From Human-Environment Interaction to Environmental Informatics (III): the Social-Ecological Systems dynamics in Knowledge-based Society

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Abstract: *Since its inception, human society has noticed that there is a close relationship between the activities it carries out and the way in which the environment behaves; however, attempts to adjust activities to health and environmental integrity have been delayed even in this Knowledge-based Society.*
Nowadays, the environment, as a third part of sustainable development modern concept, plays a crucial role in people's physical, mental and social well-being. Despite significant improvements, major differences in environmental quality and human health remain between and within countries.
The complex relationships between environmental factors and human health, taking into account multiple pathways and interactions (natural-human-human made), should be seen in a broader spatial, socio-economic and cultural context. In this sense, the present paper focuses on the Human-Environment Interaction (HEI) and the Social-Ecological Systems (SESs) dynamics.

Keywords: *Human-environment interaction, Bronfenbrenner's theory, analytic framework, system dynamics*

1. Introduction

The modern society consumer's most pressing problems (environmental pollution, urban sprawl, excessive industrialization and urbanization) - as the results of the Human-Environment Interaction (HEI) - are complex and often transcend spatial and temporal scales [1]. They also do not fall cleanly within the boundaries of a single area of interest, because of the Social-Ecological Systems dynamics (as presented in Fig. 1) - which we see as being an expansion of Bronfenbrenner's environment theory, under different thinking systems approaches [2].

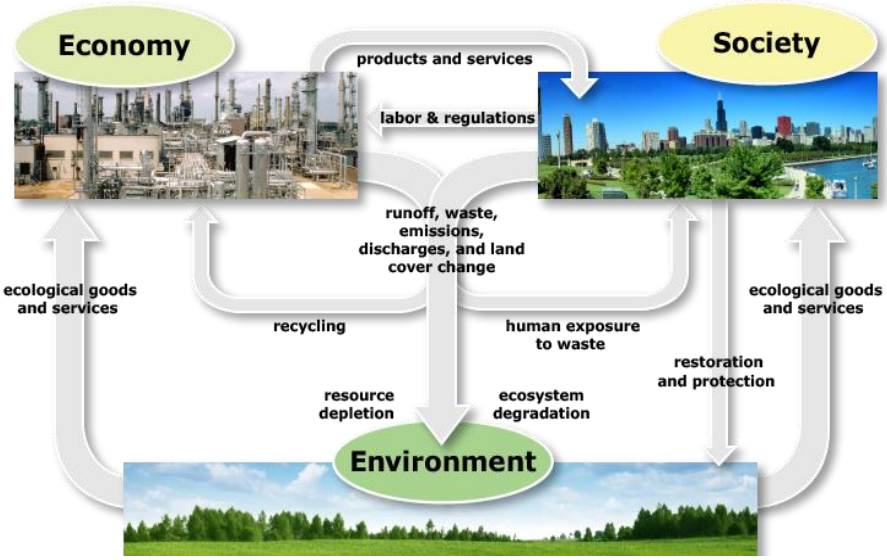


Fig. 1. The Human-Environment Interaction view as a sustainability framework [3]

Thinking system is an approach to problem solving [4] that is based on the belief that the component parts of a system are best understood in the context of their relationships and interactions with one another and with other systems.

Since its inception, human society has noticed that there is a close relationship between the activities it carries out and the way in which the environment behaves; however, attempts to adjust activities to environmental integrity have been delayed even in the Knowledge-based Society.
Expansion of cultivated areas, intensification of agricultural production process, irrational exploitation of forests, excessive industrialization and urbanization, etc. there are so many causes that cause the entire habitat, to be enable to fulfil, in part or in full, its fundamental functions [1].
The unity of the human body with the environment as the fundamental law of life, requires habitat protection against pollution, rational exploitation of resources and, as far as possible, increasing them to meet the increasing needs of humanity. These issues, together with others, require a detailed understanding of the structure, interactions and dynamics existed in our environment.

2. Exploring the Human-Environment Interaction (HEI)

The environment is our basic life support system which provides the air for breathing, the water for drinking, the food for eating and the land for a living. It is collectively portrayed all the external forces and conditions, which influences the life, nature, growth and maturity of living organism, whereas "ecology' is the scientific analysis and study of interactions among organisms and their environment [5]. Much more, understanding the dynamics of Human-Environment Systems (HESs) and developing strategies that promote their sustainability, requires a holistic, integrated approach. Although many frameworks have been developed over time [7, 8], that include social and environmental or, in other words, natural, human and human-made components (Fig. 2), managing social and environmental systems as integrated systems has been difficult in today's practice.

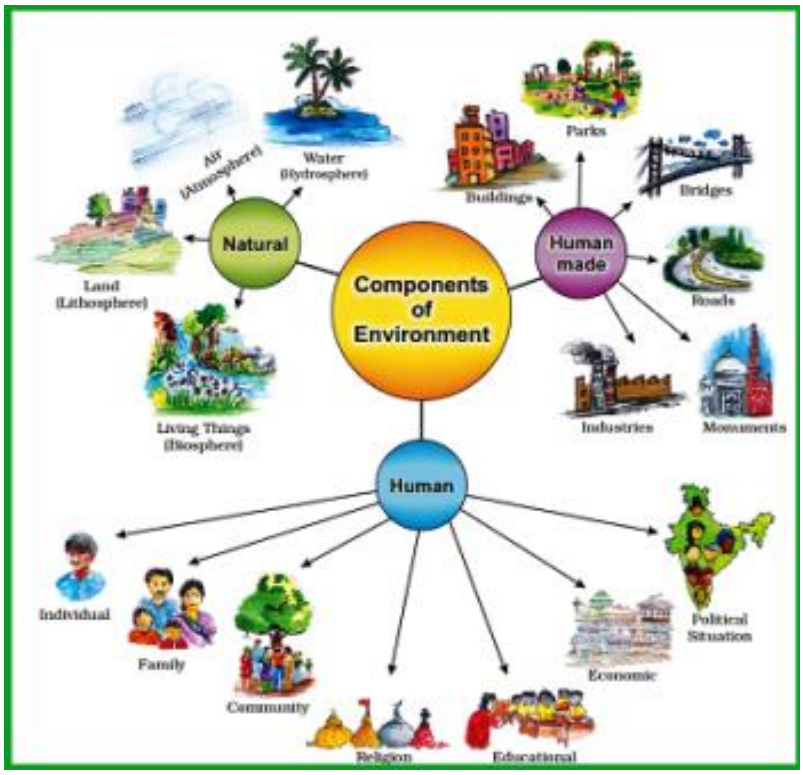
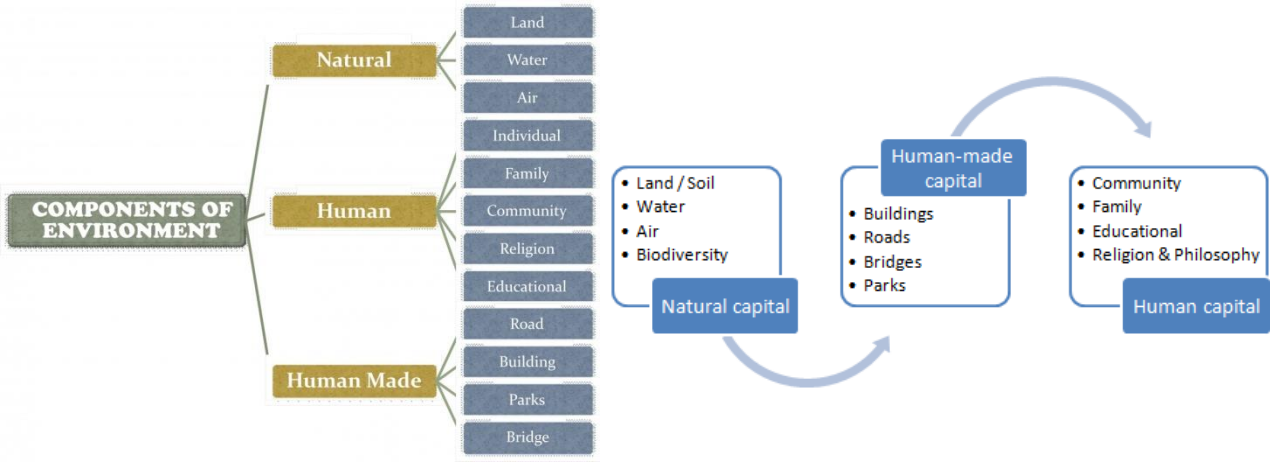


Fig. 2. Illustrated diagram version of components and structures that constitute the environment [5]

Starting from point of view expressed by *ecology* as the science of relationships between living organisms and their environment [1] and *human-ecology* as about relationships between people and their environment [9], an *ecosystem* is everything in a specified area - the air, soil, water, living organisms and physical structures, including everything built by humans. The living parts of an ecosystem - microorganisms, plants and animals (including humans) - are its biological community. The *Social System* is perceived as being everything about people, their population and the psychology and social organization that shape their behavior [9], as presented in Figure 3.



a) b)

Fig. 3. Simple diagram versions and different perspectives for the components of the environment [5, 6]

Human-Environmental Interactions (HEI) in line with the idea presented in Fig. 2 and Fig. 3 can be defined as interactions between the human social system and (the "rest" of) the ecosystem [9].
Human-Social Systems and ecosystems are complex adaptive systems, complex because ecosystems and human social systems have many parts and many connections between these parts (see Fig. 4), and adaptive because they have feedback structures that promote survival in a constantly changing ecosystem or environment [9].

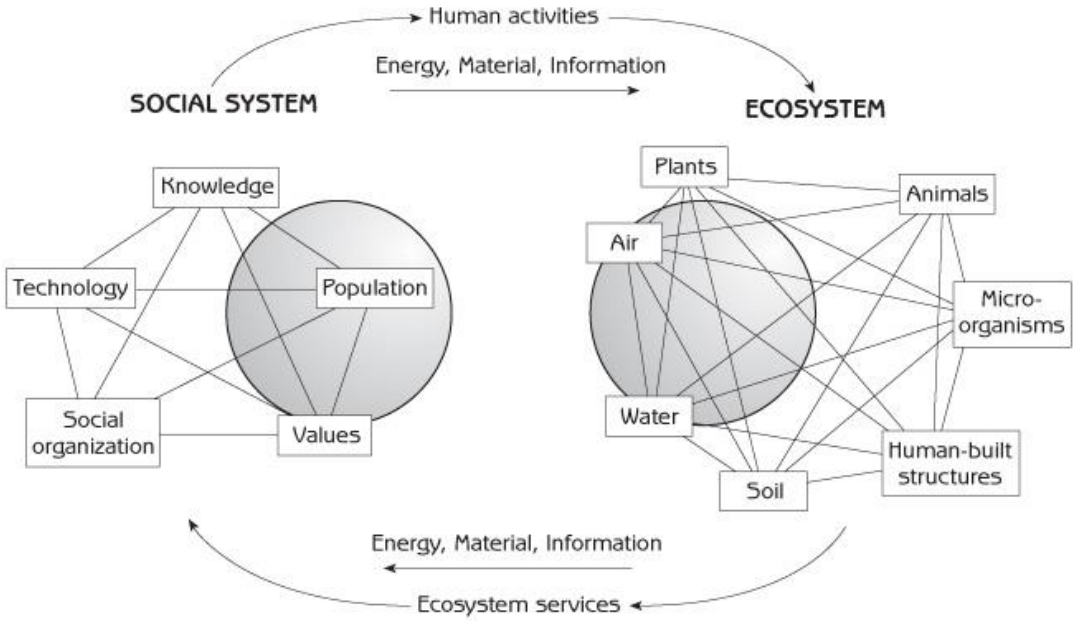


Fig. 4. Interaction of the Human Social System with the Ecosystem [9]

The Social System is a central concept in human ecology because human activities that impact on ecosystems are strongly influenced by the society in which people live. Values and knowledge - which together form our worldview as individuals and as a society - shape the way that we process and interpret information and translate it into action.
Technology defines our repertoire of possible actions, and the social organizations shape the possibilities into what we actually do. Like ecosystems, social systems can be on any scale - from a family to the entire human population of the planet (see Fig. 5). The ecosystem provides services and not only services to the social system by moving materials, energy and information to the social system to meet people's needs - in this sense we are talking about Social-Ecological Systems dynamics.

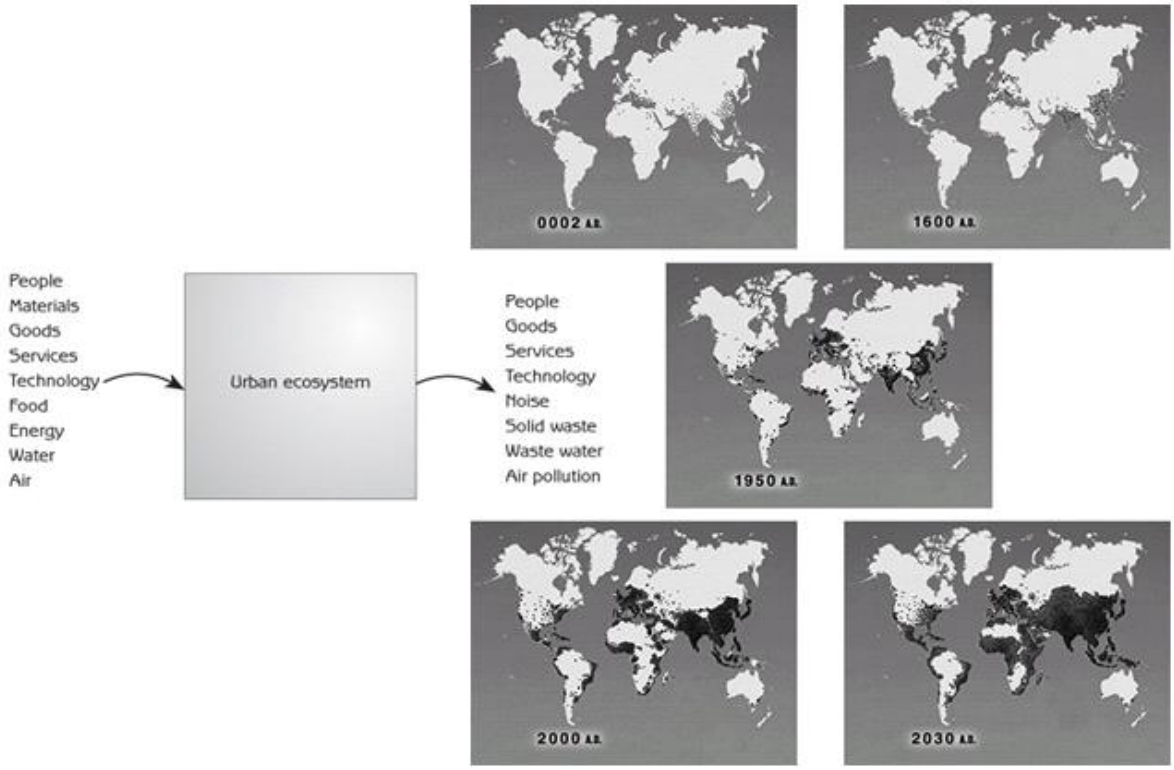


Fig. 5. Inputs and outputs of the urban ecosystem [9]

Material, energy and information move from Social System to Ecosystem (see Fig. 6) as a direct and intimate consequence of human activities that impact the ecosystem - people affect ecosystems when they use resources, after using materials from ecosystems, people return the materials to ecosystems as waste.

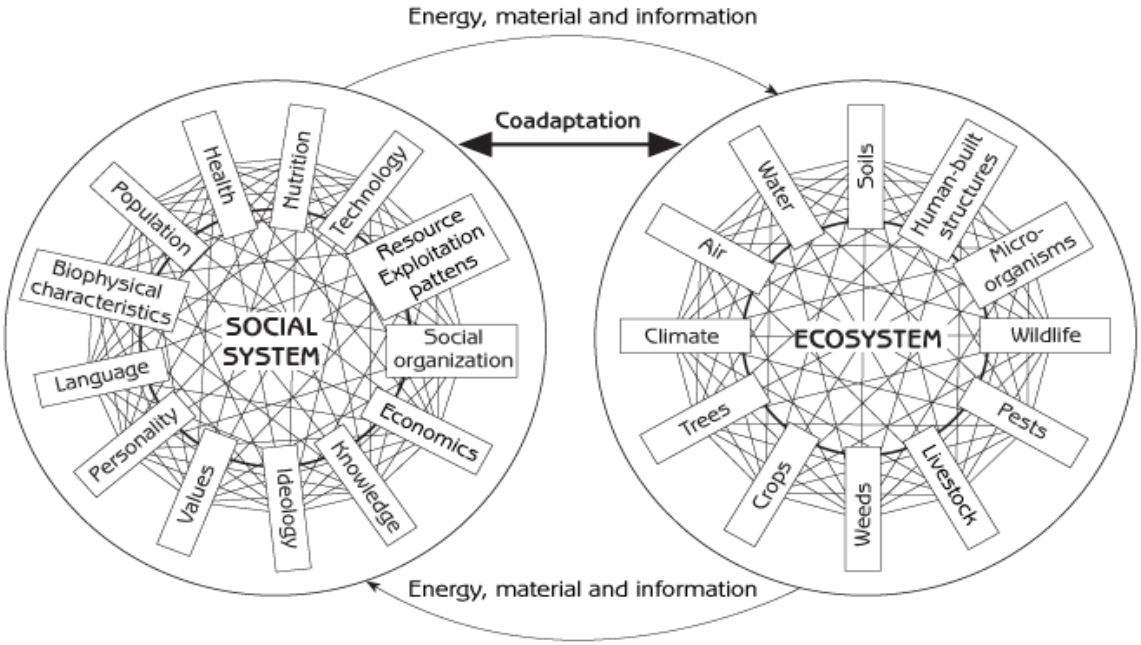


Fig. 6. Adapting of the Social System to the Ecosystem [9]

People intentionally modify or reorganize existing ecosystems, or create new ones, to better serve their needs (see Fig. 7). With machines or human labor, people use energy to modify or create ecosystems by moving materials within them or between them. They transfer information from social system to ecosystem whenever they modify, reorganize or create an ecosystem.

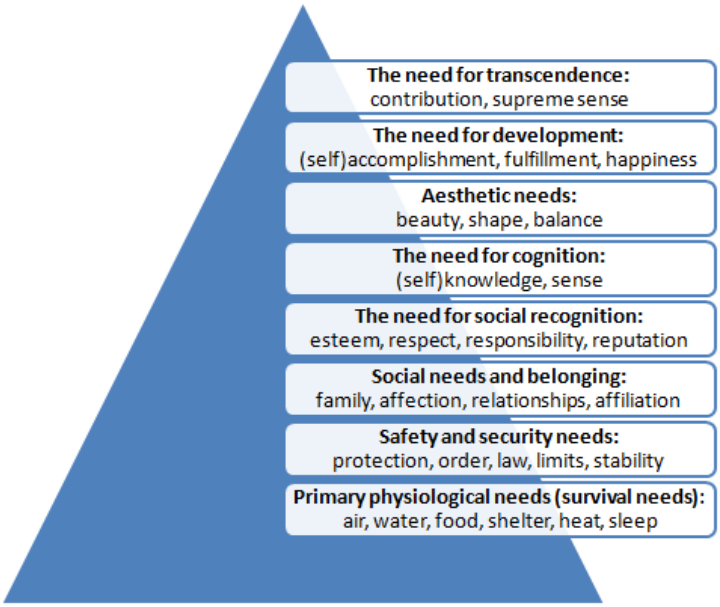


Fig. 7. The need for environmental protection from the perspective of the Maslow Pyramid [6]

Depending on the momentary needs, due to adapting attempts of the Social System to the Ecosystem we are talking about the three hypostases presented in Fig. 8, which, at a certain level, we can say they overlap the Eco-Anthropo-Techno hypostases presented in Fig. 9, within the complex relationship between Social System and Ecosystem.

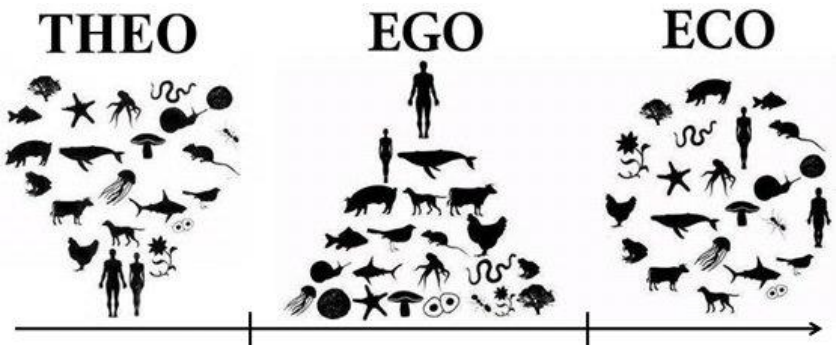


Fig. 8. Overview of human reporting to nature - the 3 hypostases [6]

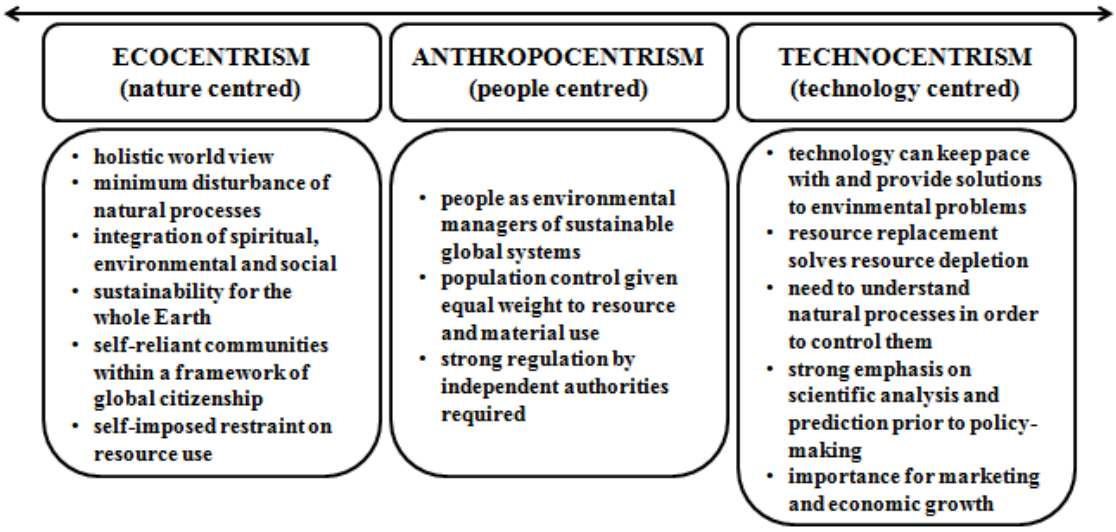


Fig. 9. Overview of human reporting to nature - the Eco-Anthropo-Techno hypostases

3. Bronfenbrenner's Ecological Theory from Human-Environment Interaction perspective

The *ecological systems theory* was developed by Urie Bronfenbrenner, who believed that a person's development was affected by everything in their surrounding environment, starting with the individual level (Fig. 10) - the child's personality, the elements of temperament and attitude.

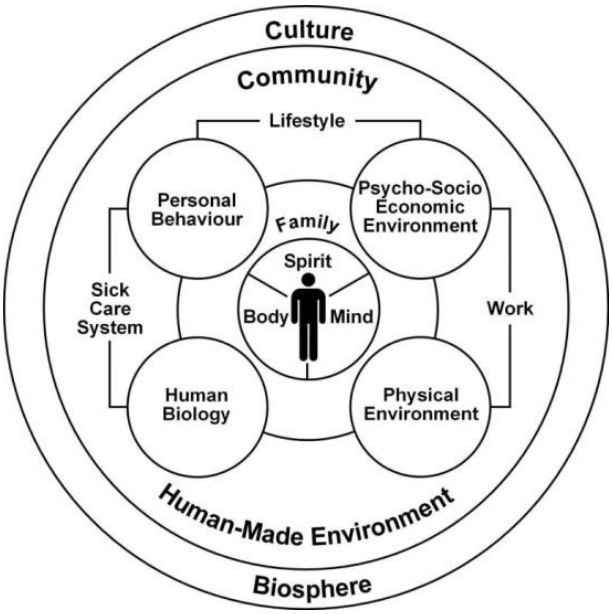


Fig. 10. Ecological Systems Theory at individual level [10]

At this point we talk about 4 aspects as follows:

- *social* - a lot of time spent with friends as well as staying connected via internet and mobile;
- *confident* - with the ability to converse with students and adults alike with ease;
- *mature* - well-mannered and appropriately behaved when required;
- *responsible* - is well presented and understands his responsibilities in the family.

Urie Bronfenbrenner divided the person's environment into five different levels (see Fig. 11):

a) *the microsystem* (*interpersonal processes* and *primary groups*) - is the environment closest to the person, the one in which they have direct contact and where is educated about the world physically, socially and psychologically.

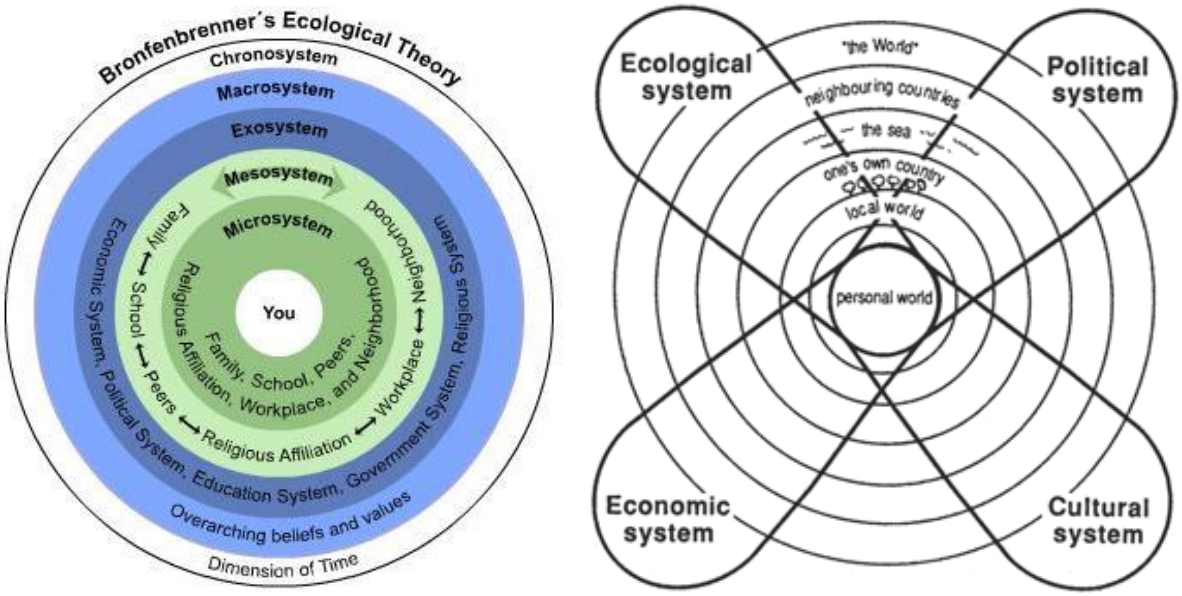


Fig. 11. Different perspectives of Ecological Systems Theory [11]

Some examples would be: *home*/*family* - values and beliefs are derived from here that he chooses to follow and live by and where support and nurture is found; *school*/*university* - place where he is uducated and embraces opportunity of education; *daycare*/*friends* - a diverse range of nationalities where he has learnt to acknowledge and appreciate different cultures; *work* - learning the difficulties that are part of life and the hard work that comes with everyday necessities.

b) *the mesosystem* - consists of the interactions between the different parts of a person's microsystem. The mesosystem is where a person's individual microsystems do not function independently, but are interconnected and assert influence upon one another.
c) *the exosystem* (*organizational factors*) - refers to a setting that does not involve the person as an active participant, but still affects them. This includes decisions that have bearing on the person, but in which they have no participation in the decision-making process.
d) *the macrosystem* (*community factors*) - this layer may be considered the outermost layer in the child's environment. While not being a specific framework, this layer is comprised of cultural values, customs, and laws. The effects of larger principles defined by the macrosystem have a cascading influence throughout the interactions of all other layers.
e) *the chronosystem* (*public policy*) - this system encompasses the dimension of time as it relates to a child's environments. Elements within this system can be either external, such as the timing of a parent's death, or internal, such as the physiological changes that occur with the aging of a child. As children get older, they may react differently to environmental changes and may be more able to determine more how that change will influence them.

In order to analyze Human-Environmental Interactions it is important to be aware of specific characteristics of the human social system. The type of society strongly influences people's attitude towards nature, their behavior and therefore their impact on ecosystems. Important characteristics of human social systems are population size, social organization, values, technology, wealth, education, knowledge and many more.
Especially values and knowledge strongly influence peoples "view of life" and consequently define the way people act. The choice of possible actions is then limited by the available technology, so people modify the environment for their purposes and obtain benefits - Ecosystem Services (see Fig. 12) from it.

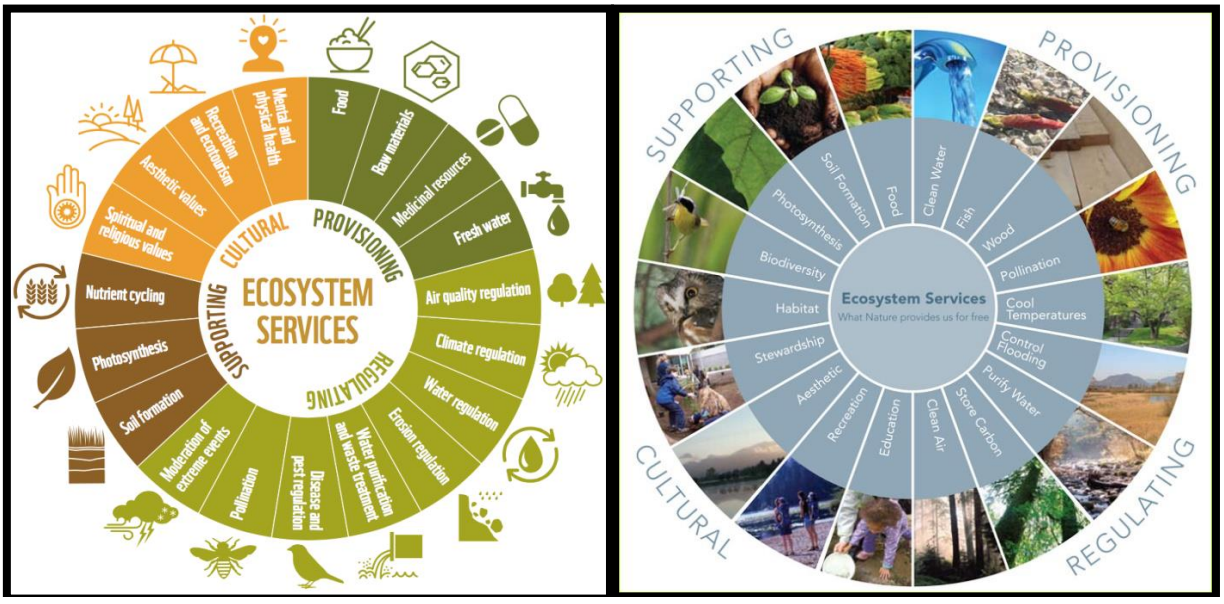


Fig. 12. Different perspectives of Ecosystem Services [12, 13]

These Ecosystem Services are essential for human well-being and include for example the provision of resources like water, timber, food, energy, information, and land for farming and many more. Obviously by using these resources people affect the environment in a lot of ways. Furthermore people often reorganize existing ecosystems to achieve new ones that seem to be more effective in serving their needs.

4. From frameworks typologies for analyzing the Social-Ecological Systems dynamics to the need for Environmental Big Data

Existing frameworks for the analysis of complex systems come in different forms, reflecting differences in the state of knowledge and different understandings of what constitutes a framework. Published frameworks range from systems of equations derived from first principles through to relatively simple box and arrow diagrams that explain quite loosely how different pieces of a system are expected to fit together. They may also be developed for different reasons.
Frameworks for social-ecological systems can be broadly grouped into five categories [8]:

a) *hypothesis-oriented frameworks* - are quite specific, focusing on pairs of variables or clearly defined theoretical questions (e.g. the landscape disturbance framework);
b) *assessment-oriented frameworks* - help people to think in a structured way about a system but are relatively mechanism-free. They are used to summarize key attributes of a social-ecological system for the purpose of describing it, typically for stock-taking or evaluative exercises (e.g. the Millennium Ecosystem Assessment Framework);
c) *action-oriented frameworks* - these recommend a particular course of action by an established set of actors in response to a particular kind of problem. They are usually focused on implementing solutions rather than establishing the causes of problems (e.g. the Nature Conservancy's 5-S framework for conservation, the Driving forces-Pressure-State-Impacts-Responses framework);
d) *problem-oriented frameworks* - have mostly been developed to initiate and facilitate the process of solving a particular kind of problem. They focus more on problem identification and problem-solving processes than on prescribing the actual actions that are to be undertaken; unlike action-oriented frameworks, they do not start with a clear definition of the solution; and
e) *theory-oriented or overarching frameworks* - are the frameworks that attempt to define and connect different pieces of theory within the domain of a particular area of research. There have been a number of attempts at producing general frameworks which either deal directly with SES theory or with relevant aspects of related theories.

The modern society - Knowledge-based Society - in accordance with the actual changes and preoccupations in the environment domain, such as Human-Environment Interaction frameworks and sustainable development [14, 15], has provided various types of informatics resources (tools, methodologies, procedures) to manage and support the ideas and actions related to the environmental issues [16, 17, 18]. The specialists that activates in the environmental protection or other connected domains needs more and more information (Environmental Big Data pool) and knowledges at every level of environmental processes management and evaluation (see Fig. 13).

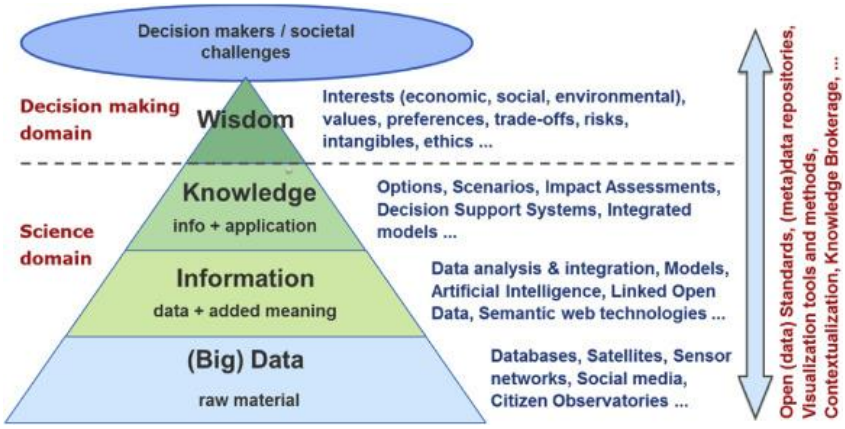


Fig. 13. DIKW hierarchy, from Big Data to decision making for societal challenges [19]

At the same time, in order to elaborate and development a sustainable development project, they need to know and to understand the environmental and phenomena conditions. The analysis used must be based on the best available techniques (B.A.T.), methods and data, and the knowledges get from self experince or from another specialists.

Traditionally, these information and knowledges - part of Environmental Big Data river (see Fig. 14) - are obtained, in accordance with the temporar requirements, by accessing directly databases, reports and documents, by transfering/sharing information and knowledge with specialists or by the contacs extablished at the workshops, conferences and simposions [16, 17, 18].

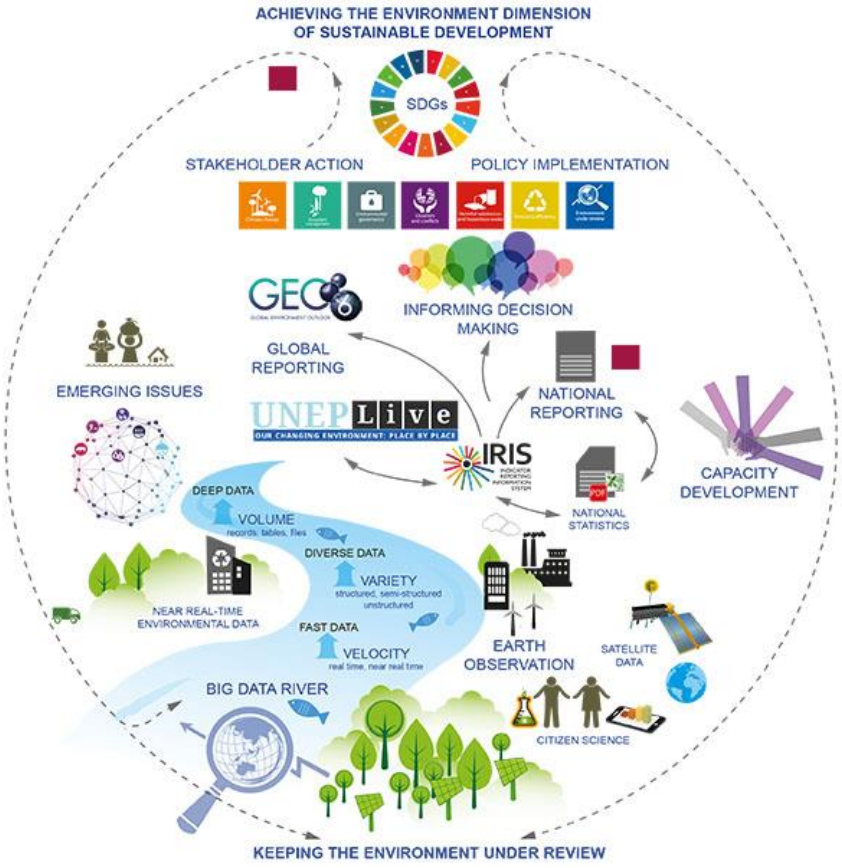


Fig. 14. From Environmental Big Data to Sustainable Development goals [23]

To improve the management capabilities and environmental assessment is necessary for specialists to be able to manage and implement concepts for effective and efficient environment that can be achieved through information software environment. They must also have a simple and efficient access to knowledge and current information enabling them to take the best decisions for sustainable development for both developed economies and those in transition [20, 21, 22].
The current approach starts from the few Romanian contributions in Environmental Informatics domain, trying to rally to the main concerns of the international level. Without going into detail to show all of the specific aspects of Environmental Informatics, we propose, for the next articles, an integrative vision on the subject of discussion as an open and dynamic system, able to perform multiple functions, particularly research, to meet the goals and needs of users.
Knowing that the environmental protection activitivity is just at the beginning in our country, with a major involvement responsiveness and only in the last two decades and that requires a comprehensive approach, multidisciplinary, I tried in these few lines to lay the foundations of future actions research and environmental protection through the tools provided by the Environmental Informatics [20, 21, 22]. The potential beneficiaries of structured information during this project are students and teachers in environmental engineering departments of universities from the country, engineers, computer programmers and support staff involved in specific environmental activities.

5. Conclusions

In our current society, regardless of how developed it is technologically speaking, the dependence on the environment is a current issue. The element that is most notable subjected to change is our vision regarding man and his' environment. If this was seen until recently as man against nature, nowadays we talk about his integration with the environment or rather his good management of it.
This new vision, *part of Knowledge-based Society* is, as we've presently shown in this paper, in very tight relationship with the environment in which man works, with local traditions and most notably his formal and informal education. In his historic context, the ecological education process is a relatively new one, and as such, a need to insist on recent results and the refinement of interdisciplinary models appears.

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