SUSTAINABLE DEVELOPMENT: FROM MODEL EVOLUTION TO SYSTEM COEVOLUTION FOR A GLOBAL GREEN INFORMATION SYSTEM

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Abstract

The paper analyses the need for modelling sustainable development as a co-evolutionary complex system, integrating economic, social and ecological perspectives. It outlines the characteristics of such a model as: heterogeneity (difference in nature and aims in these perspectives); equality (need to holistically integrate different priorities) and human stewardship (the leading role of humanity in transforming, maintaining and/or sustaining the Earth's complex system). The paper also addresses information issues arguing that purely cybernetic models cannot satisfy the requirements for modelling sustainable development, as they do not incorporate the required qualitative value-based assessment. Wide ranges of sustainability indicators are already being developed and applied for monitoring and reporting. However allowing full access to such information through a Global Green Information System (GGIS) can permit deliberative democracy processes to start implementing assessment and decision-making processes that align with humans' responsibility as guardians of the planet Earth.

Key words: Deliberative democracy, indicators, information theory, modelling, sustainability

Introduction

According to Hasna [13], sustainability refers to a development of all aspects of human life affecting sustenance. The concept of „sustainability" has been associated with a wide range of human activities related to the use of resources (e.g. natural, human and financial), implying long-term continuity and ability to carry on with these activities indefinitely [15]. Described as „use-inspired basic research" [4], in the last 30 years we have witnessed the emergence of a new field of study in relation to sustainability that aims at addressing complex problems from a new holistic perspective. This new science is still in the process of defining and developing its analytic and scientific underpinning, approach, tools, objectives, aims and tasks [24]. Although there have already been numerous attempts at modelling the various aspects of sustainable development (e.g. [3, 6], the art of modelling is yet to deliver models that satisfy the whole range of issues related to the role of humankind as stewards of the planet Earth who are in a position to protect its natural environment for present and future generations [23].

The paper presents an argument for the modelling of sustainable development to be based on the concept of co-evolution and for the need of information-based global models that allow a time horizon span larger than a century in order for global intelligent systems to emerge. It also makes the point that full access to the information required for such models can only happen through a global green information system (GGIS) that could permit policy makers, researchers, industry and the wider community to start implementing assessment and decision-making processes that originate from deliberation and align with humans' responsibility as guardians of the planet Earth.

1. Modelling sustainable development

By their nature, scientific models are a simplified representation of the reality but they also become themselves an object of study [7], thus allowing for new knowledge to emerge. The models developed in the field of sustainability studies cover the full range of categories, namely [23]:

- Pictorial visualisation models, such as the most popular Venn diagram with three overlapping circles representing the economic, social and environmental aspects of sustainability (see Figure 1);
- Quantitative models, including models instigating from econometrics, environmental sciences, physics, computer sciences, cybernetics and engineering;
- Physical models which are smaller or larger physical version mainly of the environmental aspects of the sustainability puzzle;

- Conceptual models that link sustainability to deeper philosophical, ethical or other theoretical ideas, such as the „limits to growth" paradigm or scenarios for the future; and
- Standardising models, including indicators, benchmarks and targets.

Fig. 1. Sustainability Venn diagram

It is often the case that the modelling of a particular phenomenon or system is done through a combination of models from the above categories as each one of them serves a different purpose and/or a different audience. According to Boulanger and Bréchet [3], from a policy perspective sustainable development models should be able to: (1) adopt an interdisciplinary approach; (2) manage uncertainty; (3) provide a long-range or intergenerational point of view; (4) present a global and local perspective; and (5) involve stakeholders' participation. It is yet to find a model or class of models that can satisfy all of the above criteria. A common weakness of models so far has been their focus on individual components, states, outcomes or aspirations related to sustainability with less attention paid on the processes themselves that are occurring within society, the economy and the natural environment and are generating global concerns for our future. Climate change is the most poignant example of this.

This is not to say that all the progress that has been achieved in modelling so far is unimportant. To the contrary, we have been able to devise some useful guiding tools and achieved enormous progress in developing computer power, networks and capabilities. However the nature of the sustainability challenge at the moment lies in understanding the processes that will generate a different way for humanity to relate to its hosting planet Earth and fully embrace its stewardship. The co-evolutionary paradigm offers a conceptual framework that can inform such a shift in knowledge, thinking and practice.

2. Co-evolution

In recent years co-evolution has attracted a lot of attention as a concept which is yet to develop its full heuristic potential. Originated as an exotic ontological idea about universal interconnectedness, nowadays co-evolution forms the methodological basis for knowledge generation in a wide array of areas – biology, languages or intelligent software [21]. According to Margulis and Sagan [14], it is an example of life developing through networking rather than fighting.

This interconnectivity and mutual adjustment is at the core of grasping sustainability (see Figure 2). A co-evolutionary approach implies the simultaneous self-development of humanity, economy and nature in their own individual trajectories (marked as ←) under the forces, which generate their development. The adjustments to the external forces are marked as ↑.

Understanding the co-evolution of nature, the economy and humanity requires considering the following important aspects:

- The co-evolving entities (i.e. the co-evolvents) are equally positioned in the evolution process. This implies that there is a need to balance and integrate all the value systems and decision-making that relate to environmental, social and economic priorities without compromising one for the other;
- The co-evolvents' difference in nature makes them internally independent in the sense that each co-evolving entity is self-defined, has its own internal laws, rules and regulations that make it what it is and which are independent from the others' internal laws, rules and regulations. The rules governing the economy are distinctively different to the ones influencing society and yet again very dissimilar to the ones describing the natural environment;
- The co-evolvents are externally dependent in the sense that each co-evolving entity can be informed and influenced by the others. In other words, changes

that are happening within the economy affect society and the environment; similarly environmental changes affect human society and the economy and most importantly changes in human behaviour can affect the economy and the planet's natural environment.

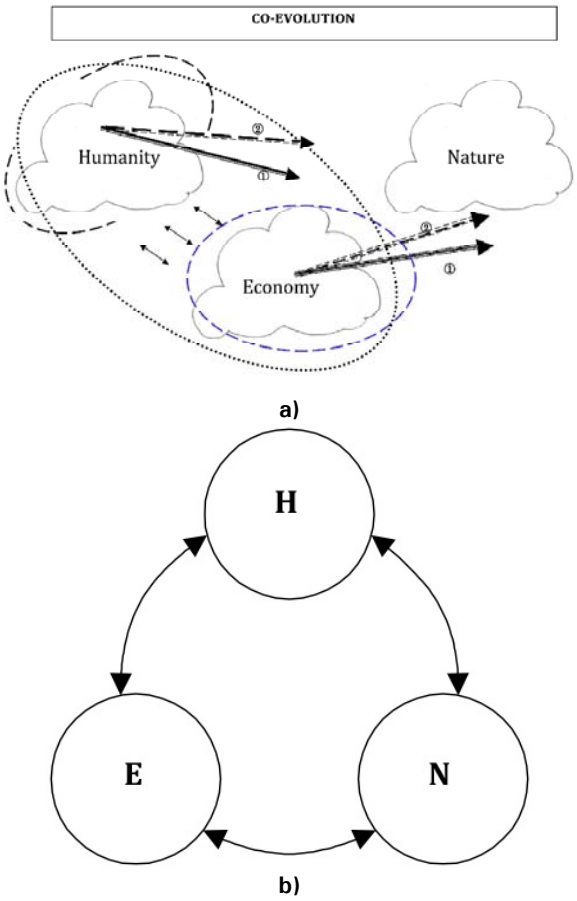

Fig. 2. Co-evolution
a) Conceptual model
b) Information model
(H–humanity, E–economy, N–nature)

Hence, the mutual interaction and influence between the three systems are the necessary and sufficient condition for co-evolution to occur. Any modelling or measuring of sustainable development needs to be able to grasp and reflect these co-evolutionary processes.

The following three characteristics, informed by the co-evolutionary paradigm, are important for modelling sustainable development: Heterogeneity, Equality and Human stewardship [21]. How to monitor and understand the co-evolutionary processes is discussed in the remainder of the paper.

3. Indicators and Information model

So far the practice of tracking development or progress towards sustainability has been through the use of sustainability indicators. According to Hart [12], „(a)n indicator is something that helps you understand where you are, which way you are going, and how far are you from where you want to be". In this sense indicators perform a standardising function as they position progress in terms of the level of what is acceptable or desirable. They are also used for policy development and decision-making. There are numerous sets of comprehensive indicators (including those developed by the United Nations Commission for Sustainable Development and the Organisation for Economic Cooperation and Development) that are quite successful in describing individually the three sustainability areas (see Figure 1) in isolation.

What Hart and the International Network for Sustainability Indicators stress is the need for sustainability indicators to be different from the traditional economic, social and environmental well-being indicators, as they need to point to areas where the links between the economy, nature and humanity are poorly understood. This in fact is exactly where the impulses produced by the three components of the global system would cause collision and contradictions outside their individual trajectories (see Figure 2) resulting in changes in direction, speed and size of development or evolution. Hence co-evolution can only be understood in the context of the mutual interactions within the global system which become a joint process of evolution (or co-evolution). Any indicators measuring this process will rely on a proper understanding and modelling of these interactions.

Information theory (originating from applied mathematics) allows the modelling of information processes occurring during the interactions of evolving systems. Its approach expands cybernetic models (which deal with data transmission within closed systems, e.g. Ash, 1999, and do not address value judgements) by considering information as a process of knowledge generation [26]. Information is linked to the cognitive processes taking place within intelligent systems and therefore it becomes subjective with epistemological properties.

The following assumptions are the basis of information theory [25]:

- Information processes are real processes of system interactions;
- They are spontaneous and occur in an environment shaped by the interactions between the system's components;
- They are subject to the law of information relevance, which is based on the system's hierarchy, nature and complexity.

Information theory requires information to be analysed as sets (triads) of the system's status related to generation, transmission and reception of information components described as the semantics, syntax and pragmatics trinity. The process itself is transformation and transmission of these states while the direction and content of the information process are determined by the information potential of the system, which in turn is indicative of its system diversity [22].

The use of this information model is for practical learning and knowledge generation to occur and they will reflect the constant processes of change triggered by co-evolution. Such learning is a property of intelligence, understood as a non-psychological, non-epistemological category (implied, for example, in artificial intelligence) and can be a property of a particular type of systems [22]. Martin [16] alludes about humanity having to deal with its own human intelligence but also with automated human thought and non-human like thought.

Many psychologists point to the fact that human intelligence is essentially expressed in various behaviours in varying contexts (instead of a general genetically inherited property) based on human beings' hallmark – their flexible central nervous system that allows for learning to occur [20]. In humans, this learning is generated not only from the perspectives of natural sciences and philosophy but also from what epistemology considers external perspectives, such as technological, sociological, economic, political, spiritual and ethical as well as experience, wisdom and intuition. Human intellect is demonstrated through actions that are based on internal values and motivation that are not always obvious.

With the advance and constantly increasing power of computer technology, such non-epistemological intelligence will be present in a new type of information machines that should be able to generate information processes, which are set-up in pragmatics. They will be in a position to inform humanity about the state of the global system, and its human, economic and environmental components, in relation to being sustainable. The role of humans however would still be to negotiate the value judgements that define their actions (or inactions) to respond to co-evolution.

4. Global Green Information System (GGIS)

It is the first time in the history of humanity that computer power allows the following two previously improbable realisations:

1. Building of a global virtual (e.g. GIS-based) model of the planet Earth. Such a model could allow not just forecasting and prediction but also scenario building and trajectory projections within the probability spaces for the future. It will represent a global virtual reality that could be studies, analysed, explored and hopefully properly understood;
2. Establishing of a global green information system (GGIS) that collects, stores and transmits sustainability information across the globe. The main functions of GGIS should be:
   - Monitoring of the co-evolutionary processes, both globally and locally – it is extremely important that the system provides a functional link between these two levels;
   - Facilitating decision-making – it is crucial that the GGIS provides an environment where decisions can be negotiated based on signals originating from all localities. The system should allow for a new way of understanding the global challenges breaking the silos between the various elements, disciplines and political boundaries and making a qualitative shift to a holistic thinking;
   - Information storage – as any information system this is a basic function, however in the case of the GGIS access to these stored information should be made available across the globe;
   - Studying the global virtual model of the planet Earth – the data from the modelling process should be accessible through the GGIS.

What GGIS should not provide is the possibility of centralised control and decision-making. In other words, there should not be any particular locality that could dominate the decision-making process or control the access to information about the co-evolving processes.

5. Sustainability assessment and deliberative democracy

The information model for sustainable development handled by learning and intelligent machines can only be a facilitator for humanity to fulfil its stewardship role on this planet. Despite its knowledge generation power, Meadows et al. [17] refer to information and information flow as only one leverage point to intervene in a system in order to restore its sustainability. It is important to accept that any modelling and knowledge generation outcomes will be put into use according to people's value systems and available decision-making systems and processes. Therefore sustainability assessment (e.g. [11]) becomes a crucial element.

According to Pope et al. [19], the most important function of sustainability assessment is the ability to provide a space for deliberation and exchange of ideas, understanding, perspectives and worldviews. It is essential that such an exchange occur in a non-hierarchical environment where there is full awareness that the tasks of achieving and maintaining sustainability are not only shared but cannot be achieved on an individual basis (be it an individual person or individual country) and without cooperation. On the other hand, sustainability as a global concept and aspiration needs to be translated into local actions. It requires things to be done differently with creativity, in collaboration and democratically.

In addition to the ever-increasing power of computer technology, more recently (particularly after 9/11) we also started to witness the appearance of a new type of democracy, namely deliberative democracy. It is based on decision-making through public deliberation by the people following social principles, such as respect, right to speak and dialogue (e.g. [5, 9, 10]).

There are already numerous examples of deliberation processes happening on-line (e.g. [2]). The GGIS can be linked and can feed expert information into such on-line deliberative processes. This will allow for a distributed decision-making around the globe with relevance to the particular localities in the presence of global information about the co-evolving global system. According to Black [2], participation in deliberative forums has shown to influence participants' political knowledge, opinions and subsequent civic participation. Similarly, it is likely that deliberating on sustainability issues will contribute towards shaping people's knowledge, opinions and subsequent civic actions. The GGIS has the potential to provide the virtual space for such deliberations to occur.

Conclusion

The global nature of the imperatives of sustainable development, and climate change in particular, require global knowledge and global action. So far the art of modelling and the science of sustainability have delivered outcomes that are only attempting to provide a more holistic way of viewing the world and gear the shift towards sustainability. Despite some insightful knowledge generation, we are now at a point where society has unprecedented computer power and unparallel opportunity to put it into use for tackling the most complex and „wicked" [8] problem in its history.

Based on the co-evolutionary paradigm, the argument presented in this paper for the establishment of a global green information system (GGIS) to facilitate deliberative democratic processes leading towards a more sustainable presence and actions by the human stewards of the blue planet Earth, could provide a way to embark upon a road of hope.

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