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GLOBAL ENVIRONMENTAL SUSTAINABILITY: THE ROLE OF GEOGRAPHY AND ITS RECENT HYBRIDATIONS

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The large scale transformation of ecosystems, the accelerated soil erosion, the anthropogenic propelled climate change, the species extinction rate, and the collapse of fisheries are some of the multiple threats with solid scientific record that currently undermine the sustainability of human society on planet Earth.

On the one hand, the traditional meristic approach, commonly adopted in most hard science research centers, is probably a shortsighted strategy to tackle the complex relationship between nature and society which underlies the sustainability problem. Undoubtedly it is necessary to quantify and measure environmental effects with precision, however the urgency calls for a strategy which captures the broad picture at the same time.

On the other hand, the magnitude of the human interference in the environment has been confirmed and reinforced all along the reports of the latest United Nations Conferences of the Parties (e.g. UNCP 2012 in London), as well as the very limited effect of global policies supposed to reverse the interference. The sustainability problem involves multiple factors, such as environmental, economic, political, technological and cultural. The modeling and understanding of each of these factors implies a level of uncertainty. As a result the approach must include a framework that handles high levels of uncertainty.

Considering the above, we first introduce the recent framework of Geocybernetics and evaluate the relevance of this emerging discipline as a contribution to solve the sustainability problem.

Second, decision makers are increasingly challenged by the accelerated and massive impacts, complexity, and dynamism of modern civilization. The urgency for data and predictions has overwhelmed the capacity of current systems conceived for one-purpose-only. A new era of globally shared risks and opportunities has emerged, in which policies and decisions must be supported by wall to wall, near real-time planet monitoring. This means a successful management of such a crisis should be conditioned to a strategy of national policies embedded into a vast international collaboration.

In this sense, we present two fundamental geocybernetic infrastructures: 1) the Global Earth Observation System of Systems (GEOSS), an international sensor network based on agreed technical standards leading to a thematically and geographically exhaustive environmental monitoring system, and 2) the development of interoperability protocoles for an online visualization interface under the concept of virtual globes.

Third, effective global actions should depend on scientifically well sustained political agreements, based on the study, modeling and behaviour prediction of major physical, chemical and biological systems of planet Earth. The recent advances of Geosciences on the Earth System have made possible the identification of planetary subsystems which, under specific environmental forcing conditions, adopt a non linear behaviour out of their current stable state. The polar icesheets are one of these subsystems.

In this sense, we present the concept of planetary limits, derived from the inflection points and forcing variables of key planetary subsystems, which in turn provide the contemporaneous scientific support for decision making in the global environmental policy framework.

Fourth, the multiple factor types of the sustainability problem, imply actions in line with the local specificity. We review some contributions of the geographical sciences that enforce the principles of global and local scale dependencies – think globally and act locally. For example Voluntareed Geographic Information and Services (VGIS) are an opportunity for the production of spatial information from a multiplicity of autonomous sources. Additionally, Participatory Geographical Information Systems (PGIS) are an opportunity for local actors to increase power over nearby spaces and make democratic decisions.

Making use of the four above mentioned hotspots in Geographical Sciences, we propose in the following lines an analysis which leads to a graphical guideline of a multiscalar, systemic and glocal approach to the global sustainability problem.

Schellnhuber & Kropp (1998) conceive a geocybernetic era as a new human age at the interaction between the ecosphere (the totality of the natural environment which is significant for human life) and the anthroposphere (humanity and all products of civilization), with the hypothesis that a coherent management strategy (Development and Protection of the Environment - DPE) is susceptible to influence simultaneously the evolution of both systems.

A sequence of DPE actions could consist in a carefully balanced set of rights, laws, regulations, economic subsidies, educational programs, international agreements, technologies, institutions. In order to attempt a minimal control over the co-evolution (Beddoe et al., 2009) of the ecosphere and the anthroposphere, it is necessary to answer the following fundamental questions of Geocybernetics:

What kind of world do we have?
What kind of world do we want?
What must we do to get there?

What kind of world do we have? Until recently, planet Earth was operating in the "holocene mode", relatively disconnected from the dynamics of the anthroposphere (Schellnhuber

& Kropp, 1998). Now with global change, a dramatically different operational mode has emerged: the "anthropocene", which can be characterized by a significant interference of the anthroposphere in the metabolism of the ecosphere.

Simulation models are the modus operandi of Geocybernetics: we only have one world and we need virtual copies which we can submit to all kinds of radical interventions such as remove tropical forests, double the CO2 atmospheric concentration, increase the acid concentration in the oceans, etc. In spite of the impressive last decade advances in the analysis of the ecosphere, the remaining to be understood still appears infinitely vast. Our ignorance with respect to cybernetics can be defined according to three types of uncertainty: surmountable cognitive uncertainty, irreductible cognitive uncertainty (e.g. highly heterogeneous nonlineal systems), and voluntary uncertainty (due to the multiple factors related to human will).

Considering the above, shall we meet the challenge, or more importantly, do we have the tiniest possibility to start controlling the complex Earth system?

An element of answer shall stem from classical cybernetics under the concept of "fuzzy control"; Dealing with a complex set of adverse situations may be solved as follows: to adopt a broad spatial and/ or temporal scale strategy based on uncertain and incomplete information, and to implement a continuous sequence of readjustments based on the knowledge of additional approximate data along time. Schellnhuber & Kropp (1998) argue that this "fuzzy control" recipe in combination with control methods derived from Complex Systems' theory should handle the Economics & Environment Compatibility challenge. A rationale of this approach is to apply the precautionary principle, which means to stay at a reasonable distance of civilizatory and ecological limits, to develop and implement flexible instruments for global action (responsiveness), and to explore co-evolutive futures in a continuous manner through a large collection of computer models of the Earth System (panoramic insight).

In 2005, the Group on Earth Observations ("GEO"; The Geo Secretariat, 2007) supported by more than 70 governments and institutions, launched, in collaboration with more than 40 organizations, the Global Earth Observation System of Systems (GEOSS), with the purpose of gathering global information more efficiently than ever before. Based on a 10 year plan, internationally agreed in 2005 GEOSS, steers a heterogeneous set of measurements from different instruments and platforms in many parts of the world, towards a thematically and geographically exhaustive Earth monitoring system. Moreover, the Sensor Web Enablement (SWE) ensures a collaboration with common standards through the unification of communication protocols.

A key mission of GEOSS is to help individual institutions around the world acquire capabilities in order to use the sensor network and be part of it, contributing with their own measurements (Group on Earth Observation, 2008). Another mission of GEOSS is to ensure the long-term, continuous monitoring of critical Earth subsystems, identified by Geocybernetic models to be particularly sensitive to the evolution of the anthroposphere. These subsystems are susceptible, with a linear change of some environmental parameters, to switch to a nonlinear behaviour and escape their current stable state. The North Pole Icesheet is one of these subsystems and would be doomed to collapse with the increase in green house gas concentrations of over 450 ppm equivalent CO2 (Hansen et al., 2013).

The study of these critical planetary subsystems has enabled the international scientific community to estimate some of the inflection points which humanity should be careful about (Rockström et al., 2009). These parameters translate into planetary boundaries in terms of global resource extraction and consumption, which means key geocybernetics findings are directly connected to a desirable collective global environmental policy. However, the prevalence of global corporative role in the economic system is associated to a diversity of political barriers to the principle of setting limits to resource extraction and consumption. This may contribute to impede global scale initiatives such as GEOSS to embrace a holist perspective. As a result, the scientific knowledge brought by geocybernetics, unfortunately, still remains largely disconnected from the broad sustainability picture.

Under these circuntances, it has become urgent to reconcile the seemingly contradicting interests of economic welfare and environmental protection. At the local scale, policies regarding the extraction of resources are usually designed without the consent or control of local communities. More generally, the production of geographic information for decision making has long been, partly because of costs and complexity, the exclusive domain of the State and large companies. To this regard NeoGeography, associated to Geographic Information Technologies (GIT) as a byproduct of the revolution in nanotechnologies and computation, offers a paradigm which involves the participation of an ever increasing number of actors in the production and distribution of geographic information.

At the beginning of this century, Participatory Geographical Information Systems (PGIS) are applied in (usually rural) settings to assist the process of local and/or indigenous knowledge integration and aim at equitative mechanisms for local planning (Capel, 2010). Since about 2005, virtual globes (e.g. Google Earth) have opened the access to spatial data to an ever increasing (mainly urban) portion of the society. Then, the development of online mapping tools triggered Volunteered Geographic Information and Services (VGIS) where local users voluntarily upload features online and form unprecedented collaborative georeferenced databases (e.g. OpenStreetMap).

In local conflict situations, PGIS has permitted the integration of a diversity of aspects of local knowledge in only one device, which was then used in negociations or lawsuits. Consequently, PGIS was reported as useful in solving conflicts between indigenous communities and the government associated to the use of natural resources, as well as conflicts related to regional and national level infrastructure projects (energy, transports, industrial production). Due to the popularization of cheap mobile telecommunication devices, VGI success stories include the collaborative production of air and noise pollution maps, instances of the emergent concept of Citizen Science, as well as spontaneous citizen-based immediate response systems to disaster situations. Altogether, the combination of these emergent GIT systems may contribute to a greater empowerment of local actors and the inclusion of their voices and perspectives in the broad sustainability picture.

In view of the above and arguing the imminent massive access to geospatial virtual infrastructure, one could hope that this will lead to an era of vast collaborative processes and eventually democratic decision making (Capel, 2010); The debate on the democratization process associated with GIT is not so straightforward. Indeed, freedom of expression and privacy have both been reported at risk because of the georeferenced information available to the telecommunication companies and the State. However, it is argued that effective democratic practices have been strengthened because the collaborative monitoring of the extractive activities of global companies, as well as lobbying activities to administrative and legislative authorities are now sustained by a wider range of actors. A next step could be to struggle and integrate these instruments in formal decision making processes, measurements and verification so that official requirements for projects would contain the participation of a wide range of actors.

A common critique to the use of GIT in participative processes is the argument that there is an initial advantage of some actors over others. Access to spatial information such as property lots and real estate is likely to mainly be used by the powerful speculative sector of the population, at the expense of local communities whose perception of the territory is not as market oriented. On the contrary this advantage gets reduced if local communities succeed in developping capacities for globally disseminating its worldviews, and for accessing relevant external information. The role of the State is mentioned as determinant in the construction of these local capacities, because official and unrevealed policies may greatly foster or discourage the access to the adequate tools for capacity development.

There is no doubt we are living times of accelerated and unprecedented global change. The form in which the society-nature relationship is developing will probably lead to abrupt changes in the ecosphere, a potentially disastrous consequence for large sectors of humanity. Are we headed to a global environmental collapse? If so, are we able to avoid this collapse?

The first section on Geocybernetics teaches us there are three requisites to enable an adaptive fuzzy control of the coupled ecosphere – anthroposphere system: 1) to stay at a cautious distance to civilizatory and ecological limits, 2) to develop and experiment flexible mechanisms, particularly international institutions, infrastructure and decision making schemes, as a basic framework for continuous policy readjustments, and 3) to constantly explore co-evolutive scenarios through computerized models that offer a panoramic and objective vision of how is the planetary situation at present and what situations we could be headed to.

The Global Earth Observation System of Systems (GEOSS), which we examine in section 2, is probably the most representative contemporaneous initiative which could attempts to integrate the three above-mentioned principles. The evolutive re-design of strategies for adaptation, mitigation and sustainable use of resources implies to connect panoramic views with initiatives of sustainable management of local resources. For this purpose national / global institutions must gain credibility and turn local actors as their ally. Indeed they (we) are the first and direct sufferers of the local environmental degradation, before everyone eventually suffer the global environmental disater.

In this sense we emphasize the role of Geographical Information Tecnologies (GIT) in section 4, as instruments of the local actor to defense use of natural resources. This essay proposes a graphical guideline (figure 2) pointing to the complementary role of the empowered society, the scientific geocybernetic community, and the GEOSS infrastructure, in the search for a solution to the sustainability problem.

At the end of the day the current environmental crisis is a valuable lection for humanity. We all are in the same boat. We ought to act in an equitative and solidary way if we ever wish to avoid sinking.