Our World, Our Environment: How to Protect Our Planet?

Angheluta Vadineanu and Radu Stefan Vadineanu

Starting in the late 50s/beginning of the 60s of last century, significant changes in the state of global environment have been witnessed, related to the economic growth or human activities patterns and rates in both developing and developed world.

The acceptance of that evidence by politicians, decision-makers, business or even academic community and the public as large, has not been easy, due to the complexity and the modulation of the process.

In fact, natural and environmental dynamics is an intrinsic property driven by external (e.g. variation in solar output, cosmic radiation or meteorite collision) and internal factors (e.g. volcanic eruptions, biological activity), on which the changes driven by human activity are superimposed.

In these circumstances was and is not easy to discriminate and count between natural and human driven changes influencing the state of global nature and environment, unless a new vision of environment and human world is properly established and applied.

That explains why, in the first instance, we decided to provide a brief presentation of the major elements of the new conceptual model which address the environment, bringing clarification and allowing an effective holistic approach.

Following that conceptual clarification we are able to identify some of the main steps made for building global awareness on human induced environmental changes, as well as the main types of human impacts upon and trends in the dynamics of global environment.

Finally, this work contains an attempt to suggest a set of conceptual statements and operational initiatives which, we believe, can help to protect our planet. In fact, this goal can be achieved by promoting a new model of social-economic development, based on ecological and social security.

BASIC CONCEPTUAL ELEMENTS

The concepts dealing with the environment and the respective ways of approaching the environmental issues have been changed and improved as the ecological theory developed from the early stage, when it was described as "biological ecology", towards the current stage and its definition of "systems ecology".

The identification and description of the natural, seminatural and human-dominated or created environment has changed accordingly to a former conceptual model which defined the environment as a set of factors (air, soil, water, biota and human settlements) to the most recent one, which considers the environment as having a hierarchical organization across large space and time scales (Fig. 1 & 2) (Odum, E., 1993, 1997; Claudia Pahl-Wostl, 1995; Vadineanu, A., 1998, 2001).

The wide variety of ecological systems falls into four hierarchical levels of complexity which behave as self-organizing or life supporting systems.

The natural and seminatural systems entirely, and the man-dominated ones partially, behave as self-maintaining and productive units. In this respect, the dynamic network consisting in abiotic components and biotic tropho-dynamic modules function as a productive and self regulating structure based on three processes: energy flow, biogeochemical cycling of chemical elements, and information flow. Productivity and self regulation define the carrying capacity of the self maintained ecological systems or, in other words, the potentiality to provide physical support, natural resources and services to the human created systems.

In this regard, we may say that such productive units constitute the Natural Capital (NC) and the foundation or the footprint of the man-made ecological systems.

According to the existing knowledge concerning the organization of life, one can discriminate among five hierarchical levels on top of biological individuals and four spatio-temporal levels within the ecological hierarchy. It has to be noticed that 3-dimensional space of the hierarchical organization integrates upper lithosphere, ocean basins and troposphere and the time constants of the ecological systems are years, decades, centuries or millennia.

All components of the ecological hierarchy are non-linear dynamic and adaptative systems undergoing the successive phases of the adaptative cycles: growth (r); accumulation or maturation (K); release or "creative destruction" (Ω), and restructuring and reorganization (α) (Holling, C.S., 2001; Gunderson, I. and Holling. C.S., 2001). They are also dissipative systems continuously fueled by solar energy and in

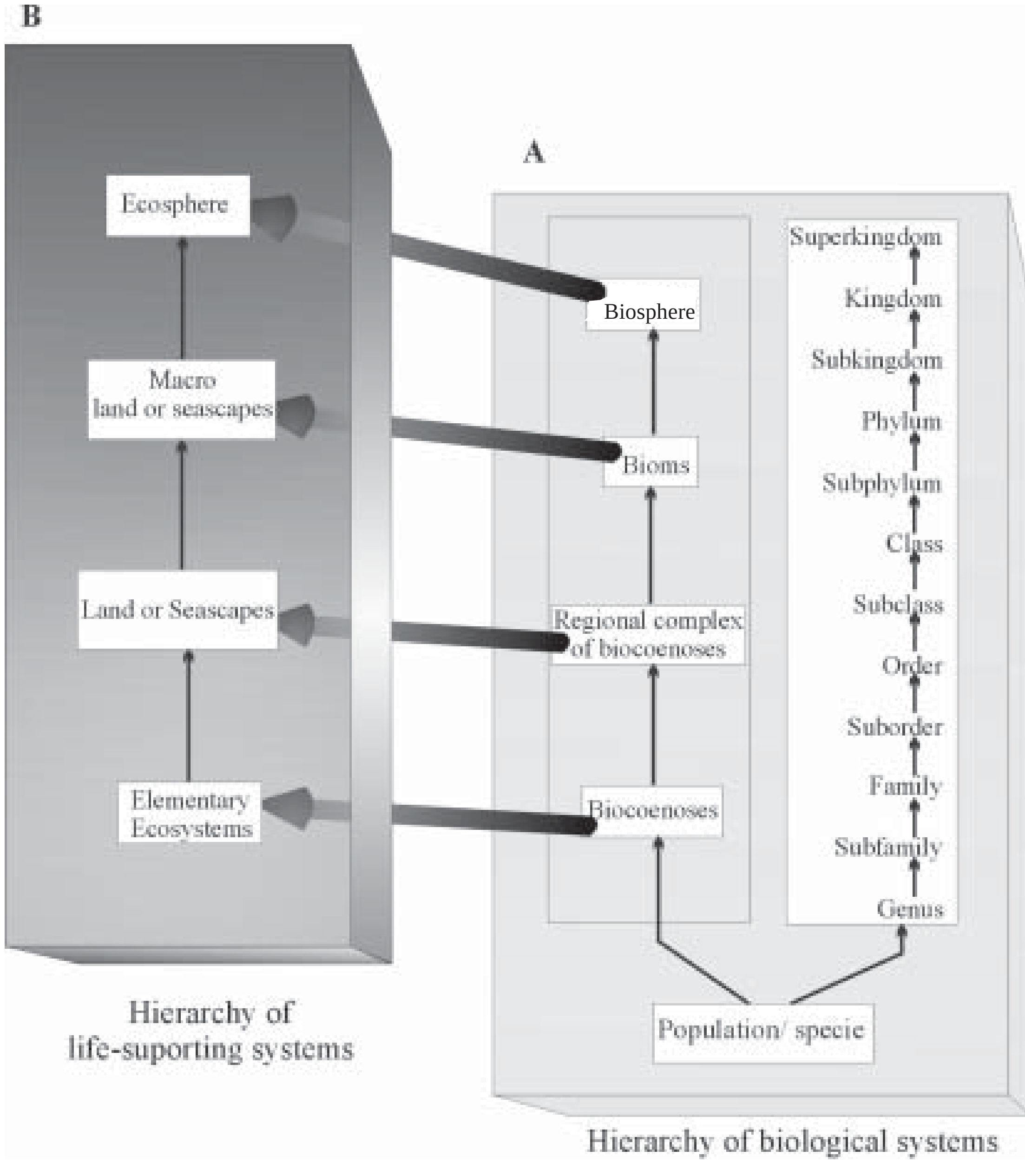

Fig. 1. Relationships between taxonomic and organizational hierarchies of the living systems (A) and their integration within the hierarchy of life supporting systems or ecological systems (B). (After Vadineanu A., 1998 & 2001)

A1 - covers the diversity of living organisms and it reflects hierarchical order of the taxons established based on the similarity between ordered entities.
A2 - hierarchical organization of living organisms in large and complex biological systems.
B - reflects the hierarchy of spatio-temporal organization of the upper layer of lithosphere, hydrosphere, troposphere and biosphere.

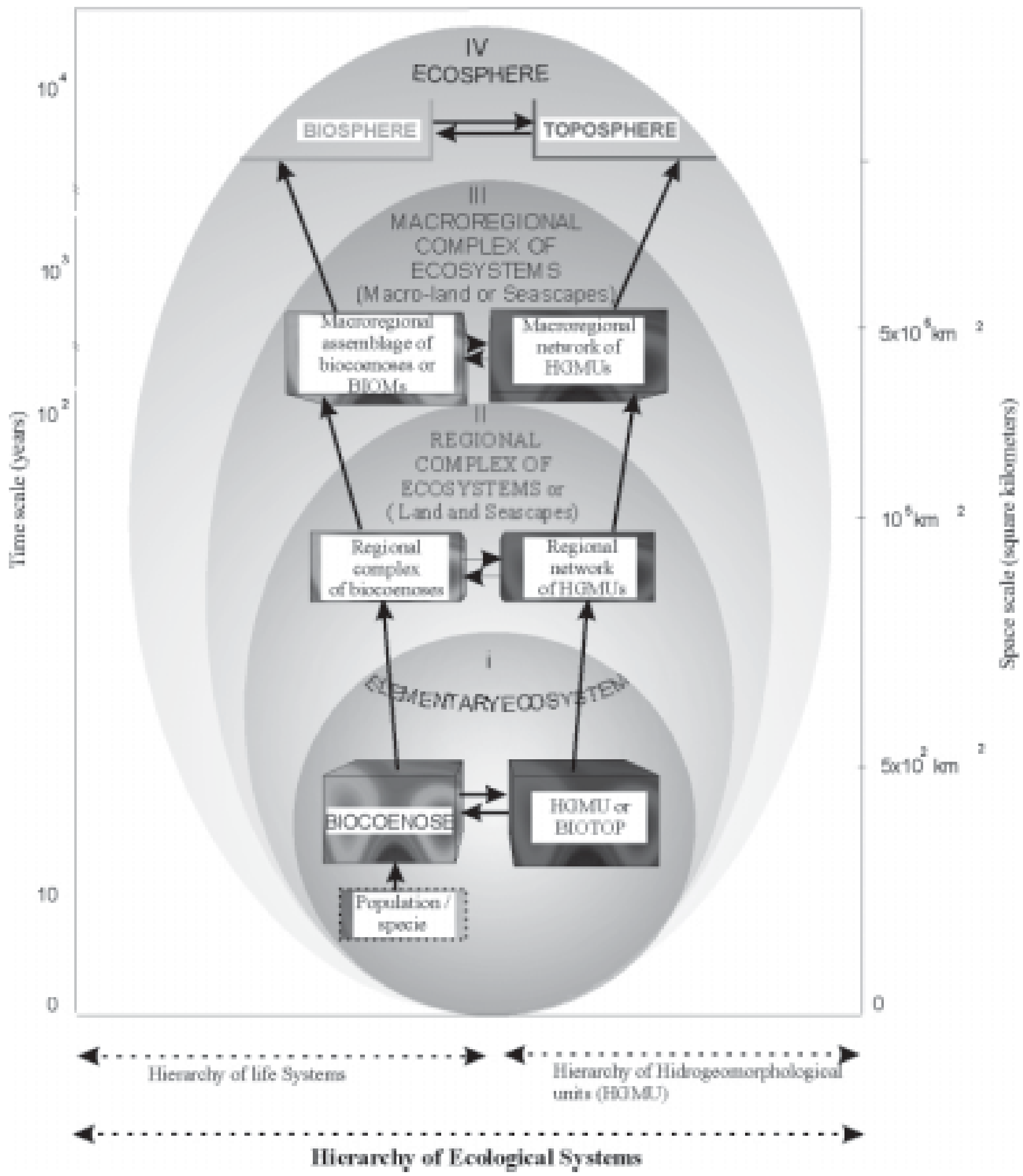

Fig. 2. Hierarchical organization of natural, man-transformed and man-created physical, chemical and biological environment (After Vadineanu A., 1998 & 2001).

different degrees by chemical and auxiliary energy (e.g. wave and tide energy; wind energy; concentrated energy in non-living organic matter or fossil energy).

However, a distinction has to be made within the hierarchy between natural and seminatural systems, which are totally self-maintained and able to provide a wide range of natural resources and services (e.g. Lower Danube Wetlands System - Fig. 3) as well as between the human-dominated ones, which are dependent in different extents on commercial auxiliary energy and material inflow (e.g. agrosystems, intensive fishery) and human made

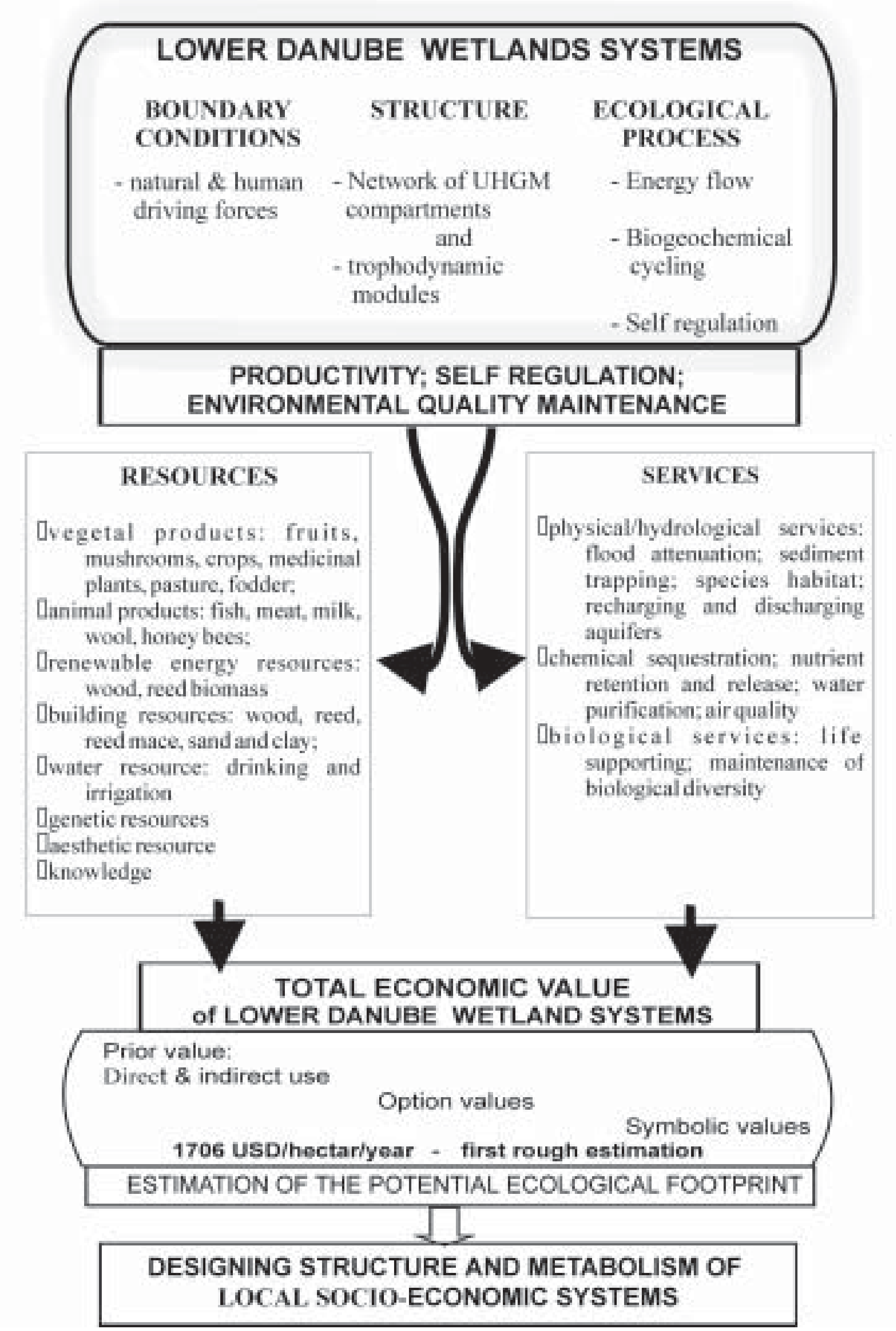

Fig.3. A framework view of Lower Danube Wetland System as resources and services provider (potential footprint) to the local socio-economic system.

systems (e.g. urban ecosystems, industrial complexes), which are totally dependent on commercial energy and material inflow (Odum, E., 1993; Vadineanu, A., 1998, 2001).

The human dominated and in particular human created systems, exhibit in addition to the above characteristics at least three other features: foresight, communication and technology (Holling. C.S., 2001). After Holling, these features play a major role in changing the type and location of variability within the spatio-temporal hierarchy of the dynamic and adaptative systems or within the panarchy. The panarchy is the metaphor introduced by Holling (1986) and developed later in so called "panarchy theory" by combining the idea of space and time hierarchy with that of adaptative cycles (Holling, C.S., 2001; Guderson, I., Holling, C.S., 2001). However, this theory is in many respects equivalent to the theory of Systems Ecology, which recognizes that physical and biological environment (including the man-made one) is organized at large space and time scales into a hierarchy consisting in non-linear dynamic and adaptative ecological systems (Vadineanu, A., 1998, 2001). According to the above conceptual views it has to be accepted that the global "ecological crisis" established progressively in the last century reveals a clear and increasing dichotomy, within the ecological hierarchy, among the components of Natural Capital and Socio-Economic Systems (SES). That should be the result of cutting the links between the adaptative cycles of both components' categories, at all hierarchical levels, by promoting inappropriate economic strategies and policies.

In these circumstances, it makes also sense to consider that up to now, the economic growth has been done at the expense of nature and of the quality of physical environment.

The same context let us propose for the term "biodiversity" the broader meaning, covering on one hand the components of Natural Capital together with their taxonomic and genetic diversity and on the other hand, human social organization, ethnic, linguistic and cultural diversity.

In other words, we can say that the biodiversity consists in Natural, Social and Cultural Capital and provides, on one side, the footprint which supports and feeds with resources and services the Socio-Economic Systems and, on the other side, the interface between Natural Capital and the Structure and metabolism of the "economic subsystem" (see Fig. 4).

A - The man-made physical capital: I - the infrastructure of the economic subsystem dependent on the renewable resources provided by the components of the Natural Capital; II - the industrial infrastructure of the economic subsystem dependent on "non-renewable" resources; III - Systems* for commercial energy production using as primary resources: fossil and nuclear fuels and hydro-power potential; IV - the human settlements infrastructure. B - Social capital; C - Cultural capital; D - Man-dominated components of the Natural Capital; E - natural and semi-natural components of the Natural Capital: 1 - flow of renewable resources; 2 - flow of raw materials; 3 - flow of fossil and nuclear fuels; 4 - flow of electrical energy; 5 - material and energy inputs (fertilisation, agrotechnical works, irrigation, selection etc.) to support the management of man-dominated systems; 6 - dispersion of heat and of secondary products (wastes) in the troposphere and in the HGMU components.

The relationships between "humans and nature" have more recently been referred to as "development and environmental" relationships or relationships between "economy and ecology". They should be further reformulated and recast as the adaptative and dynamic relationships at local, regional and global scales between the structure and metabolism of Socio-Economic Systems, on one side, and the structure, productivity and carrying capacity of the natural, seminatural and human-dominated systems (NC), on the other side.

As far as the methodological approach is concerned, in the last decade we noticed very clearly a rapid shift from the sectoral, reductionistic and inappropriate temporal (months and years) and spatial scale approach towards a holistic and long term approach (decades and centuries). Systems analysis and modeling are more extensively used for the identification and description of the ecological systems (including SESs) as large, complex, dissipative as well as dynamic and adaptative systems.

PATTERNS OF HUMAN IMPACT AND ECOLOGICAL CHANGES

According to the adopted conceptual frame, the socio-economic systems are components of the ecological systems hierarchy. Each local and national socio-economic system is equivalent to a regional or macroregional complex of urban, rural, industrial and "cultivated" or human dominated ecosystems, interconnected through transportation and communication systems (Vadineanu, A., 1998, 2001).

Socio-economic systems have always been

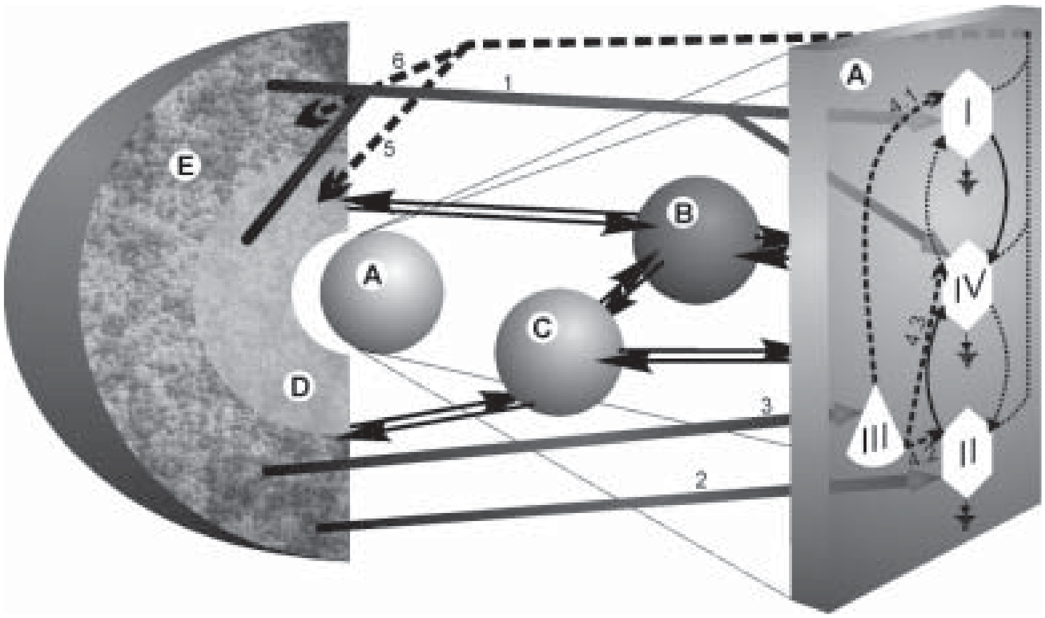

Fig. 4. The general physical model of the socio-economic system and its relationships with Natural Capital. (After Vadineanu A., 1998 & 2001).

subjected to integration processes at regional or macro-regional level and only in the last five decades they undergone a rapid integration leading to a global socio-economic system. The spatial architecture of each socio-economic system has or should have a foundation established at a very significant extent (~50%) by a network of natural and seminatural components of the hierarchy.

They exhibit structural and functional changes at space and time scales, driven by external and internal forces. The external forces may have origin within the ecological hierarchy (e.g. productivity and carrying capacity of natural components) or out of this space and inside the Planet Earth, while the internal forces are mainly: i) the exponential dynamics of human populations size; ii) the evolution of life style and free market, and iii) the technological progress. The spatial relationships between the socio-economic systems and their ecological foundation as well as the mass and energy exchanges among them evolved, at least apparently, until mid of the twentieth century within the carrying capacity and the resilience of the entire hierarchy. Since that time a clear imbalance among the dynamics of the global socio-economic system and its ecological foundation started to became evident. In order to prove and to assess such disruptions many national or international researches and monitoring programmes were carried out. Among them, those sponsored by UNESCO and ICSU have brought the major contribution.

They focused on: i) geological resources (IGCP), fresh water resources (IHP) and biological resources (DIVERSITAS); ii) human dimension as in the case of International Human Dimensions Programme (IHDP) or the Programme on Management of Social Transformations (MOST); iii) climate and oceans as in the case of the International Geosphere-Biosphere Programme (IGBP) and the World Climate Research Programme (WCRP); and iv) the interactions among people and nature, like in the case of the Man and Biosphere Programme (MAB) (di Castri, 2000).

As a result of implementation of such programmes, a huge bulk of reliable data has been produced and assessed in the last decades and they certainly proved that the major impacts on the environment have a human origin, a thing that explains the occurred disruptions and divergent dynamics. In the following pages we have decided to address briefly the main patterns of human impact and trends in human induced changes upon the ecological hierarchy at global scale.

Demography and human ecology experts as well as the specialized bodies of the United Nations have witnessed that the exponential growth of human population in the last century, and the respective increase of the human demands for space, food resources and better life conditions, have driven the dynamics of the socio-economic systems. Two thousand years ago, the human species consisted of less than 500 million individuals. In a period of eighteen centuries, the human population size increased slowly and reached one billion individuals.

In another hundred and thirty years the number doubled again (2 billion in 1930), and it required only another 60 years to reach the 5.29 billion individuals, of which 78 % lived in developing countries. At the rate of growth recorded at the beginning of 1990s, the human population was estimated to grow every year by 97 million individuals. The global human population size already exceed six billion individuals (McNeely, 1996; Vadineanu, 2001). According to the most likely demographic scenario, the expected growth of the global population through 2030 will be around 80 % higher as compared to the reference value in the year 1990, which amounts to a total number of about 9.5 billion individuals.

i) Under these circumstances, spatial expansion was respectively one main feature of socio-economic systems dynamics and a major way of impact upon the structure of ecological hierarchy. The process of spatial development involved extensive and intensive conversion of different types of natural and seminatural ecosystems into human dominated ecosystems (mainly agricultural ones) or human created ecosystems (e.g. urban and industrial ecosystems). The result was that in two centuries of spatial development of the global socio-economic system, the weight of some major categories of natural and seminatural ecosystems have been reduced at a very high extent. In this regard, it is worth mentioning that at the beginning of the eighteen century, forest accounted for more than 50 % of the land and two centuries later, they accounted for less than 23 %. They have been converted mainly into arable land for crop production and grasslands. In the same interval of time, the wetlands ecosystems have been also extensively replaced by intensive crop farms, tree plantations, industrial fish raising, harbors, industrial ecosystems or urban ecosystems (Schot, 1999, Musters et al., 1998; Arrow et al., 1995; Costanza, 1995).

Most affected were the coastal and freshwater wetlands (e.g. floodplains) or peatlands. The available estimates show that more than 55 % of natural wetlands has been converted in the USA, over 90 % in New Zeeland and almost 100 % in many parts of Western Europe (McNeely, 1972; Schot, 1999). An average of 80 % of the former floodplain of the Lower Danube River Stretch has been also converted into agricultural land between 1960 and 1988 (Vadineanu et al., 1998).

ii) In order to meet the demands for food of the exponential growing human population or those for supplying with material and energy resources the production systems and metabolism of the socio-economic ecosystems, the needs for natural resources have constantly increased. The overexploitation of both renewable and non-renewable resources, thus became a common phenomenon and one of the most severe pattern of impacting on the quality of the environment and upon the structure, productivity and carrying capacity of the ecological foundation supporting and feeding the socio-economic systems.

Currently it is estimated that human populations directly or indirectly use about 40 % of the total net primary production of the terrestrial ecosystems (Vitousek et al., 1986). About one third of the land use of the planet is devoted to the production of food resources, and out of this total, 1.5 billion hectares consist of arable land (Kendall et al., 1994; Doos, 1994).

Since 1950 many hopes have been placed on the results of an intensive farming system based on the use of the most productive varieties of plants, best agricultural technologies, fertilizers, irrigation and effective pest control, in order to allow an annual crop production which was supposed to meet the increasing demand for food of the exponentially growing human populations. After two to three decades of intensive agriculture the externalities associated with such practices have been so great that they have raised serious doubts about the possibility of continuing to achieve the above goal.

The over-exploitation of soil resource combined with some severe damages like erosion, salinization, water-logging and soil compaction have reached an alarming level. Thus soil erosion has exceeded 16 to 300 times the rate of soil resource renewal. It is estimated that about 0.7 % of top soil was lost annually. If that loss rate is maintained, we will expect about 30 % of the most fertile layers of soils to be lost by the year 2050 (Goodland, 1997; Pimental et al., 1995).

According to recent estimates, over the last forty years, about a third of the arable land has been damaged as the result of the over-exploitation of soils and over-grazing. Currently it is estimated that more than 10 million hectares of arable land is lost annually, of which 5-7 million hectares due to salinization, 2-3 million hectares due to water-logging and 2-4 million hectares through extensive urbanization (Kendall et al., 1994; Goodland, 1997); about 16 million hectares are added annually by conversion to natural and seminatural ecosystems from forested, arid, semi-arid and heavily accessible areas (e.g. slope areas or areas with rocky substrate). It has also been estimated that the potential available land for the extension of agricultural area is around 1.5-1.7 billion hectares.

Almost everywhere in the world, all types of forest ecosystems have also been affected by the intensive exploitation of wood resources in order to meet the increasing demand of the wood industry, pulp and paper industry, constructions and fuel for individual households.

Likewise, the current reduction rate of the area covered by rain forests, as a consequence of over-exploitation and substitution, is valued as more than 17 million hectares per year.

Water is intensively used in socio-economic systems for domestic consumption (9 %), industrial processes (about 26 %) and for irrigation of more than 18 % of agricultural crops (about 65 %).

Of the total volume of water in the ecosphere, the renewable fresh water resources accounts for only 2.86 %. Of this volume, 2.24 % is stocked for a longer term in ice caps and icebergs, 0.61 % in the ground water, 0.009 % in lakes, 0.001 % in the troposphere, and only 0.0001 % in the network of surface running water (Allen et al. 1994).

The heterogeneity of the hydro-geo-morphological units and of particular climatic conditions modulate, at spatial and temporal scales, the local and regional hydrological cycles, i.e. the dynamics of freshwater resources. Given these circumstances, there are many terrestrial areas where the amount of precipitations and surface or ground water reserves maintain an annual available fresh-water resource at or below 500 cubic meters per capita, one half of the critical value of the UN standard (1.000 cubic meters per capita) for maintaining sustainable development.

In large geographical areas, distributed like the others mainly in Asia, Middle East and Africa, the level of available freshwater resources is around or below the critical level of 1.000 cubic meters per capita annually (Falkenmark, 1984). Developing socio-economic systems established in these areas are under stress of chronic shortage of water. The background stress is very often enhanced by mismanagement of the catchments (e.g. wetlands drainage; stream flow regulation; soils compaction; land use changes), water pollution, over-population and over consumption, and, last but not least, by the very significant losses from the irrigation and supply system (e.g 40-80 % from the irrigation system, 40-50 % from water supply systems).

The scenarios developed for assessing the impact of human driven changes in the Climate system seem to make the current problems more severe and to entail further water deficits and shortages. In such circumstances the world population, increasing from an estimated 1.5-2 billion people to about 5 billion people in 2025 will probably face the chronic or severe water deficit (Kasperson and Kasperson, 2001; IPCC, 2001; Vadineanu, 2001).

Like the soil, forest and freshwater resources, the biological resources produced in the freshwater and marine ecosystems or in the natural and semi-natural terrestrial ecosystems have been used in most cases at a rate significantly higher than the respective net primary or secondary productivity.

The growing demand for more diverse and larger amounts of biological resources have stimulated the over-exploitation of stocks which rapidly ended into severe reduction or even depletion of many of them.

According to the FAO statistics, between 1960 and 1990, sea catches increased by 44 % as the number of fishing vessels and of their tonnage was doubling.

Most of the countries with direct access to the sea have been attracted by the perspective of increasing the number of workplaces and developing their economies by stimulating industrial fishing and by investing in the development of their fishing fleets.

The reason was to maximize catches and flexibility in regard to the range of species objects of fishing, (while the stocks are decreasing by more than 50 %) as well as to ensure extension of autonomous fishing activity over very large areas of the Earth's ocean.

Since the early phases of such aggressive over-fishing, it has been detected a stock reduction of more than 50 %, in the case of sixteen species and a collapse for eight most valuable species (e.g the stocks of herring in the Atlantic Ocean after 1966 or those of anchovy along the Pacific Coast of South America after 1980) (Weber, 1994; Fairlie et al., 1995).

Although the global fishing industry received annual subsidies amounting to more than 54 billion USD, which in fact stimulated the process of over-fishing, after 1990 a slight but continuous decline of total catches has been registered. This creates many and very important social and economic problems at regional and global scale (Goodland, 1997).

Assuming that a total amount of 90 million tons of biological products will be provided annually by the sea and freshwater fisheries in the next five decades, when the global human population is expected to almost double, we may consider reduction of a half of the available amount of fish per capita comparing with the current level. Under these circumstances, semi-intensive and intensive aquaculture together with reclamation of freshwater fishery is considered the only available, even rather expensive, alternative for supplementing this type of food resource (Goodland, 1997; Vadineanu, 1998; 2001).

The dynamics of socio-economic systems structure and metabolism during the industrial era, and in particular in the last five decades, when global human population has doubled its size, required a multiplication of the input's rates of both renewable and non-renewable resources.

As non-renewable resources, the mineral and fossil energy resources have a crucial role for building the infrastructure and feeding the economic subsystems. That was the reason for carrying on extensive and intensive human activities dealing with identification of mineral and fossil fuels deposits, development of the appropriate mining technologies and development of the efficient production technologies.

Over a period of five decades the production of copper doubled, that of steel increased almost four times, while that of aluminum increased more than ten times.

Currently, the developed countries almost stabilized the production and consumption of metals at the highest rates, while the developing countries continue to increase per capita consumption at a relatively slow rate (Tilton, 1990; Cook et al., 1997). Although developed countries are supposed to maintain the current high consumption rate in the next decades, the global consumption of mineral resources is expected to grow, because of the contribution brought by developing countries due to the growth of both human population size and per capita consumption.

The danger for depletion of the current known mineral deposits comes from the established imbalance between the process of new rich and accessible mineral deposits identification or the development of economically efficient technologies for the use of poor mineral deposits on one hand, and the effort for minimizing consumption in the process of producing or recycling the metals, on the other.

Different scenarios dealing with the long term availability of basic non-renewable mineral resources show that there is an urgent need for rethinking and redesigning the structure and metabolism of socio-economic systems. According to such scenarios, we will count for another 2-3 centuries, on the currently exploited and forecast reserves, if current average per capita consumption rate and the global population size are maintained (e.g. copper, cobalt, platinum ores) or only for 3-4 decades, if we consider a global population size of ten billions of people and a high consumption rate equivalent to the current one in the United States.

The situation seems to be even worse in the case of non-renewable and non-recyclable energy resources. The contribution of concentrated energy to the total input in the global socio-economic system, which fueled its metabolism in the last decades, was estimated at a level of 80 % (Azar et al., 1996). This suggests an annual consumption of fossil energy equivalent to the solar energy concentrated and accumulated in the ecosphere in about one million years (Gibbons et al., 1989). If one considers the current level of per capita consumption and accepts, just for reasons of analysis, the unrealistic assumption of maintaining the global human population at 6 billions people, then it follows that currently accessible oil deposits will be depleted in the next forty years, while natural gas deposits in about sixty years.

In order to overwhelm this critical situation, an urgent and significant reduction of per capita energy consumption as well as a very consistent reduction of the fossil energy based contribution to the total energy input is required. Unfortunately the current technological developments cannot guarantee the fulfillment of the abovementioned requests in the next decades (e.g. the fossil energy based input cannot be diminished more than 10-20 % or nuclear energy based input cannot be increased without accepting high and unmanageable risks).

iii) The most documented and discussed pattern of human impact upon ecological hierarchy concerns the quality and efficiency of the socio-economic system's metabolism, which in fact drives the well known process of pollution.

There's a considerable amount of scientific literature and number of national and global reports or books dealing with pollution. That is why we decided to focus here very briefly on few aspects which fits into the conceptual framework described above.

The dynamics or development of global socio-economic system as dissipative structure, requires continuous feeding by resources, processing and production of marketable goods, delivering and using goods and services for or by people. The coupled processes of mass, energy and information transfer end into goods, services and by products or wastes which is the metabolism of socio-economic system (Ayres and Simonis, 1994; Anderberg, 1998; Vadineanu, 1998, 2001).

It also has to be noticed that most of the goods, at the end of their life cycles, becomes wastes unless they are recycled or re-used.

In related to the nature and quality of resources which feed a socio-economic system and to its structure and metabolic rate, a given human made system generates a wide range and different amounts of gaseous, liquid and solid wastes (e.g. dissolved and particulate organic matter, radionuclides, heavy metals, dust, NO_x, SO_x, CO_2,CH_4).

Additionally more than 100,000 chemical compounds (pesticides, plastics, medicines, additives, fertilizers, food preserving agents or chlorofluorocarbons and hallons) are daily produced and used, of which 7,000 are commercialized in large quantities (Connel D., 1987; Novotny, 1995; Vadineanu, 2001).

Many of the wastes coming out in the technological processes (in the industrialized countries about 70% of the wastes comes from chemical and petro-chemical industry) or the produced chemical compounds are proved to be of high risk for the health of the human populations and for the ecological systems.

All sorts of wastes or chemical compounds have been released or used in the environment in very high amounts and to a great extent on the base of different assumptions regarding dilution, retention and processing capacity of their hierarchical components. In most cases the knowledge available on the retention and processing capacity of the receivers (e.g. abiotic compartments of the hierarchy; different types of ecological systems) was very poor and the emission standards have been established only on the base of dilution coefficients estimates.

In addition, the main features of the hierarchically organized systems have been almost totally neglected, like connectivity, large time coefficients (years, decades or centuries) for describing their non-linear dynamics, cumulative and long distance response.

Given these circumstances, it is not surprising that we are currently facing at global scale an advanced process consisting in overloading the environment with a wide range of pollutants, i.e. one of the most powerful pressure factor upon the climate system and the structure and functioning of the life supporting systems.

iv) Introduction of "non-native" or "alien" species in the structure of natural, seminatural or man-dominated ecosystems is a world wide process running since centuries. Plant and animal species, and their products, have been introduced in different countries for many reasons (e.g. as food, construction materials, livestock, ornamental plants, pests control). The existing historical data show that the intentional introduction of many species have been successfully managed by providing specific conditions in well established systems of production. Many other species intentionally or non-intentionally introduced by people have been integrated into new ecological systems without any adverse effects.

However, a significant percentage of non-native species established in new habitats as large and uncontrolled populations which, in turn, disturbed the trophic structure by replacing or endangering valuable or vulnerable native species. They also diminished habitats and productivity of the invaded ecosystems.

These species introduced in new ecosystems which cause or are likely to cause economic or ecological harm or harm on human health have been recognized as invasive species. Stimulated by the rapid global expansion of trade, transport and travel, invasive species and their costs on society are increasing at an alarming rate. Thus, in the last decade a great effort was focused at national and global scale in order to assess the economic and social price due to invasive species. For such estimation a wide range of effects have been considered, like unemployment, damaged goods, services and equipment, food and water shortages, increased rates and severity of natural disaster, disease epidemics and habitat deterioration. The estimated cost in monetary terms has reached, in most cases, a level of tens and hundreds billion USD every year.

Significant ethical and practical concerns regarding introduction of the genetic modified organisms (GMO) in agricultural and other production processes have been recently expressed by scientists and by public opinion from all over world.

Even if there's no clear evidence, many people believe that exchange of genetic material between GM sources and other organisms is inevitable in the long term

- All human driven relationships between socio-economic systems and the other components of the hierarchy of life supporting systems belong to one of the four patterns identified and briefly described above.

The results consist in a wide range of cumulative and long-distance ecological effects. However, we consider that the following set of effects or changes comprehensively describes the ecological impact of the global socio-economic system dynamics at different time and space scales.

- Erosion of ecological systems diversity by loss or weight reduction of natural and seminatural ecosystems and landscapes, habitat fragmantation, desertification, salinization of soils, loss of connectivity and isolation of valuable natural systems.
- Erosion of biological systems diversity by loss of species and higher taxons, loss of genetic resources, increase in number of critical, endangered and rare species, and by significant and rapid reduction in ethno-cultural diversity.
- Depletion or rapid reduction in stocks of renewable and non-renewable natural resources.
- Changes in global hydrological and biogeochemcal cycles and in global Climate System through overloading troposphere, surface waters (fresh and coastal waters) and soils with nutrients, heavy metals, radionuclids and many other chemical compounds, green house effect and ozone depletion. These changes, in turn, cause global warming, ice caps melting, droughts, desertification, increase of the risk of natural disasters, eutrophication of fresh and coastal sea waters, and acidification of soils and freshwaters.
- Reduction in productivity and carrying capacity of global socio-economic system's foundation or "Ecological Footprint";
- Alarming increase of "debt to natural capital" or of "environmental liability" which risks the development of future generations.

In fact, all the dimensions of ecological impact we have listed above refer to the structural and functional erosion of a large part of ecological systems hierarchy, which provides the current or potential "ecological footprint" for the global socio-economic system.

According to the conceptual framework we have briefly described previously, we may correctly understand that the human induced ecological impact affects, at its turn, the socio-economic system's development. In this regard, we would like to add two major dimensions which refer to the related social and economic impacts.

- Increase of economic disparities and inequalities within society (among rich and poor), between states (developed and developing countries) and regions (north and south).
- Increase of poverty, social insecurity, and political and military instability in most parts of the world. Such type of feedback among human driven ecological, economic and social impact, which stimulates each other, explains the established and evolving dichotomy between the dynamics of global socio-economic system and that of its ecological foundation.

BUILDING GLOBAL AWARENESS

In the early 1960s, the process began with the first publishing of Carson's book "Silent Spring". The author has integrated, along with her own, those findings recorded in the literature and proved the ecological and epidemiological effects of toxic chemical compounds, in particular pesticides.

Almost in the same period, covering the 1950s and 1960s, the UNESCO launched and sponsored a major project, the Arid Zones and the Natural Resources Research Programme, while the International Council of Scientific Unions (ICSU) launched a ten year (1964/1974) study programme well known as the International Biological Programme (IBP) (di Castri F., 2000).

The goal was to identify the biological and ecological mechanisms and processes affected by the global environmental deterioration.

One of the main output of such scientific effort, was consisting in a clear correlation between the ways and rates of human population and economic growth on one side, and natural environment deterioration on the other side. The topic was analyzed in depth by members of the Club of Rome in the late 1960s and the process culminated in an extensive and coherent report which was suggestively entitled "Limits to

Growth" (Meadows et al., 1972). It was the first attempt to develop and analyze different long term scenarios based on a set of estimates regarding the size of human species, the availability and rate of use of renewable and non-renewable natural resources, the technological progress and industrial production and consequently the potential impact on the environment.

Another consequence of that very productive period of scientific activity was the recognition that the natural resources should be considered a production factor in human created systems, together with the capital stocks and the labour force (Sotelo J., 2001; Vadineanu, A., 2001).

At the beginning of 1970s the discipline entitled "economy of resources" emerged as an effect of the growing awareness of the importance of the environment; in particular of natural resources as a production factor, the impact due to resources limitations, and the efficiency in their use (Sotelo J., 2001). After Sotelo, the baseline and source of origin for this discipline are: i) the concerns about the future limited availability of resources; ii) the instrumental framework developed by Jevons, and iii) the Hotelling's rule for the exploitation of non-renewable and non-recyclable resources.

The concept of externalities was also formulated and applied in order to account for the impact of the economic activities upon environmental degradation. Environmental economy was established as a new field in economic sciences, mainly for applying the concept of externalities and the respective set of economic tools in order to minimize the environmental degradation. Thus it was expected that by applying the optimum exploitation procedures to natural resources and by taking into account the externalities of all economic activities it would have been possible to meet the criteria of social welfare.

In this context of increasing evidence pointing to the correlation between global deterioration of the environment and the economic growth, the United Nations organized the Conference on the Human Environment/Stocklom-1972. In that occasion a set of decisions has been adopted regarding the need of co-ordinated common actions for environmental protection as well as of the establishment of a scientific institutional infrastructure and programme focused on regional and global environmental issues. Immediately after launching the United Nations Environment Programme (UNEP), different states and regions developed and implemented individual or common sets of measures consisting in working out strategies, action plans, treaties, international conventions and agreements or the establishment of specialized institutional infrastructures dealing with the most critical issues related to the impact of economic development on the environment.

We do not mean to go into details regarding the different initiatives and their efficiency. However we consider it very important to point out a major feature of that hard work carried out in different sectors and at different levels or space scales. It deals with the fact that the environmental concern was considered marginal to the economic development and translated mainly into actions which were focused on identification of critical environmental damages and development of plans for pollution abatement or reclamation and reconstruction of the damaged sites. The financial investments required by the implementation of such curative actions has increased almost exponentially and became a major threat for economic growth in most developing and even developed countries. Thus, so called environmental investments have been soon perceived by the public opinion and by politicians as a limiting factor for the economic development and consequently for the fulfilling of their short and medium term aspirations.

The statement according to which the investments supporting the actions for environmental protection are affordable only by the developed and rich economy countries was easily formulated and widely spread out.

A second UN-Conference held in Nairobi/1982, accompanied by a wide range of governmental and non-governmental reactions or initiatives, was focused on the need of further improvement of our understanding concerning the relationships between development and environment.

In this regard, it was established in 1984, under the chairmanship of H.E. Gro Harlem Brundtland, Prime - Minister of Norway, the World Commission for Environment and Development (WCED).

The Commission made the first attempt to assess on global scale the interdependence among social, economic, cultural and environmental problems. It was recognized that until 1980s the development model had been designed and described exclusively or predominantly in economic terms. The results was that always and almost everywhere in the world, the economic growth had been reached at the expense of nature and environmental quality. As previously stated, the environmental protection concerns and measures have been viewed and treated as collateral to the economic development itself.

That was also accompanied by the lack of any consistent system of ethical and moral norms for guiding the use of nature. The Commission's report, well known also as Brundtland Report, was published in 1987 and it represented one of the most powerful and convincing proof of the need of a new model of development which has to integrate environmental, social and economic dimensions across different time and space scales.

The sustainability concept, addressing the new model of socio-economic development, has received a first formulation and coherent description as well as world wide recognition together with the report titled "Our Common Future".

Additional arguments and clarifications to the concept and model of sustainable development have been brought after the WCED's report publication. In this respect, a major role was played by UNESCO, UNEP or ICSU and IUCN (International Union for the Conservation of Nature) by promoting former and new regional and global research and monitoring programmes, critical analysis, as well as by the improving information and communication activities.

The result was that at the beginning of 1990s it was possible to mobilize the national, regional and global political and operational (both governmental and non-governmental) bodies in the very complex and difficult preparatory process of the UNCED, which was held in Rio de Janeiro, June 1992.

Although the overall framework for the preparatory work and the conference itself has been established according to the well documented need for integration of environmental, social and economic dimension into a new model of development, the main documents adopted are dealing mainly with the relationships among environment and economic development.

The main products of the preparatory work which have been improved and agreed upon at UNCED are: i) the Rio Declaration which proved the political will of most UN member states to take part to the global transition towards the model of Sustainable Development, based on ecological security; ii) the Agenda 21, which in its four sections and forty chapters, deals with long term projections and more comprehensive description (at least in some respects) of Sustainability, and iii) the first set of international conventions which supposed to enforce at global scale the provisions dealing with biodiversity conservation and Climate Changes.

Thus we may say that a very important step forward was done for the implementation of the sustainability concept into the model of economic development, but the social dimension is still missing, which remains a marginal concern.

Soon after Rio, a significant degree of ambiguity and vulnerability regarding the concept of sustainability and the lack of a coherent and strong operational infrastructure, able to support conversion of the new concept into practice, has been documented.

All the shortages previously listed explain the very widespread opinion among politicians, decision makers and public opinion that the needed holistic or ecosystem approach of all our economic, social and engineering activities is just written down in strategic papers but it is not really practiced in such a way which would allow to speak of sustainable development.

In other words, it might be easier now to use terms like ecological integrated crisis or holistic approach of the environment and carrying capacity. But it's still very hard to conceptualize that the ecological crisis has to be linked with the dichotomy in the dynamics of Natural Capital components and socio-economic systems; the integrated or holistic approach requires the understanding that physical and biological environment has a hierarchical organization which integrates the socio-economic systems; and the carrying capacity of Natural Capital is linked to the stability in a broad sense, as well as to the dynamic capacity of the ecological systems to provide goods and services and to assimilate the wastes released from the human made systems (Ring, I.,1997; Constantza, R., 1996; Musters et al., 1998; Vadineanu, A., 1998, 2001).

Under these unfavorable circumstances, which are basically linked with the severe shortages in the human resources development and training system as well with the lack or underdeveloped Support Systems for Adaptative Management (SSAM), it was even more difficult for the decision makers to put in practice dynamic strategies and policies targeted to adapt economic patterns of development to ecological succession's patterns.

However in the last decade it has been recorded a significant increase in the scientific understanding and awareness of the fact that the structure and metabolism of any sustainable socio-economic system should be well rooted in a diverse, self-maintained and productive "ecological footprint" (Wackernagel and Rees, 1996).

A new philosophy, dealing with the sustainable market and development as well as new managerial patterns focused on biological and landscape diversity conservation have been derived from the theory of systems ecology and ecological economics.

Although a lot has been achieved, especially in the last years, for assuring ecological security, the world is confronted with overpopulation, unemployment or inappropriate employment, increase of poverty and poor nutrition, health deterioration, class inequalities, a growing dependence upon distant global markets, and growing violence and insecurity (Vadineanu, A., 2001; Swaminathan, S., 2002; Kasperson and Kasperson, 2001).

Such type of human society evolution suggested that any positive effects of the investments made for assuring the ecological security will be sooner or later threatened by the impact of social insecurity, as long as the social issues will receive only marginal consideration.

In these circumstances, at the Social Summit held in Copenhagen in 1995 it has been unanimously recognized that there's an urgent need to integrate the social dimension into the model of sustainable development.

It will be this the final stage of a long and costly process of integration of the social, ecological and economic elements into a renewable and adaptable social and economic construction built on a strong and dynamic ecological foundation.

At the World Summit on Sustainable Development which was held in Johannesburg, (September 2002), the representatives of world nations has adopted the improved version of Sustainable socio-economic development model. The new model is supposed to be based on knowledge, information and innovation resulting in flexible and high efficiency technological infrastructures, sustainable markets, job and welfare generation and equitable access and sustainable use of the potential ecological footprint.

By implementing such a model of development, ecological and social security and poverty reduction is thus expected to be achieved, at the appropriate time scale.

HOW TO PROTECT OUR PLANET?

A brief answer is proposed based on three fundamental elements which have been almost entirely neglected in the past. First, the problem of identification and formulation in the most scientific and pragmatic terms. Second, the structure of a set of norms intended to establish the dynamic framework for assessing and planning spatio-temporal structure of the ecological foundation or footprint, which is the natural capital as well as the structure and metabolism of the socio-economic system. Third, the operational infrastructure or the "support system for adaptative management" which is intended to play the key role in the process of implementation of the sustainability vision in practical policy decisions.

i) According to the conceptual framework presented in the second section of this paper, we are promoting the model of co-development of socio-economic systems and their ecological foundations as the practical target of sustainability. The protection of our planet Earth against human impact, might be translated or formulated as follows: "designing and implementing adaptative management in order to re-establish and maintain the balance between the socio-economic systems and their ecological foundations across space and time scale". This involves continuous adaptation of the socio-economic systems development cycles to the ecological systems ones which form the foundation. This involves also actions targeted to adapt socio-economic systems across hierarchical levels (from local to global scale).

ii) The following norms are proposed for defining the overall frame where the dynamic of SESs should be maintained through adaptative management:

- Maintaining and improving (reclamation and reconstruction) the structural and functional integrity of the potential footprint (natural capital) of the SESs (local, regional and global);
- Assessing productivity, carrying capacity and stability of the potential ecological footprint across space scale;
- Natural and seminatural ecological systems should constitute at least 50 % of the foundation of SESs.
- Structure and metabolism of economic subsystem;
- Structure of social subsystem (social capital)
- Life style
- Moral and ethical norms for guiding the access to the natural capital and economical, technological and cultural benefits.

The set of moral and ethical norms should be applied to states, regions and people from current or coming generations.

- New markets adapted to the norms of co-development or sustainability.

iii) The structure of the Support System for Adaptative Management (SSAM) which is proposed in this paper was designed to integrate valuable elements already existing in the structure of social and cultural capital and also to clearly show what it is further needed for its development.

In the first instance, we consider as key components for any coherent and powerful SSAM the knowledge and data generation subsystems and the complementary information and knowledge subsystem dealing with structural and functional dynamics of different categories of Natural Capital components and Socio-Economic Systems.

In order to avoid any misinterpretation we are stressing once more that we are not speaking here about huge bulk of existing data concerning different “environmental factors” or some components of the ecological systems, which were produced very often by implementing sectoral research and monitoring programmes, designed and carried out at inappropriate spatio-temporal scales.

Very often less than 30% of the existing data and information, when they are properly structured and available, can effectively support the decision making process.

In recent years it has been manifested an increasing effort focused on the identification and establishment of the structure of the knowledge and data generation subsystems (Gosz, 1999; Wiens, 1997; Likens, 1989).

They are designed to be progressively developed as interconnected national, regional and global networks of representative ecological systems for both Natural Capital and Socio-Economic System and corresponding networks of institutions which are expected to function as long term integrated research and monitoring platforms.

In other words, they are expected to provide the needed scientific basis for policy decisions and integrated management dealing with the components of the Natural Capital, structure and metabolism of the Socio-Economic Systems and the dynamic relationships among them.

The knowledge concerning mechanisms and processes of the systems structural and functional dynamics together with the data showing the variability of their key state variables and driving forces, feeds the specific information and knowledge subsystems.

In the end, the information subsystems have to contain the required knowledge and data or the “scientific basis” and the methods and modeling techniques in order to integrate ecological, social and economic information for policy and decision making dealing with balancing the development of NC components and SESs.

From this perspective it is obvious that the information and knowledge subsystems should be considered as the core of SSAM.

The other two components of the SSAM consist in a package of complementary methods for economic valuation of non-marketable goods and services provided by the components of NC and a package of procedures for Ecological Impact Assessment (EcIA) of comprehensive or sectoral economic development plans and individual development project; they can be considered as being in an advanced stage of development.

The questionable role and efficiency of these two components of the SSAM for the decision and policy making, so often revealed in recent times, may be explained in a less extent by intrinsic shortages of the methods and procedures and more by the lack or underdeveloped information and knowledge subsystems.

In spite of the existing shortages which directly or indirectly relate to these components of the SSAM, they are the only effective tools for integrating ecological, social and economic information into the process of solution formulation.

Once a set of solutions are formulated for any particular problem and their potential ecological impact (long term, cumulative and long distance) is estimated, choosing the best solution which fits to the overall goal of sustainability as well as the development of the management plan is the next crucial steps.

For these stages of decision making and implementation process, any support system for adaptative management has to integrate other specialized compartments like the flexible subsystem for communication, education and training and the coherent and effective subsystems of regulatory and non-regulatory tools. It is obvious that all the above listed components of the SSAM are or have to be grounded in a complex, flexible and free of overlapping and parallelism institutional infrastructure which unfortunately is not the case at our time.

However, the institutional infrastructure of the SSAM tends to integrate governmental and non-governmental as well as public and private institutions in order to establish the needed flexible and effective system of checks and balances throughout the decision making and sustainable management plan process (Ruijgrak et al., 1999; Mustures et al., 1998; De Groot, 1998; Weyns, 1998; Boon, 1998; Meppem et al., 1998).

It is also widely accepted that the governmental institutions have to play the major role in developing the operational subsystems of the SSAM and policies while the NGOs and private interests have to provide for the implementation link with the community structure.

As far as both processes of decision making and implementing the adaptative management plans are dealing with complex and dynamic systems at large spatio-temporal scale, we strongly believe that there is a need for integration within the SSAM structure of a specific subsystem containing the evaluation and monitoring methods and indicators of the overall co-development process.

In other words, it might be said that by integrating the evaluation and monitoring subsystem within the structure of SSAM it will be established the loop for specific feedback on the status of progress towards the goal of sustainability.

FINAL REMARKS

Two decades ago, looking for the future of human civilization in a post-industrial era, many experts and policy makers launched the concept of "information based society". Soon after that, people realized that the opportunities brought by the technological progress in the field of information and communication technology is providing support for integration of socio-economic systems at global scale and for increasing efficiency in their governance, but is not able to help getting long term solutions to many critical issues we are currently facing or global human population will be facing in future.

Most ideas formulated or integrated in this paper, suggest that in the twenty first century humans have to create fundamentals for a new civilization.

Among those fundamentals, few might have the essential role: i) a new vision and way of thinking which has to enable knowledge development about the hierarchical and non-linear dynamic systems; ii) new ideology and a new meaning for the concept of globalization; iii) a new approach for designing structure and metabolism of socio-economic systems based on an effective set of norms which ensure ecological and social security, social justice, technological innovation, and new markets, and iv) integrated operational infrastructure enabling the adaptative management of socio-economic systems and their ecological footprints across space and time scales.

KEYWORDS Ecology. Human Impact. Globalization

ABSTRACT The view and understanding of relationships among of natural and human transformed or created environmental across space and time scales have been improved significantly in the last two decades. A critical analysis upon the main theoretical achievements has enabled us to establish a comprehensive conceptual model about hierarchical organization of the "environment" or "nature" of the Earth planet and about the relationships among environment and human dominated and created systems at global scale. That conceptual model has been applied for the assessment awareness development about human induced environmental changes and identification the main types of human impacts and trends in the dynamics of global environment. In the last sections of the paper we focused on a potential operational infrastructure and new and long term targets for actions in order to achieve the overall goal of sustainability of the Earth's hierarchy of socio-ecological complexes.

REFERENCES

Allen, L. R. J. et al.: *Paleoclimates and their Modeling: With Special Reference to the Mesozoic Era*. Chapman & Hall, London, New York, Tokio, Melbourne, Madras (1994).

Anderberg, S.: Industrial metabolism and the linkages between economics, ethics and the environment. *Ecological Economics,* **24:** 311-320 (1998).

Arrow, K., Bolin, B., Costantza, R., Dasgupta, P., Folke, C., Holling, S. C., Jansson, O., Levin, S., Maler, G. K., Perrings, C. and Pimentel D., *Ecol. Econ.:* **15(2):** 91 - 97 (1995).

Ayres, R. U. and Simonis, U. E. (Eds.): *Industrial Metabolism: Restructuring for Sustainable*. United Nations University Press, Tokyo (1994).

Azar, C. et al.: Socio-ecological indicators for sustainability. *Ecological Economics,* **18:** 89-112 (1996).

Boon, K.E.: Environmental planning, p. 69-88 In: *Environmental Management in Practice*. B. Nath, L. Hens, P. Campton, D. Devuyst, G. Routled (Eds.). London, New York (1998).

Connell, W. D.: Ecotoxicology - a framework for investigations of hazardous chemicals in the environment. *Ambio,* **16(1):** 47 (1987).

Cook, J. P. and Shearth, D.: World mineral resources and some global environmental issues, *Nature & Resources,* **33(1):** 26-34 (1997).

Costantza, R.: Economic growth, carrying capacity and the Environment. *Ecological Economics.* **15(2):** 89-90 (1995).

Costantza, R.: The Importance of Envisioning in motivating change toward sustainability. *Ecological Economics Bulletin,* **1(2):** 11-13 (1996).

De Groot, U.: Problem in Context: a framework for the analysis, explanation and solution of environmental problems, p. 22-43. *Environmental Management in Practice.* In: Vol.I B. Nath, L. Hens, P. Campton, D. Devuyst, G. Routled, (Eds.). London, New York (1998).

Di Castri, F.: UNESCO/ICSU, UNESCO and ICSU International Scientific Programmes on Environment and Sustainable Development, UNESCO, PARIS (2000).

Doos, B. R.: Environmental degradation, global food production and risk for large scale migrations. *Ambio,* **23(2):** 124-130 (1994).

Fairlie, S., Hogler M.: O'Riordan B.: The politics of overfishing, *The Ecologist,* **25 (2/3)**: 46-73 (1995).

Falkenmark, M., New Ecological approach to the water cycle: Ticket to the Future. *Ambio,* **13:** 152-160 (1984).

Gibbons, G. H., Blair, P.D. and Gwin, H.J.: Strategies for energy use. *Scientific American,* **26(3):** 136-143 (1989).

Goodland, R.: Environmental sustainability in agriculture: diet matters. *Ecological Economics,* **23:** 189-200 (1997).

Gosz, J., International Long Term Ecological Research: collaboration among national networks of reserach sites for a global understanding, p. 9-21. In: *Long Term Ecological Research: Exemples, Methods, perspectives for Central Europe" Proceedings ILTER* Regional workshop, 16-18 september

1998, Madralin, Poland, Kodruk (1999).
Gunderson, L. and Holling, C.S., (Eds.): *Panarchy: Understanding Transformations in Human and Natural Systems*, Island Press, Washington DC (2001).
Holling, C.S.: The resilience of terrestrial ecosystems: local surprise and global change. In: W.C. Clark and R.E. Munn, (Eds.): *Sustainable Development of the Biosphere*. Cambridge University Press, Cambridge. p. 292-317 (1986).
Holling, C.S.: Understanding the complexity of Economic. *Ecological and Social Systems Ecosystems*, **4:** 390-405 (2001).
Kasperson, E.R. and Kasperson, X.J.: *Climate Changed, Vulnerability and Social Justice, Risk and Vulnerability Programme*, Stockholm Environment Institute (2001).
Kendall H. W. and Pimental D.: Constraints on the expansion of the global food supply. *Ambio,* **23(3):** 198-216 (1994).
Likens, G.E. (Ed.): *Long Term Studies in Ecology.* Springer-Verlag, New York (1989).
Meadows., D.H., Meadows, D.L. and Ronders, J.: *Limits to growth*, Universe Books, New York, (1972).
McNeely, A. J.: *Conservation and the future: Trends and options toward the year 2025*, IUCN World Congress, Montreal, Document paper, Nov. (1996).
Meppem, T. and Gill, R.: Planning for Sustainability as a learning concept. *Ecological Economics*, 121-138 (1998).
Musters, M.J.C., De Graaf, J.M. and Ter Keurs, J.W.: Political and Economic Inequality and the Environment. *Ecological Economics,* **26(3):** 243-258 (1998).
Novotny, V. and Somlyody, L. (Eds.): *Remediation and Management of Degraded River Basins: with emphasis on Central and Eastern Europe*.: Springer, Berlin, New York (1995).
Odum, E.: *Ecology and Our Endangered Life-support Systems*. Sinauer Assoc. Inc. Publishers, Sunderland (1993).
Odum, E.: *Ecology: A bridge between Science and Society*. Sinauer Associates, Suderland (1997).
Pahl, Wostl Claudia: *The Dynamic Nature of Ecosystems*. J. Wiley and Sons, New York, 1995.
Pimental, D.U., Harvey, C., Resosudarmo, P., Sinclair, K., Kurz, D., McNair, M., Crist, S., Shpritz, L. and Blair, R.: Environmental and economic costs of soil erosion and conservation benefits, *Science,* **267:** 1117-1123 (1995).
Ring, Irene: Evolutionary Strategies in environmental policy, *Ecological Economics,* **23:** 237-249 (1997).
Ruijgrok, E., Vellinga, P. and Goosen, H.: Dealing with Nature, *Ecological Economics* **28:** 347 (1999).
Schot, P.P., *Wetlands* In: B., Narth, L., Hens P. Compton and D. Devuyst: (Eds.) *Environment Management in Practice.* vol 3, Routledge, London, New York (1999).
Sotelo, A.J.: *Environmental Europe*. Oxford University Press, Oxford - Madrid (2001).
Swaminathan, S.: Environmen, the New Economy and New Employment", http://www.mssrf.org/dialog2002.html (2002)
Tilton, J. E.: (Ed.). *World Metal Demand: Trends and Prospects*. *Resources for the Future*, Washington DC (1990).
Vadineanu, A.: *Dezvoltare Durabila: Teorie si Practica, Vol. I*, Ed. Universitatii din Bucuresti (1998).
Vadineanu, A.: *Sustainable Development: Theory and Practice Regarding the Transition of Socio-economic System Towards Sustainability*. Studies on Science and Culture, UNESCO-CEPES, p. 305 (2001).
Vitousek, P. M., Ehrlich, R. P., Ehrlich, H. A. and Matson, A. P.: Human appropriation of the products of photosynthesis. *Bioscience,* **36:** 368 (1986).
Wackernagel, M. and Ress, W.: *Our Ecological Footprint, Reducing Human Impact on the Earth.* New Society Publisher, Gabriola Island, Philadelphia (1996).
Weber, P.: *Net Loss: Fish, Jobs and the Marine Environment*, World Watch Paper 120, Worldwatch Institute, Washington, p. 15 (1994).
Weyns, W.: The cultural filter, p. 44-61, In: *Environmental Management in Practice - Vol.I.* B. Nath, L. Hens, P. Campton, D. Devuyst, G. Routled (Eds.). London, New York (1998).
Wiens, J.: Lengthy ecological studies. *Trends in Ecology and Evolution*, **12:** 499 (1997).
IPCC (Intergovernmnetal Panel on Climat Change: *Climat Change 2001: Synthesis Report*, Cambridge University Press, Cambridge (2001).

Authors' Address: **Angheluta Vadineanu and Radu Stefan Vadineanu,** Departement of Systems ecology
91-95 Splaiul Independentei 050095 Bucarest ROUMANIE
E-mail: anvadi@bio.bio.unibuc.ro