding of SESs.

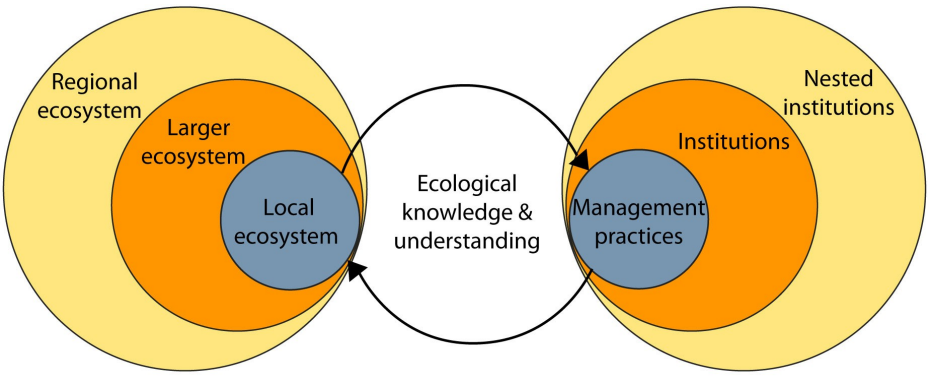
In general, a "framework" can be understood as a "family of models" which "not necessarily depend on deductive logic to connect different ideas (i.e., it does not have to present a single argument in which the conclusions follow from the premises)". For example, such a "framework" can consider SESs as interactional systems of humans and nature, with different sub-modules focusing primarily on the social aspects of SES, such as decision making within social networks. Strictly speaking, "frameworks" are always "metatheoretical schema facilitating the organization of diagnosis, analysis, and prescription". Such frameworks relate to different objectives and are never "right" or "wrong". In this respect they resemble worldviews that also cannot be "true" or "untrue" either, since they are the first to set the criteria for the evaluation of statements. This means that "frameworks" always define the epistemological conditions under which SES can be observed and analysed in principle.

None of the existing SES theories already meets all seven criteria, so that Cumming states: "The development of a stronger theoretical framework remains an important goal for SES theory" or "we still lack a cohesive body of SES theory". Especially with regard to their epistemology, the central SES theories often differ substantially, since they reflect their own epistemic presuppositions in different ways, i.e. they are aware of their own conditionality to a different degree. Here a certain naivety in following the chosen approach, i.e. a lack of self-reflection, often becomes apparent. Too little consideration is given to "the processes by which decisions are made directly influence their outcomes". According to Cumming, the development of a more coherent theory depends in particular on further progress being made in the following three respects: "(1) the development of better standards and more effective ways of assessing the quality of SES research, increasing rigor in analyses of SESs; (2) the

creation of clearer linkages from the specific to the general, with case studies contributing more obviously to theoretical advancement; and (3) the development of better translation modes using theoretical constructs to generate evidence-based recommendations for social-ecological interventions which would enhance desirable aspects of social-ecological resilience". One of the peculiarities of social systems as components of SES is that not only the assumptions about the nature and delimitability of an SES play a role in its analysis, but also the results of each SES analysis have an impact on the SES analyst's view, so that any appropriate SES analysis must always also imply an analysis of the made suppositions (a "self-analysis", so to speak). Consequently, this is not only about the development and application of mathematical formulas for the description of natural SES phenomena, but also about the methodological self-image of the SES scientist, which is influenced by certain interests. Cumming therefore rightly says: "Rather, because of the 'Social' in SES, they will need to take into account the unique properties of social systems and the unavoidable subjectivity involved in analyzing themselves". This is also where what we discussed above under the term "constructivism" with regard to the construction of "social-ecological systems" becomes apparent: The empirical collection of objective data and its feed into certain epistemic and pragmatic models always links objectivity with subjectivity, insofar as there can be no "disinterested" description and explanation of the relationship between social and ecological systems. Our practical interests towards nature always influence our theoretical view of it.

However, whatever approach is preferred, it should always be borne in mind that "ecological knowledge and understanding" is a critical link between complex and dynamic ecosystems on the one hand and adaptive management practices and public institutions and social networks on the other; like as Colding and Barthel (2019) have proposed:

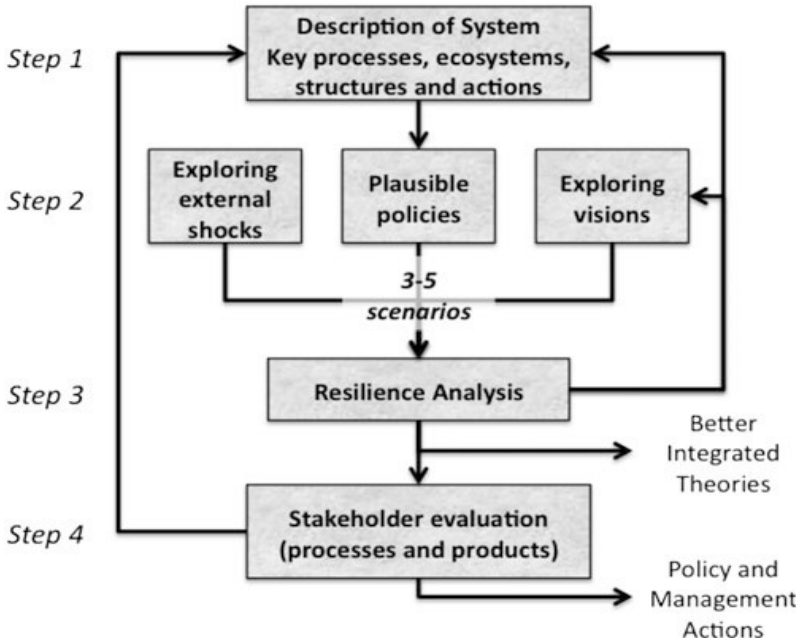
Figure 1. Ecological Knowledge & Understanding



Source: this scheme is a modification of a scheme by Folke & Berkes 1998

SES frameworks can have a very complex structure and their practical implementation can involve numerous work phases. This is demonstrated by the example of a problem-oriented SES approach:

Figure 2. An example of a problem-oriented framework: resilience analysis



Source: Walker & al. (2002)

And this is still a relatively simple example, as only the most important factors and process steps with regard to the special aspect of resilience are shown schematically here. Any profound SES theory that strives to include all relevant factors will have to take into account numerous variables whose evaluation and linkage is anything but easy - especially when it comes to conducting empirical studies and formulating and implementing managerial decisions (measures). In the following, at least the most important of these variables (or factors) are listed (according to Partelow 2018: 36):

- Operational choice rules
- Property rights systems
- Norms, trust, social capital
- History or past experiences

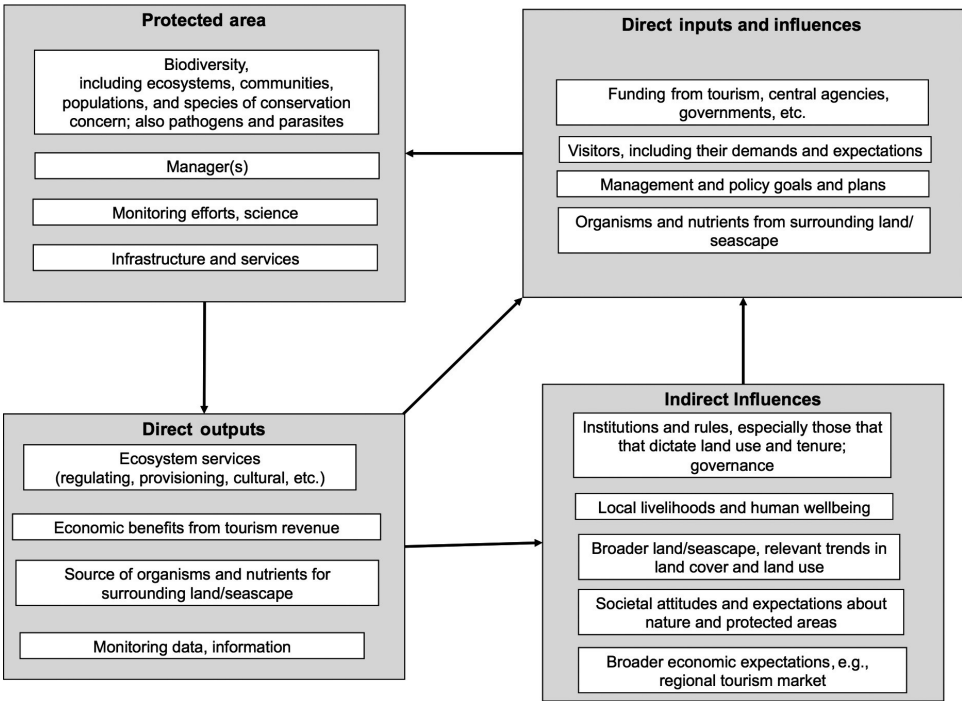
- Government organizations
- Economic value
- Spatial and temporal distribution
- Predictability of systems dynamics
- NGOs
- Technologies available
- Investment activities
- Demographic trends
- Climate patterns
- Pollution patterns
- Self-organizing activities
- Lobbying activities

Although this list is only a selection, it is intended to give a feeling for the large number of variables to be considered; to which still must be added the complexity of networking and the interdependencies of all these SES variables. It will be difficult to avoid certain model-like simplifications in the sense of a "reduction of real complexity"; just as they are accompanied by the implementation of concrete measures by which the relationship between man and nature is to be "regulated". However, nature rarely forgives such simplifications, since they are always present and effective as a whole with all its details at the same time. Turner et al. therefore rightly state: In practice, "four common general elements of human interventions" have to be considered, which can lead to negative effects: namely "simplification, reduction in natural variability, fragmentation and loss of contigious processes, and the introduction of hard boundaries" (Turner et al. 2001).

This is especially true if certain "protected areas" are to be established within the ecosphere: "For example, in the context of protected areas, people may reduce hibitat diversity, harvest animals or plants [...] or construct fences that limit movement and population expansion". This can have very drastic consequences: "As ecosystems respond to intervention and use by people, they often do unexpected things; for example, pest outbreaks and unusually large fires occur, forests are lost, or shollow lakes become dominated by toxic algae." (Cumming/Allen 2017: 1710) All these dangers pose great challenges to SES theories, with three issues in particular that SES theories have to address: "They [have to] include (1) increasing attention to the

resilience and sustainability of protected areas and the landscapes in which they occur; (2) increasing consideration of the relevance of spatial context and scale for protected areas and the ecosystems services they provide; and (3) efforts to reframe what protected areas are and how they both define and are defined by the relationships of people and nature." (Cumming/Allen 2017: 1710). The cited authors present a scheme for this, in which the socio-ecological feedbacks between human interventions and the reactions of a protected area are presented:

Figure 3. A systems perspective on social-ecological feedbacks in protected area management



Source: Cumming & Allen 2017, p. 1711

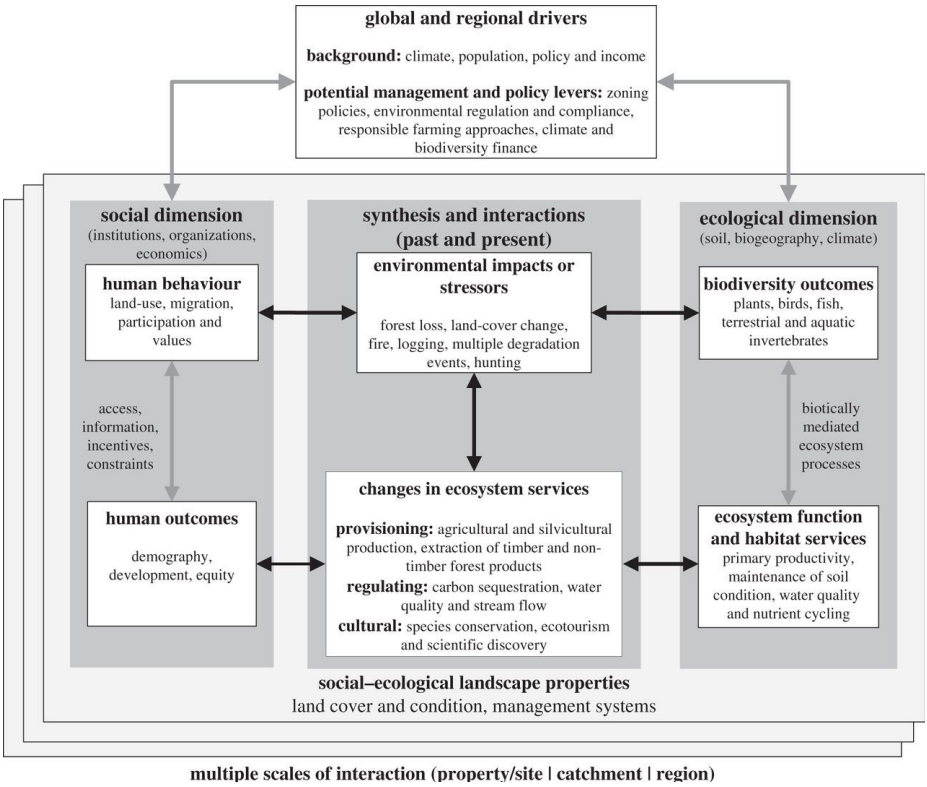
In addition to interactions and feedbacks that occur within protected areas, their direct outputs have add-on effects that subsequently influence both their internal dynamics and their future outputs.

It was above all the growing awareness of the complexity of possible ecosystem impacts, which can only be predicted to a very limited extent, that brought the SES theory to the fore. The SES approach has led to a real change of perspective or paradigm in ecological thinking and especially in the management of "protected areas": "The shift in thinking entailed by SES approaches is to move away from efforts to optimize production, and towards less 'efficient' but ultimately more resilient and more

sustainable ways of achiving conservation and socioeconomic goals." (Cumming/Allen 2017: 1711)

If one now tries to determine the central components of SES, one arrives at the following scheme, for example, which shows how closely and at the same time complexly the "social dimension" is linked to the "ecological dimension" (even if this scheme was developed primarily for the "ecological assessment" of land use in the tropical regions of Amazonia):

Figure 4. Multiple scales of interaction



Source: Quoted from Gardner & al. 2013

In conclusion, the most important challenges that every SES theory has to face and which, in case of success, also mark those learning successes that are indispensable in theoretical *and* practical terms in order to be able to manage social-ecological systems appropriately, will be summarised:

"Some of these that seem to us to be of highest priority include (1) developing and working with spatial data sets, such as atlases and remote sensing data, to better

understand spatial dynamics and the role of heterogeneity within protected areas; (2) developing a better general framework to facilitate or direct the interactions of protected areas with their surrounding landscapes, including both ecological and socioeconomic spillover effects; (3) learning to align ecological, social, and economic processes and their interactions, especially where spatial, temporal, or functional mismatches between scales (...) are possible; and (4) developing a better understanding of when feedbacks between social and ecological system elements are important and when they can largely be disregarded." (Cumming/Allen 2017: 1713)

It was the intention of this chapter to point out exactly these requirements to the (not only young) reader and to make them accessible: The aim is to convey "systemic thinking" to the people of today, which is of paramount importance almost everywhere, but especially in socio-ecological contexts. Above all, dealing with complexity and understanding non-linear processes are essential if a "new contract" with nature is to be concluded and a future worth living for all living beings on this planet is to be made possible.

6.2. Systematic Indicators

6.2.1. Organized learning through youth education

"So let us plant an apple tree. The time has come"

Hoimar v. Dithfurth

"Youth education is characterised by its institutions, by its history, by young people and by lifelong learning. The traditional idea of two phases of life, which coincide exclusively and separately with either the acquisition or the application of education, is replaced by the idea that organized learning cannot be limited to an educational phase at the beginning of life. (Deutscher Bildungsrat, 1973) Can changes in the natural environment not also make continuous learning possible? Here we must first distinguish that the life situation and experience are quite different from those of children, in the sense of mediation, and that self-learning is needed. The prerequisites must therefore be examined and they must be geared to what young people bring with them. (Tietgens, 1979: 25) Or as Horst Siebert has said: "The young person must be able to determine for himself the purpose for which he learns".

In this sense, the education of young people requires first of all the awareness of the implicit interpretation of societies in terms of an environmental crisis and it is closely linked to historical development. The objectives must be seen as dependent on social interests, but social conditions can change. "Therefore one can dare to say that

learning and achievement efforts in the emancipatory structure can fulfil a function in every learning area which promotes democratisation - and vice versa, that the authoritarian learning and achievement structure can again support the technocratic tendency in all areas of educational activity, especially in youth education" (Strzelewicz, 1979: 134 ff.) Technocratic and emancipatory approaches are relevant for the ecological education of young people. The question here is how these approaches relate to overcoming the ecological crisis. (Brumlik 1983: 406) In this area, however, one speaks more of learning goals than of educational goals. "Youth education is thus characterised by its institutions, by its history, by young people and by lifelong learning. The traditional idea of two phases of life, which coincide exclusively and separately, either with the acquisition or with the application of education, is replaced by the view that organised learning cannot be limited to an educational phase at the beginning of life". (Siebert, 1972: 76)

Siebert (1972) finds three forms of justification:

- the derivation from scientific disciplines,
- the empirical analysis of the use situations and
- a needs analysis of the addressees. (Siebert 1972: 76)

These goals cannot be defined scientifically, but must be negotiated in a social communication process, against the background of the respective historical and social conditions. On the basis of this background analysis, it must be considered the task of science to participate in the discussion. This means that although the goals are derived from the scientific discipline, they cannot be set absolutely. Rather, they must be seen as a contribution to a social discourse in which at least the lecturers and participants in youth education must be involved.

Three aspects of ecology are relevant here:

- the scientific, which includes above all hard facts, i.e. technical-biological knowledge.
- the philosophical, , which addresses aesthetic and ethical questions
- the political.

It places human society at the centre of the human-nature relationship. "Ecology can be defined as the science of the interactions between different organisms, between organisms and the environmental factors acting on them, and between different environmental factors. Organisms are here defined as microorganisms, plants, animals and humans".(Bick, 1987: 16 ff.)Nature is seen as a life-support system for humans; humans are also part of nature. Ecology as a biological science represents nature systematically. (Odum, 1991: 43)

Different principles can be distinguished:

- The first is the hierarchical structure, i.e. a sequence of functional units. In the ecological hierarchy, the units organism, population, biocoenosis, ecosystem, landscape as well as biome, biogeographical region and biosphere can be distinguished.

- The second principle is functional integration and means that each level of the hierarchy influences the adjacent levels. (Odum, 1991: 43)

- The third principle is homeostasis. Homeostatic mechanisms are balancing, forces and control loops.

With this we want to make clear as our position that a discussion about ecology in view of the environmental crisis must not be content with technological developments or damage descriptions, but that in the sense of a critical enlightenment a "fundamental discussion about the orientation crisis of progress" is necessary in the broadest sense for the search for a new economic and social order. (Altner 1982: 16) Here, this means in particular the participation of the individual and his or her ability to do so, but also the questioning of social structures. The concept of ecology is thus determined here by man's description of the environment, by man's assessment of the environment and by man's actions in the environment.

6.2.2. **Indicators for a sustainable development**

Youth education is therefore the first term. The second is how to get round the indicators for socio-ecological production landscapes. These must be introduced in the sense of organised learning, which cannot be limited to an educational phase at the beginning of life, about the economic and ecological problems.

The concept of sustainable development is the central vision for the future of humanity in the 21st century. Based on the Brundtland Report and the 1992 Rio Convention (Agenda 21), the concept of sustainable development has now acquired great international significance. Out of responsibility for the social and material living conditions of future generations, economic, ecological and social concerns are to be taken into account equally in social decision-making processes. Agriculture is of outstanding importance within the framework of global sustainable development, because securing food supplies, preserving biological diversity and protecting natural resources such as soil, water and air is inconceivable without taking agriculture into

account. No other sector of the economy is so closely linked to all three aspects of sustainability.

The discussion about the various facets of sustainable development in agriculture has changed significantly in recent years. The starting point was initially comprehensive analyses and descriptions of the situation, with the emphasis mostly on resource protection and biodiversity. In addition, there has been intensive debate about the supposedly best definition of sustainable agriculture, but if sustainability is to be more than just an ethically demanding concept, so-called indicators must be found to assess the various aspects of sustainable development. The selection of indicators is of paramount importance here for two reasons. On the one hand, appropriate units of measurement must be identified in order to be able to compare sustainable development in the national and international framework as a basis for agreements in the economic but also in the environmental field. On the other hand, indicators are an absolutely necessary prerequisite for sustainable development at national and international level. There have therefore been numerous attempts in recent years to establish suitable parameters for assessing sustainable development for various economic or social contexts. In addition to publications in the scientific literature, there are a number of proposals for individual indicators or comprehensive indicator concepts at the level of national and international organizations (UN, FAO, Commission of Sustainable Development, Federal Environment Agency, etc.) that relate to environmental quality, agricultural production or land use.

The present study therefore has the following objectives:

- Documentation of the current state of discussion on the assessment of sustainable development in socio-ecological systems.

- Critical evaluation of the proposed individual indicators in terms of relevance, methodological validation, modelling possibilities and limit value capability.

- Development of a proposal for systematisation and improvement of the indicator concepts.

6.2.3. Indicators for socio-ecological production landscapes

The use of such indicators lends itself to a general view, as they are a key tool. Here, with the help of the methods tested, individuals and communities can increase their ability to respond to social issues. They can address their economic and environmental constraints in order to improve their environmental and economic conditions. In this way, social and environmental resilience can be increased. Ultimately, this can lead to progress towards a society that is in harmony with nature.

The approach here focuses on "participatory assessment workshops". They include:

- Discussion
- An evaluation procedure for the set of twenty indicators

For the use of the indicators in the past, certain aspects of the evaluation process should be highlighted in order to understand the meaning and purpose of the indicators. Therefore, two basic concepts are examined here:

1. "Socio-ecological production landscapes".

2. "Resilience".

6.2.4. Socio-organic production

Humans have influenced most ecosystems on earth through production activities such as agriculture. These human influences are often considered harmful to the environment, but many such human-nature interactions are beneficial to the conservation of biodiversity.

"All over the world, efforts by local communities over many years to adapt to the surrounding environment have created unique and sustainable landscapes and seascapes that have provided people with goods such as food and fuel, and services such as water purification and fertile soils, while also harboring a diversity of animal and plant species. These landscapes and marine landscapes are highly diverse due to their unique local, climatic, geographical, cultural and socio-economic conditions. However, they are commonly characterised as dynamic biocultural mosaics of habitats and land and marine uses in which human interaction with the landscape or increases biodiversity and provides people with the goods and services necessary for their well-being". (UNU-IAS, 2014: 2)

They are called "socio-ecological production landscapes" (SEPLS). They are designed to guarantee biological diversity and provide local communities around the world with ecosystem services.

"Recent rapid growth in human demand for food and other goods and changes in socio-economic systems due to industrialization, urbanization and globalization have transformed various production sectors into more integrated systems that require intensive use of external inputs such as chemical fertilizers, pesticides and herbicides.

These impacts can be measured in terms of a loss of resilience and sustainability in productive areas, to an extent that threatens human well-being due to the degradation of natural resources and the reduction of ecosystem services. (UNU-IAS, 2014: 2)

6.2.5. **Resilience**

In addition to the effects of shocks, i.e. extreme weather events, through forest fires, droughts and short-term disturbances, ecosystems are affected by relatively gradual but continuous changes in climate and socio-cultural practices and institutions. Socio-ecological systems vary in such a way that individuals or communities can resist or recover from ecosystem damage. The capacity of such systems is what is known as "resilience". In this way, systems can play a critical role in securing long-term ecosystem services and sustainable production systems that both benefit local communities and contribute to the global goals of sustainable development.

Strengthening SEPLS resilience through local communities ensures the long-term survival of SEPLS managed by the community. They have appropriate management and use of natural resources and biodiversity defines them as resilient systems. Nevertheless, many communities face growing challenges in maintaining these landscapes and the social and environmental processes to sustain them. Given the rapid and often interrelated changes in socio-economic systems, as these are accelerated by increasing climate change and ecosystem degradation. Communities are primary stewards of processes and resources, and they need to strengthen existing management practices and institutions and be innovative. This is because they must adapt to these changes while restoring or strengthening the social and environmental resilience of landscapes and marine landscapes.

The resilience of SEPLS is a product of ecological, social, cultural and economic systems that are dynamically interconnected in a synergistic way. Improvements in ecosystem services may, for example, require the introduction of new methods of natural resource management or new types of crop, animal and related species diversity. Greater sustainability of agro-ecosystems may also require addressing access and equity issues, such as supporting the role of women in crop selection, production and marketing.

When we speak of interdependent social and environmental systems, they require the ability to accept and manage complexity and constant adaptation. This is linked to rural communities that depend on the wide range of functions with products and services that their landscapes offer. Resilience indicators are designed to help communities feel responsible for planning, implementing, monitoring and evaluating their production and resource management. "The knowledge and insights gained from these activities can then be used to provide local visions and strategies for resilient landscapes and productive ecosystems as input to overarching policies and programmes that impact on community livelihoods and further planning for nature conservation and resource management". (UNU-IAS, 2014: 8)

6.2.6. About the indicators

The resilience of local communities increases as they gain a more comprehensive understanding of the state and changes in the conditions of their landscapes and marine environments. However, because this resilience is a very complex and multifaceted process, it can be difficult to measure. This toolkit introduces an approach to monitoring SEPLS, using a set of indicators that define a general measure of SEPLS resilience.

"The resilience indicators for SEPLS consist of a set of 20 indicators designed to capture different aspects of key systems - environmental, agricultural, cultural and socio-economic. They include both qualitative and quantifiable indicators, but the measurement is based on the observations, agreements, perceptions and experiences of the local communities themselves. They should be flexible in their use and can be adapted to the specific landscape or marine environment and the communities associated with it". (UNU-IAS, 2014: 9)

For the spatial extension of these SEPLS in the context of using the indicators, the members of the local communities themselves must identify the area on which they depend for their survival and livelihood. It usually involves the mosaic of land uses from which communities obtain their goods and services. This means that they depend directly or indirectly on it. At the same time, however, they exert a direct influence on the resource base, that is. That they have regular interactions with natural biodiversity. A SEPLS can be delimited by administrative boundaries, such as a national park or national borders, or by a water catchment area as a geographical boundary, or by other factors.

The indicators aim to define the points that are essential for the resilience of SEPLS, providing a framework for communities to discuss and analyse socio-environmental processes. (UNU-IAS, 2014: 9) "This refers to critical life and development goals such as food security, agricultural sustainability, institutional and human development, provision of ecosystem services and conservation of biodiversity, strengthening community and landscape level organizations, and landscape design for equity and sustainability. The discussion of indicators within communities stimulates the exchange of knowledge and analysis, which are key factors in the creation of social capital for landscape design, planning and management, and promotes community ownership of this process". The periodic use of these indicators will enable the assessment of progress towards the objectives of this development and sustainable management, and the identification of priority actions for local innovation and adaptive management. (UNU-IAS, 2014: 9)

The indicators can provide input for local communities and other stakeholders in the following areas:

- Understanding SEPLS resilience. The indicators provide an analytical framework for understanding resilience and its status and changes in SEPLS.

They are defined and measured in terms that are easy for local communities to understand and use and can be adapted for successive analyses. By assessing current conditions and trends in different aspects of SEPLS, users can understand resilience as a multidimensional goal.

- Support the development and implementation of strategies to strengthen resilience.The indicators can help to identify and track social processes, institutions and practices of land use, conservation and innovation that are part of the adaptability and change capacity of a resilient system. By reviewing and discussing assessment results, communities can learn which areas and factors they should focus on, which may include components of agricultural biodiversity, food security, ecosystem services, livelihoods, governance and others.

- Improve communication between stakeholders.

- Empowering communities to make decisions and manage adaptively

- The use of indicators facilitates a continuous discussion and participation process within local communities and leads to insights into what works and what does not. This type of adaptive management model promotes a greater sense of ownership among people living in SEPLS and encourages them to take action at the policy-making level. Using the indicators as a framework for discussion also helps to build consensus on what needs to be done to build or improve the resilience of the whole landscape and guide decision-making and implementation. (UNU-IAS, 2014: 9)

6.2.7. Who can benefit from the use of the indicators?

Although the indicators are primarily designed for use by local communities, they have the potential to be valuable tools for others such as NGOs, development agencies and policy makers. The indicators can also be useful for researchers to understand SEPLS and how communities view their landscape or marine landscape. The role of the facilitator may be more important in situations where it is difficult for communities to use the indicators alone.

Below are some possible benefits for different users.

Local communities:

- Improving the common understanding of SEPLS (e.g. conditions and threats to SEPLS) within and outside of community members.

- Identify priority issues and measures to sustain SEPLS that will benefit livelihoods and well-being, and assess the Community's efforts to date.

- Contributing to strengthening trust and social capital in communities and to conflict resolution.

- Inform policy makers, donors and relevant stakeholders about the situation of their SEPLS, and Areas for more efficient support.

Exchange of experience with municipalities that have tried out the indicators NGOs and development agencies that implement the projects in SEPLS:

- Improving the understanding of resilience from the perspective of local communities.

- Promoting participatory processes.

- Monitoring and evaluation of project interventions for resilience and biodiversity protection and identification of areas to be supported.

- Communicate more effectively with policy makers and donors on the situation of the SEPLS they are working with and on areas of support needed.

Policy makers and project planners:

- Better understanding of local conditions from the perspective of local communities.

- Improving communication with local communities.

- Identify areas for improvement and take them into account in policy making, planning and other decision-making processes.

- Increasing coherence between different project sites by applying a common analytical framework and common tools.

Researcher:

- Improving the multidimensional understanding of local conditions from the perspective of local communities.

- deepening the understanding of resilience by examining the results from different sites.

- Identify gaps in research.

Indicator approaches are now used everywhere, and increasingly in different sectors and contexts:

For example, they play an important role at global and national level in monitoring progress towards specific goals and targets. For example, around 100 indicators have been listed to monitor progress in the implementation of the Strategic Biodiversity Plan 2011-2020 and the Aichi biodiversity targets adopted at CBD-COP 10 in Japan in 2010, to provide a framework for action by all stakeholders to protect biodiversity and enhance its benefits for people. The MDG indicators are a set of 60 indicators to measure progress towards the achievement of the Millennium Development Goals (MDGs), eight international development goals to be achieved by 2015 to combat extreme poverty. The United Nations agreed at the Rio+20 Conference in 2012 to develop a set of Sustainable Development Goals (SDGs) and is currently working on the definition of the targets and relevant indicators to be adopted in 2015.

Indicators need to be quantitative and at the same time they are allowed to aggregate data on a larger spatial scale. They must stand for comparison over space and time at national and global level. Indicators must also be scientifically valid and objective, with evaluation often carried out by experts. This does not contradict them. In contrast to these overarching indicators, the resilience indicators introduced in SEPLS are determined for use at the local level, i.e. they include both qualitative and quantifiable indicators. The measurement is based on the observations, perceptions and experiences of the local communities themselves.

These local observations may be supplemented by scientific data and information from global and national observations and data sets as well as from previous studies. However, it should be possible to integrate external data into the local knowledge base. The indicators in this toolkit provide a framework for local communities to discuss both current conditions of resilience and potential areas for improvement as part of the adaptive management process. This can lead to rapid and proactive efforts by local communities to strengthen the resilience of their productive and marine landscapes. It also provides a consistent process for monitoring the resilience of the landscape or marine landscape and implementing measures to address components and factors that lead to reduced resilience. (UNU-IAS, 2014: 9)

The resilience indicators in SEPLS partly overlap and complement some of the overarching indicators. Resilient landscapes resulting from the use of the indicators and the implementation of measures resulting from their use also contribute to global and national targets, such as those set out in the CBD (e.g. the Aichi Biodiversity Targets and the National Strategic Biodiversity Action Plans) and the FAO International Treaty on Plant Genetic Resources for Food and Agriculture. The Socio-Ecological Production Landscapes and Marine Landscapes Sustainability Indicators (SEPLS) and this toolkit have been developed in cooperation within the International Partnership for the Satoyama Initiative (IPSI).

As an international platform open to organisations dealing with SEPLS, IPSI has sought to promote synergies in the implementation of their respective activities as well as other activities planned under the Initiative. To date, over 20 IPSI collaborative activities have been initiated under IPSI, including this toolkit and its indicators. (UNU-IAS, 2014: 9)

They have been endorsed by the

- Bioversity International,
- Institute for Global Environmental Strategies (IGES),
- United Nations Development Programme (UNDP) and
- UNU-IAS were carried out. (UNU-IAS, 2014: 9)

The criticism of the co-optation is related to the question of whether the mutual is still competitive. This discussion goes much further, e. B. in the problems of increasing equity. But from an economic point of view, there are a few reasons to keep this form of insurance and to compete with the stock corporation.

6.2.8. The twenty Toolkits[38]

(1) Landscape/seascape diversity

The landscape or seascape is composed of a diversity/mosaic of natural ecosystems (terrestrial and aquatic) and land uses.

Examples:

Natural ecosystems: mountains, forests, grasslands, wetlands, lakes, rivers, coastal lagoons, estuaries, coral reefs, sea grassmeadows and mangrove forests.

Land uses: home gardens, cultivated fields, orchards, (seasonal) pastures, haymaking lands, aquaculture, forestry and agro-forestry, irrigation, canals, water wells.

38Source: Toolkit for the Indicators of Resilience in socio-ecological Production landscapes and seascapes (2014).

(2) Ecosystem protection

Areas within the landscape or seascape are protected for their ecological and/or cultural importance.

Note: Protection may be formal or informal and include traditional forms of protection such as sacred sites.

Examples:

Strict nature reserves, national parks, wilderness areas, heritage sites, community conserved areas, marine protected areas, limited-use areas, sacred sites, grazing reserve areas, rules and regulations to exclude outsiders from the (seasonal) use of natural resources, etc.

(3) Ecological interactions between different components of the landscape/seascape

Ecological interactions between different components of landscape or seascape are taken into consideration in natural resource management.

Examples:

Areas slated for conservation or restoration benefit, other areas through pollination, pest control, nutrient cycling and increase of animal population. Forests protect water sources and provide fodder, medicine and food. Agricultural activities can affect other parts of the landscape. Marine protected areas may increase marine populations also in other in fishing areas (spillover effects).

(4) Recovery and regeneration of the landscape/seascape

The landscape or seascape has the ability to recover and regenerate from environmental shocks and stresses.

Examples:

Pest and disease outbreaks; Extreme weather events such as storms,extreme cold, flooding and droughts; Earthquakes and tsunamis; Forest fires.

(5) Diversity of local food system

Foods consumed in the landscape or seascape include food locally grown, gathered from local forests and/or fished from local waters.

Examples:

Cereals, vegetables, fruits, nuts, wild plants, mushrooms, berries, livestock, milk, dairy products, wildlife/insects, fish, seaweeds, etc.

(6) Maintenance and use of local crop varieties and animal breeds

Households and/or community groups maintain a diversity of local crop varieties and animal breeds.

Examples:

Seed guardians, expert animal breeders, animal breeding groups, home gardens, community seed banks.

(7) Sustainable management of common resources

Common resources are managed sustainably in order to avoid overexploitation and depletion.

Examples:

Grazing regulations; Fishing quotas; Sustainable tourism; Control of wildlife poaching and illegal logging; or harvesting of forest products.

(8) Innovation in agriculture and conservation practices

New practices in agriculture, fisheries and forestry are developed, adopted and improved and/or traditional practices are revitalized.

Examples:

Adoption of water conservation measures such as drip irrigation or water harvesting; Diversification of farming systems; Introduction or re-introduction of drought- or saline-tolerant crops; Organic agriculture; Terracing; Reintroduction of native species; Shifting and rotation of grasslands; Reforestation; Replanting of corals, sea grass and mangroves; Fish houses;Selective fishing gear.

(9) Traditional knowledge related to biodiversity

Local knowledge and cultural traditions related to biodiversity are transmitted from elders and parents to young people in the community.

Examples:

Songs, dances, rituals, festivals, stories, local terminology related to land and biodiversity; Specific knowledge about fishing, crop planting and harvesting, and the processing and cooking of food; Knowledge included in school curricula.

(10) Documentation of biodiversity-associated knowledge

The biodiversity in the landscape or seascape, including agricultural biodiversity, and knowledge associated with it is documented, stored and made available to community members.

Examples:

Traditional knowledge registers; Resource classification systems; Community biodiversity registers; Farmers' field schools; animal breeding groups; Pasture co-management groups; Seed exchange networks (animal and seed fairs); Seasonal calendars.

(11) Women's knowledge

Women's knowledge, experiences and skills are ecognized and respected in the community. Women often have specific knowledge, experience and skills about biodiversity, its use and management, which are different from those of men.

Examples:

Know-how about the production of particular crops; Collection and use of medicinal plants; Caring for animals.

(12) Rights in relation to land/water and other natural resource management

Rights over land/water and other natural resources are clearly defined and recognized by relevant groups and institutions, for example governments and development agencies. Recognition can be formalized by policy, law and/or through customary practices.

Examples:

Land-use groups; Community forestry committees; Co-management groups or communities.

(13) Community-based landscape/seascape governance

The landscape or seascape has capable, accountable and transparent local institutions in place for the effective governance of its resources and the local biodiversity.

Examples:

Organizations, rules, policies, regulations and enforcement aimed at resource management; Traditional authorities and customary rules; Co-management arrangements, for example joint forest management, between local people and government.

(14) Social capital in the form of cooperation across the landscape/seascape

Individuals within and between communities are connected and coordinated through networks that manage resources and exchange materials, skills and knowledge.

Examples:

Self-help groups; Community clubs and groups (women's and youth groups); Intercommunity networks; Associations of federations with a focus on natural resource management.

(15) Social equity (including gender equity)

Rights and access to resources and opportunities for education, information and decision-making are fair and equitable for allcommunity members, including women, at household, community and landscape levels.

Examples:

Upland and lowland communities; Community members belonging to different social or ethnic groups; Women's voices and choices are taken into consideration in household decision-making and at community meetings where decisions about collective actions are made.

(16) Socio-economic infrastructure

Socio-economic infrastructure is adequate for community needs.

Examples:

Schools, hospitals, roads and transport; Safe drinking water; Markets; Electricity and communication infrastructure.

(17) Human health and environmental conditions

The overall state of human health in the community is satisfactory, also considering the prevailing environmental conditions.

Examples:

Absence or regular occurrence of diseases; Frequency of disease outbreaks that affect a large number of people; Absence/presence of environmental stresses like pollution, lack of clean water, exposure to extreme weather events.

(18) Income diversity

People in the landscape or seascape are involved in a variety of sustainable incomegenerating activities. Note: Diversity in economic activities can help households in case of unexpected downturns, disasters, changes in environmental conditions, etc.

(19) Biodiversity-based livelihoods

Livelihood improvements in the landscape or seascape are concerned with innovative use of local biodiversity.

Examples:

Handicrafts using local materials, e.g. wood carving, basketry, painting, weaving etc.; Eco-tourism; Processing of local foods, bee-keeping, etc.

(20) Socio-ecological mobility

Households and communities are able to move around to take advantage of shifts in production opportunities and avoid land degradation and overexploitation.

Examples:

Shifting cultivation and crop rotation practices; shifting between agriculture and herding/fishing; seasonal migration of herders; shifting fishing grounds; maintaining reserve areas for periods of hardship.

6.2.9. Education as the all-embracing factor

"The cohesion and social development of our society, our prosperity and the competitiveness of the economy increasingly depend on the importance of education. Education is the decisive factor for the future of our country, but also for the opportunities of every single person." (Coalition agreement of 11 November 2005)

Along with education, however, the broad concept of culture is also decisive: “The Committee considers that culture, for the purpose of implementing article 15 (1) (a), encompasses, inter alia, ways of life, language, oral and written literature, music and song, non-verbal communication, religion or belief systems, rites and ceremonies, sport and games, methods of production or technology, natural and manmade environments, food, clothing and shelter and the arts, customs and traditions through which individuals, groups of individuals and communities express their humanity and the meaning they give to their existence, and build their world view representing their encounter with the external forces affecting their lives. Culture shapes and mirrors the values of well-being and the economic, social and political life of individuals, groups of individuals and communities.”

This understanding of culture includes not only art and literature, but also ways of life, values, traditions and beliefs. The principle of cultural diversity plays a central role in this context: "The protection of cultural diversity is an ethical imperative, inseparable from respect for human dignity. It implies a commitment to human rights and

fundamental freedoms, and requires the full implementation of cultural rights. This includes not only art and literature, but also ways of life, fundamental human rights, value systems, traditions and beliefs."

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QUESTIONS

True/false questions:

1) (T / F) Balance and stability are the same

2) (T / F) Ecosystems are self-organized systems

3) (T / F) The environmental management only considers the ecological aspects

4) (T / F) Social-ecological systems are only theoretical constructions

5) (T / F) Ecosystems are "open systems" in every respect

6) (T / F) Resilience includes robustness and adaptability

7) (T / F) The behaviour of social-ecological systems is only partially predictable

8) (T / F) The complexity of a dynamic system depends on the complicated structure of the system

9) (T / F) The emergence of new characteristics is a basic feature of social-ecological systems

10) (T / F) Dynamic systems generally show a linear development

Multiple Choice Questions 11-30

11) What is organised learning?

a) Organised learning is limited to an educational phase at the beginning of life

b) Organised learning is determined by its history

c) Organised learning is determined by young people

d) Organised learning is determined by technocratic and emancipatory approaches

12) What is ecology I?

a) Ecology is the economic approach

b) It is the social approach

c) It is the approach that includes scientific, philosophical, ethical and political questions

d) It is the musical approach

13) What is ecology II?

a) Plants considered as organisms

b) Ecology as a biological science represents nature systematically

c) Microorganisms are summarized

d) Animals are observed

14) What is organic farming?

a) Securing food supplies, preserving biodiversity and protecting natural resources is linked to it

b) The soil is so closely related to agriculture

c) Water and air are closely related to agriculture

d) The economy is closely related to agriculture

15) Are ecosystems influenced by man?

a) The influence of man is negative

b) The influence of man is positive

c) Human influence is important for food supply

d) There are many human-nature interactions that are beneficial for the conservation of biodiversity

16) What are socio-ecological production landscapes?

a) They guarantee social studies

b) They guarantee ecological coalescence

c) They guarantee the coexistence of local communities

d) They should guarantee biodiversity and provide local communities around the world with ecosystem services

17) What can we call "resilience"?

a) In this way, systems are crucial for securing services in the short term

b) Systems are capable of ensuring long-term ecosystem services and sustainable production systems

c) They are resilient for the effects of shocks

d) They are essential for securing services from forest fires and droughts

18) What are socio-ecological production landscapes?

a) They include the land uses from which communities obtain their goods and services
b) They exert an indirect influence on the resource base
c) They designate goods and services
d) They have boundaries defined by water, soil and plants

19) What are indicators?

a) Are they a framework for discussion

b) They build consensus

c) The drought shocks need to be reduced

d) They should build the resilience of the whole landscape

20) For what are the indicators important?

a) They are important for marine landscapes

b) They should heil to understand socio-ecological production landscapes

c) They lay an important role as mediators

d) They improve priority themes

21) Why do we need socio-economical production landscapes (SEPLS)?

a) Land-uses are necessary for this

b) They are composed of a diversity of natural ecosystems and land uses

c) Mangrove forests are necessary

d) Natural ecosystems are necessary

22) Are the fishing grounds necessary for SEPLS?

a) They avoid land degradation

b) They are necessary

c) They will be needed for the Eco-tourism

d) They are not necessary

23) What is ecosystem protection?

a) This means national parks

b) Community conserved areas and marine protected areas are very important

c) Sacred sites are very important for the wilderness life of humans

d) They are protected because of their ecological and/or cultural importance

24) What are the livelihoods that can be considered?

a) This includes adverse changes in environmental conditions
b) Income generating activities fall under this category
c) Body sport is included
d) Ecotourism is recognised

25) What is recovery of landscape?

a) The landscape is protected from droughts

b) The landscape is protected from water floods

c) Water fronts are protected from earthquakes and tsunamis

d) The landscape is protected in its ability to recover from environmental shocks

26) Is the traditional knowledge located?

a) There is no knowledge that is protected

b) All knowledge is protected

c) Space is protected by means of traditional knowledge

d) Local and cultural knowledge is protected by elders and parents

27) Are the fishing grounds necessary for SEPLS?

a) They are not necessary

b) They are necessary

c) They avoid land degradation

d) They will be needed for the Eco-tourism

28) Is the knowledge of women recognized as SEPLS?

a) The knowledge of women is recognized and respected
b) The care of the sick is protected for women
c) The knowledge of women since 2000 is protected
d) The knowledge of women in the 15th century is protected

29) What are the bases of life that can be considered?

a) Ecotourism is recognised

b) Income-generating activities fall under this category

c) Body sport is included in this

d) It includes the adverse change of environmental conditions

30) Should the socio-economic infrastructure be taken into account?

a) Markets belong to the socio-economic structure

b) Drinking water cannot be considered

c) It should be considered from 2030

d) This has been taken into account since 1980

Correct answers: See annex "Answers"!

CHAPTER 7

CASE REPORTS

7.1. Turkey

The terms environmental literacy, ecological literacy and ecoliteracy have enormous importance in our lives and they are needed to be taught in detail to the society in order to save the resources of our environment. Numerous frameworks for environmental education, ecology and broader humanities are presented for the supplement of ecoliteracy awareness and sustainability of the protection of the nature and the world. Therefore, in order to have healthy societies, what we need is; clean air, natural resources and a nontoxic and undistorted environment.

To be an ecoliterated human being, we have to obey some rules related with ecological literacy and here are some examples presented:

- An ecological literate architect and engineer; pays attention to the fact that the buildings it builds are constructed using sustainable materials and it conserves energy savings.
- An ecologically literate urban regional planner chooses bridge and road routes without affecting the areas of natural habitats where the city breathes and does not open first grade agricultural lands to industry and settlement.
- An ecological literate fisherman hunts in a way that he allows the fishes to continue for their generations,
- An ecologically literate mayor does not approve the constructions to take place at stream beds,
- An ecologically literate individual defines the need and consumes only as much as it needs,
- An ecological literate parent feeds her child with nature-friendly products,
- An ecologically literate parent; pays attention to the harmonization of processes such as nutrition, habitat, school, social environment of the child with nature.
- An ecologically literate youth; while trying to lead his personal and business life, he tries to take care of all entire life of living things.
- An ecological literate teacher; realizing that it is a part of nature, it supports students' learning process with their experiences of nature.
- An ecological literate greengrocer; pays attention to the fact that the products it sells are manufactured in a manner that protects human health with a nature-friendly approach and away from chemicals.

To give the education on ecoliteracy, in Turkey, there are many Universities, schools, training centres, associations, fellowships and societies and their aims are the same, to give the ecological literacy to the people. Also various conferences, seminars, workshops and meetings are organised to give the literacy on ecology and environment.

Best practice examples in Turkey are listed below:

1. **Project Name:** Clean Environment Project with Natural Treatment Facilities
Promoter: Bursa Special Provincial Administration
Subject: Sewages of the villages in and around Bursa province created environmental pollution and was a threat for water resources. Through this project, Bursa Provincial Directorate created an opportunity to solve the bad smell and the environmental pollution caused by domestic wastewater from villages sewage.
Objectives: Within this project, it is aimed to improve living conditions of rural areas and to disseminate countrywide the sense of clean and living environment through environment friendly waste water natural treatment technology.
Outcomes: The project contributed to the prevention of the epidemic diseases and pollution created by wastewater of villages. It also ensured solving the wastewater problems through natural treatment or constructed wetland which also has economic aspects and it is a system of an alternate solution for treatment of waste water.

2. **Project Name:** Establishment of a Sustainable Packaging Waste Management System in cooperation with Industry, Local Authorities and Customers in Turkey
Promoter: Environmental Protection and Packaging Waste Recovery and Recycling Foundation (ÇEVKO)
Subject: Increase in the amount of packaging is directly correlated with the rise in consumption and product variety. Packaging waste is eligible for recovery under conditions of proper separation and collection. Environmental, economic and social costs arise when packaging waste is disposed of with organic waste. Recovery of packaging waste allows increasing of secondary materials while contributing to reservation of natural resources such as energy, oil and precious metals. Managing packaging waste within a separate system also results in creation of new sectors and job opportunities.
Objectives: Cooperating with local authorities for countrywide application of collection, separation and recovery activities; ensuring information accumulation in waste management through domestic and international applications; informative and training activities regarding environmental awareness; taking place in R&D activities, provision of advisory and technical support to relevant stakeholders.
Results: Approximately 2,500,000 tons of packaging waste has been collected in the Project period and within this framework over 12 million barrels of oil have been saved. This amounts to about 5% of 236 million barrels, an amount equal to the yearly gross oil consumption in Turkey. Approximately 16 million trees have been saved as a result of the recovered paper and similar packaging products.

3. **Project Name:** Sustainable Management of Local Electronical Wastes in Istanbul
Promoter: Istanbul Metropolitan Municipality (IMM)

Objectives: Making a feasibility study about collection and evaluation of waste electrical and electronic equipment (WEEE). Collecting at least 6.000 units of computer wastes. Reaching 60% as the ratio of repaired amount to all collected.
Subject: Public foundations, private companies and citizens who want to donate their computer wastes to IMM's workshop contact with IMM by telephone or e-mails throughout Istanbul and state the information related to the equipments. On this request, technicians go to the collection points and receive the equipments in exchange for official report. The equipments are tested if they are working or not. Then they are classified as reusable materials, recyclable materials and hazardous wastes. The equipments that will be repaired are stocked for reuse after their data are erased and they are repaired. Stocked equipments are then donated to the educational, public and social institutions that are in need. The equipments that are not possible to be repaired are separated into parts such as plastics, metals etc. and sent to recycling points. The materials consisting of hazardous materials are sent to licensed firms to be disposed.
During the project period, it has been learnt that; recycling of WEEE is important. We have seen that the citizens and stakeholders (producers, companies, etc.) are really willing to participate in the process. It can simply be managed to attract their attention with good advertisements.

4. **Project Name:** Kaçkar Mountains Sustainable Forest Use and Conservation Project
Promoter: The Turkish Foundation for Combating Soil Erosion, for Reforestation and the Protection of Natural Habitats (TEMA)
Objectives: Scientific Approach for Conservation and Planning and Developing scientific methods for the conservation of Kaçkar Mountains, and establish a conservation model to convey its values to the future; Rural Development Supporting the local people to turn the resources of the forests into additional sources of income, and to improve their quality of life ; Wildlife Development Monitoring, conservation and development wildlife, while providing local people with the methods to conserve their products without damaging wildlife ; Sustainable Tourism Developing tourism, the most important and promising source of income for the local people, through environment friendly methods. Potential additional sources of income, namely non-timber forest products and other natural products were researched and demonstrated. Problems in the product marketing chain were addressed via pilot projects in order to improve agricultural income generation. Critical training was provided to increase agricultural productivity.
Results: About 320 households earned an alternative income through sustainable site specific practices, more than 1,000 people got trained on sustainable and productive practices of agriculture, animal husbandry, tourism, insulation, techniques of avoidance from damages associated with wildlife and 50% of the people in the project area became aware of the unique natural worth of the region at the end of the project. A pilot Vegetable-Fruit Drying Facility was built, agricultural training was offered to farmers and potential of income generation activities such as fodder crops plantation, beekeeping and fruit orchard management were demonstrated. The most important output of the project "Kaçkar

Mountains Management Plan" is the anticipation that it will become a model for Turkey through local ownership and effective implementation.

7.2. Bulgaria

The application of SES for achievement of sustainable economic development is illustrated with a case study "**Agrarian sustainability - economic, social and ecological aspects on sectoral macro-level**". The data presented are based on official statistical and other information as well as on expert evaluation. On their basis, the sustainability index for economic, social and ecological aspects was calculated and the critical areas that lead to improving the level of agrarian sustainability in Bulgaria are identified.

The evaluation of Bulgarian agrarian sustainability is based on a methodology, initially developed for analysis of governance system and sustainability levels in Bulgarian agriculture. The system for assessing agrarian sustainability includes selected principles, criteria, indicators and reference values for each of them:

- The principles are the highest level which expresses the state of sustainability within the economic, social and ecological aspects;
- The criteria are related to indicators, which express the state of agricultural sector assessed when the relevant principle is realized;
- The indicators are quantitative and qualitative variables, e.g. behavior, business, investment, outcome, impact that can be valued and measurement of correspondence with the criteria, giving idea of sustainability in all its aspects can be done.
- Reference values are the desired values of each of the indicators, which assist the evaluation and give direction to improve/achieve sustainability.
- Welfare of employed in agriculture;
- Conservation of farming;
- Gender equality;
- Social capital;
- Adaptability to the social environment.

The lowest level has the sustainability index for the Social capital principle, the Gender equality principle and the Welfare of the employed in agriculture. Bulgarian agriculture is characterized by low productivity at labor, land and livestock. This is due to the fact that the labor productivity in Bulgaria is lower than the EU average because of low or old technology use, low labor quality, lack of qualification, lower motivation due to insufficient payment, aging labor force and other socio-economic factors.

The Welfare of employed in agriculture was assessed with Insufficient sustainability, while higher sustainability score was gained for the Conservation of farming principle, although the share of trained farms is very low. More employed in the agriculture should receive training and possibilities to develop their skills and knowledge in order to increase the sustainability of the agricultural sector.

Gender inequality is another major issue that Bulgarian agriculture faces and which is the reason for the low score for the Equality principle. Based on data of the share of women farm managers the indicator value suggests that there is inequality.

The highest is the value of the Index of adaptability to the social environment. Having in mind the changing social structure, the decline in the number of employed in agriculture, as well as the demographic crisis in the rural areas, there is a positive trend in the ratio of gross fixed capital formation to labour availability. That means that the shortage of labour could be successfully resolved with more capital formation.

The **environmental sustainability** of the Bulgarian agriculture is evaluated in general as Good. This is the assessment subject with most diverse indicators covering eight principles of environmental sustainability. The highest level of sustainability has been measured for the Effective energy consumption and the Adaptability to the environment. Concerns stem from the level of the indexes for some of the principles that are critical for ensuring environmental sustainability. Such principles are the Air quality, Biodiversity, Animal welfare, and Organic production.

Applying this systematic approach, the Social - Ecological sustainability of Bulgarian agriculture is assessed as ***Good***. However, the data reveal that there is still much work needed in order to ensure that the agriculture does not harm the environment and the biodiversity. It is important to point out that in several aspects, Bulgarian agriculture demonstrates strong sustainability; the effective energy consumption for instance. What is important, is to make sure that in case of more intensive economic growth these high scoring factors will not deteriorate.

7.3. Germany

There are numerous case studies by the Federal Environment Agency (UBA) on all areas of environmental protection: from transport and agriculture to water protection and biodiversity.

Case 1:

A has won the lottery. He wants to invest the money. He's very resourceful at car washes. The question is, what is the first thing he needs to clarify in terms of environmental law if he wants to start a car wash.

Immission control permission, §§ 4, 6 BimSchG.

The Federal Immission Control Act (BimSchG) is the most important specialist law in the field of environmental protection as a whole.

Law for the protection against harmful environmental effects caused by air pollution, noise, vibrations and similar processes (Federal Immission Control Act - BImSchG)

§ **4 Approval**

(1) The construction and operation of installations which, by virtue of their nature or operation, are particularly likely to cause harmful effects on the environment or

otherwise endanger, seriously disadvantage or seriously disturb the general public or the neighbourhood, as well as of fixed waste disposal installations for the storage or treatment of waste, shall require a permit. With the exception of waste disposal facilities, facilities that do not serve commercial purposes and are not used within the framework of economic activities only require a permit if they are particularly suitable for causing harmful effects on the environment through air pollution or noise. The Federal Government, after hearing the parties involved (§ 51), shall determine by statutory instrument, with the consent of the Bundesrat, which installations require a permit (installations requiring a permit); the statutory instrument may also stipulate that a permit is not required if an installation, as a whole or in its essential parts specified in the statutory instrument, has been approved according to its type of construction and is constructed and operated in accordance with the type approval.

§ 6 Licensing requirements

1. Authorisation shall be granted if

1. It is ensured that the obligations resulting from § 5 and a statutory instrument issued on the basis of § 7 are fulfilled, and

2. Other regulations under public law and occupational health and safety concerns do not conflict with the construction and operation of the installation.

In the case of installations which serve different modes of operation or in which different substances are used (multi-purpose or multi-substance installations), the licence shall be extended to cover the different modes of operation and substances upon application if the requirements under para. 1 are met for all modes of operation and substances covered.

An applied for modification permit may also not be refused if, after its implementation, not all immission values of an administrative regulation pursuant to § 48 or a statutory instrument pursuant to § 48a are complied with, but if

(1.) the immission contribution of the installation is reduced by the project significantly and to a greater extent than is enforceable by subsequent orders pursuant to Article 17 para 1, taking into account Article 17 para 3 a sentence 3,

(2.) further air pollution control measures are implemented, in particular measures that go beyond the state of the art in newly constructed plants,

(3.) the applicant also submits an immission management plan to reduce his share of the polluters in order to achieve subsequent compliance with the requirements under Article 5 (1), No. 1, and

(4.) the specific circumstances do not require a revocation of the permit.

§ 21 Biotope network, cross-linking of biotopes

(1.) The network of interlinked biotopes serves to permanently safeguard the populations of wild fauna and flora, including their habitats, biotopes and biotic communities, and to preserve, restore and develop functioning

ecological interrelationships. It should also contribute to improving the coherence of the Natura 2000 network.

(2.) The biotope network should be transnational. The “Länder” shall consult with each other on this.

Case 2:

What if one wants to set up his plant in a very beautiful agricultural area? Are there any agricultural restrictions?

Nature conservation law: general rules of intervention, §§ 18 - 21 BNatSchG, § 4 ff LG NRW 2. designation of protected areas, §§ 22 ff BNatSchG

§ 16 Stockpiling of compensation measures

Nature conservation and landscape management measures that have been carried out with a view to expected interventions shall be recognised as compensatory or replacement measures, provided that

1. The requirements of § 15 paragraph 2 are fulfilled,

2. They were carried out without any legal obligation,

3. No public funding was used for this purpose

§ 18 Relationship to building law

If encroachments on nature and landscape are to be expected on the basis of the establishment, amendment, supplementation or cancellation of urban land-use plans or bylaws pursuant to § 4 (4) sentence 1 number 3 of the German Building Code, decisions on avoidance, compensation and replacement shall be made in accordance with the provisions of the German Building Code.

§ 19 Damage to certain species and natural habitats

Damage to species and natural habitats within the meaning of the Environmental Damage Act is any damage that has significant adverse effects on achieving or maintaining the favourable conservation status of such habitats or species.

§ Article 21 Biotope network, cross-linking of biotopes

(1) The purpose of a biotope network is to permanently safeguard populations of wild fauna and flora, including their habitats, biotopes and biotic communities, and to preserve, restore and develop functioning ecological interrelationships. 2 It should also contribute to improving the coherence of the Natura 2000 network.

(2) The network of biotopes is to be transboundary. 2 The Länder shall consult with one another on this.

(3) The biotope network consists of core areas, connecting areas and connecting elements.

Case 3:

A sets up his paint plant in a beautiful area where a river flows by in the immediate vicinity. From time to time he secretly dumps the toxic chemicals produced in his business into the river. Is he allowed to do this and can he be punished for it?

(1) Water law (WHG, LWG): water law permits and authorisations for the use of water bodies in the sense of the water law WHG, §§ 7, 8 WHG, §§ 25 - 28 LWG NRW

(2) Law for the order of the water balance (Water Resources Act - WHG)

§ 8 Permission, Licence

(1) The use of a water body shall require a permit or authorisation, unless otherwise provided for by this Act or by regulations issued on the basis of this Act.

(2) No permit or authorisation shall be required for the use of water bodies for the purpose of averting a current danger to public safety, provided that the threat of damage is more serious than the adverse changes in the properties of the water body resulting from such use. The competent authority shall be informed of such use without delay.

Criminal liability for environmental offences (not only water pollution): §§ 324 ff StGB; furthermore administrative offences, here § 41 WHG.

Criminal Code (StGB) § 324 Water pollution

Anyone who without authorisation pollutes a body of water or otherwise adversely affects its properties shall be punished with imprisonment for up to five years or a fine. (2) The attempt is punishable

7.4. Spain

We have selected some experiences that have been carried out in Spain under the umbrella of public administrations and private management.

Case Study 1:

The *Autonomous Organization for National Parks*, under the Ministry for Ecological Transition, organizes the **National Park Volunteer Program** annually. It is a unique opportunity to get to know these protected areas by collaborating in ecosystem conservation and natural and cultural heritage restoration programs. In order to participate it is necessary to be of legal age. All the participation expenses are paid by the organization, except for the travel expenses to the protected area, which must be paid by the volunteer. The Volunteer Program assumes the double challenge of:

- facilitate awareness, consciousness-raising and change of attitudes towards the environment as a tool for environmental education

- offer a space that satisfies the growing demand for social participation in knowledge and intervention on the quality and conservation of the environment

The **environmental volunteer** offers:

- dedication, commitment and contribution to the improvement of the natural heritage
- interest, motivation and free time

The **Autonomous Organization of National Parks** provides:

- technical management, information and training
- accommodation, meals and transport within the Parks
- accident, health and liability insurance
- materials for activities and identification of volunteers

Figure 1. Volunteers in a National Forest Park

Source: Ministry of Ecological Transition and Demographic Challenge (Government of Spain)

Case Study 2:

"Green Homes" It is an educational program aimed at families concerned about the environmental and social impact of their decisions and daily habits. With this initiative we want to accompany them in the process of change towards a more responsible management of their home:

- promoting self-control of domestic water and energy consumption
- introducing cost-saving measures and behaviours
- helping to make a more ethical and greener purchase

The program offers participants:

- Quarterly meetings where information is exchanged on basic and very practical issues related to the topics being addressed at any given time

- Personalized attention, in person or by telephone and e-mail, to help resolve all the doubts that may arise
- Materials with practical recommendations and information and a simple sample and savings kit

Participants make a commitment in their homes to:

- Complete an initial and final questionnaire on water, energy and mobility
- Provide data on your domestic consumption

Case Study 3:

The **International Foundation for the Restoration of Ecosystems (FIRE)** is a private non-profit organization that was created in 2006 with the aim of restoring and conserving ecosystems, transferring academic knowledge to operational projects with the highest possible social return. It is composed of a network of more than 30 professors, researchers, students and professionals from different academic institutions, non-governmental organizations and companies from several European and Latin American countries.

Its objectives are:

- Develop applied research for ecosystem restoration
- Promote, coordinate and execute restoration projects
- Disseminate knowledge for decision making in the field of public policies for sustainable development
- To promote relations between the scientific community and different social actors, with the aim of developing projects and actions for the restoration of ecosystems
- Design, implement and evaluate education and training programs for students, professionals and technicians
- Promote and support the creation, consolidation and development of companies and social initiatives aimed at the sustainable use of natural resources

In addition to collaborating in important international projects, the main projects carried out are:

Life Fields: to reconcile ecological restoration actions with the agricultural use of the territory. It includes the revegetation of boundaries and paths, the introduction of islets of woody vegetation, the restoration of water points (ponds, fountains, troughs), the placement of nesting boxes for birds and the construction of shelters for wildlife

Custody of the Territory: strategies and instruments to facilitate conservation initiatives and the good use of a territory's natural, cultural and landscape values and resources through the direct participation of civil society.

Avian pest control: to evaluate the ecological restoration actions of certain species of insectivorous birds and small and medium sized birds of prey, which are useful for the biological control of agricultural and forest pests

RestauRural: ecological restoration project and improvement of the environmental quality of the rural environment, which is carried out with the voluntary participation of schoolchildren for the detection, collection and classification of waste in their municipalities

Diploma "Restoration of ecosystems and environmental services": on-line training on ecological restoration

Publication of the tale "The adventures of Lady Acorn": written by Victoria Gonzalez, is intended to bring knowledge about the natural regeneration of the Mediterranean forest to children

Figure 2. Project "Analogous Forests for the ecological restoration of the Mediterranean"

Source: FIRE 2018

7.5. Italy

7.5.1. The INFEA program

The INFEA (INFormazione Educazione Ambientale - Environmental Education Information) program was created in 2000 under the initiative of the Ministry of the

Environment: it aims at spreading information, training and environmental education structures throughout the country.

The INFEA system is configured as an integration of systems on a regional scale, where the regional administration plays a role of listening, proposal and coordination, promoting a continuous dialogue with the actors involved in the world of environmental education and ecoliteracy.

The INFEA program, the expression of the above mentioned system, spreads structures and tools throughout the country to assist and strengthen the role of the Regions and to guide actions towards the construction of a National System for Education, Training and Environmental Information/ecoliteracy.

The State, the Regions and the autonomous Provinces therefore are directly addressed and committed to strengthen and develop their joint action in the field of environmental education and sustainable development, through the stipulation of concerted program agreements co-financed with regional, national and local communities.

7.5.1. The INFEA network

The IN.F.E.A. network of Information Training and Environmental Education is a tool of the National System IN.F.E.A. to promote the sharing of objectives and projects aimed at sustainability and environmental protection as a common good among the subjects that are in the network itself.

The network is the union of all environmental education centres – both public and private – and is coordinated by the Ministry of the Environment across the regions.

Each Region therefore has the role of coordinating the centres set within its territory, in collaboration with the Regional Environmental Protection Agencies, and the Regional School Offices.

The network is made up of over 200 Environmental Education centres, 360 natural areas and 1500 subjects.

All the entities that make Environmental Education in the context of the INFEA network must have agreements with public bodies.

The activities of the network

The network, in each region

a. carries out Environmental Education/ecoliteracy interventions for the promotion, programming and implementation of educational projects, by making comparisons, awareness raising, training, information on the issues related to education for sustainable development;

b. collects information and data to feed the Regional Information System: it plays the dual role of collecting and spreading environmental education initiatives that are

carried out in each area in order to give visibility to projects and allow teachers, educators, administrators, individual citizens to access the available resources from the web or directly from the centres;

c. operates in the following areas of intervention: Environment and health, Food and agriculture, Biodiversity, Citizenship and common goods, Consumption and lifestyles, Sustainable energy, Business and green economy, Sustainable mobility, Environmental resources, Land use.

7.5.2. The local Agenda 21 processes

The processes of aware participation of citizens find expression in the local Agenda 21, the local action of sustainable development through interdisciplinary, participatory and empowering methods and tools.

Agenda 21 takes sustainable development as its underlying philosophy, accompanying it in a process generating strategies, objectives, tools, actions, criteria and methods for evaluating results. The definition of the objectives is strictly connected with the construction of the conditions necessary for the concrete action: consent, interest, synergies, human and financial resources.

The methodological basis of local Agenda 21 is the integration of the environmental factor with the economy of all sectors, industry, transport, energy, agriculture, tourism and with the social aspects, employment, the condition of women and young people, training, health quality of life, especially children and the elderly and for vulnerable groups.

The public bodies that have developed and that develop Local Agenda21 processes act ecoliteracy through the participation and training meetings of the local thematic working groups which generate local Sustainable Action Plans.

7.5.3. Italian Alliance for Sustainable Development - Asvis

Asvis was founded in 2016 to raise awareness in Italian society, economic actors and institutions of the importance of Agenda 2030 for sustainable development and to mobilize them to achieve the Sustainable Development Goals. The Alliance currently brings together 270 of the most important institutions and networks of civil society and business.

In its commitment to creating a more sustainable world, education plays a crucial role and has therefore launched numerous activities to support educational pathways for each person to become an agent of change, equipping themselves with the knowledge, skills, values and attitudes to be able to make informed decisions and act responsibly for environmental integrity, economic sustainability and a fairer society for present and future generations.

ASviS collaborates with the Ministry of Education in the implementation of the "Plan for Sustainability Education". Thanks to the working group, the Alliance has signed a Memorandum of Understanding with the Ministry to promote and disseminate

information, training and dissemination initiatives of the culture of sustainable development addressed to all components of the school world of all levels. Asvis also collaborates closely with the "Network of Universities for Sustainable Development" (RUS).

Among the activities and projects launched by the Alliance in this field, or that have seen the collaboration of the same, are worth mentioning:

- the national competition Miur-ASviS for Italian schools on SDGs, entitled "Facciamo 17 Goal. Transforming our world: the 2030 Agenda for Sustainable Development", with the aim of promoting knowledge, diffusion and assumption of the lifestyles foreseen in the 2030 Agenda for Sustainable Development;
- the ASviS e-learning course, available online, which lasts about three hours and illustrates the Agenda 2030 and the SDGs system;
- the Siena Summer School on Sustainable Development, launched by ASviS to educate on sustainability issues, in collaboration with Fondazione Enel, Leonardo, University Network for Sustainable Development (Rus), Sustainable Development Solutions Network Italia, Sustainable Development Solutions Network Mediterraneo and University of Siena Santa Chiara Lab. The school focuses on understanding the challenges posed by an unsustainable world and promoting concrete solutions.

On the website of Asvis is available a Catalogue of materials for Education for Sustainable Development with materials produced over the years by non-governmental organizations, foundations, public bodies and the world of education for development education and global citizenship.

ANNEX: ANSWERS

Chapter 1

1) F	2) T	3) F	4) T	5) T	6) F	7) F	8) T	9) F	10) T
11) D	12) B	13) C	14) A	15) D	16) C	17) C	18) D	19) B	20) A

Chapter 2

1) T	2) F	3) F	4) T	5) F	6) T	7) F	8) T	9) F	10) T
11) F	12) T	13) T	14) F	15) T	16) T	17) F	18) T	19) T	20) D
21) B	22) C	23) D	24) B	25) A	26) C	27) A	28) D	29) A	30) B
31) C	32) C	33) A	34) C	35) D	36) C	37) D	38) B	39) D	40) B
41) C									

Chapter 3

1) F	2) T	3) F	4) F	5) T	6) T	7) T	8) F	9) T	10) T
11) A	12) C	13) B	14) D	15) B	16) D	17) D	18) D	19) A	20) B

Chapter 4

1) F	2) T	3) T	4) F	5) T	6) T	7) F	8) T	9) T	10) F
11) D	12) A	13) D	14) C	15) A	16) D	17) B	18) D	19) B	20) A

Chapter 5

1) T	2) F	3) F	4) T	5) T	6) F	7) F	8) T	9) F	10) F
11) C	12) D	13) C	14) A	15) C	16) B	17) C	18) A	19) B	20) A

Chapter 6

1) F	2) T	3) F	4) F	5) F	6) T	7) T	8) F	9) T	10) F

11) d	12) c	13) b	14) a	15) d	16) c	17) b	18)a	19)d	20) c
21) b	22) a	23) d	24) c	25) b	26) a	27) d	28) c	29) b	30) a