Green Accounting beyond GDP: Entropy Production the Metric for the Integration of the RIO Declaration with the Agenda 21.

The RIO Declaration focused the attention of the World to the limitations of the Planet to support the high material-energy consumption of the 7 billion Homo sapiens, of which half crowd into intense activity space of the urban habitat. Brundtland Report succinctly expressed this inconvenient truth as follows:

The Earth is one but the world is not. We all depend on one biosphere for sustaining our lives. Yet each community, each country, strives for survival and prosperity with little regard for the impact on others. Some consume the Earth's resources at a rate that would leave little for future generations. Others, many more in number, consume far too little and live with the prospect of hunger, squalor, disease, and early death. (WCED, 1987, p. 27).

RIO Declaration, following the Report to the UN of the World Commission on Environment and Development, annunciated the ethical principles for a Global Sustainable Prosperity for all humankind:

Principle 1: *Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature;*

Principle 3: *The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations;*

Principle 7: *States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit to sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command;*

Principle 8: *To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies.*

Chapter 40 "Information for Decision Making" described the need for, but not the how to, of an (integrated) System of Environmental and Economic Accounts, (SEEA). The UN Study on method (UN, 1993), describes the general framework for incorporating the environmental parameters in the System of National Accounts (SNA). Thus, restricting the accounting domain to the interaction, rather than interdependencies, of the economy and the environment. While recognising the validity of the science (and logic) of subsuming the SNA in a larger-scale ecosystem accounting structure, the authors of the Study relegated the so-called 'ecosystem approach' to some indefinite future research programme in favour of a parallel, associative, system of 'satellite accounts'.

The decision to make the SEEA a subset of the SNA was made by UN Statistical Commission 26th Session, New York 1991. For ecological economists the forcing of environmental parameters into the SNA framework was Procrustean Bed. Not only was this to become the Achilles Heel for the true integration of natural and social science databases, but ultimately closed the door towards pluralism in valuation methods, (Friend, 1989, 1993, Norgaard, 1989, 1993).

While at the time the idea of expanding the SNA towards the linear methods of valuation of environmental assets and services made sense, it turned out 20 years later that the assumption of equivalences (and substitutability) of economic and ecosystem production functions is not only logically inconsistent, but the relationships are nonlinear. In other words, 'weak sustainability' is no longer a tenable position in nonlinear accounting systems. Further, the design element of the SEEA does not permit (directly) to construct the correlation coefficients which connect the qualitative vectors of the degradation of ecosystem and human welfare functions with the quantitative parameters of technological change and material (global) consumption.

This paper takes the position that pluralism in valuation methods is a necessary, but not sufficient, condition, to develop the nonlinear parameters required for the "Green Accounting beyond GDP." The sufficient condition being the necessity for a common metric which connects the state, and change of state, of the environment, with the state, and change of state, of the economy.

We propose that the common metric is the rate 'entropy production' in any well-defined process, which permits the multi-dimensional mapping in Topological Domain Space (TDS) of the qualitative/quantitative properties on objects and functions, (see **Figure 1a**). These are defined in a hierarchic-structured value system as follows:

(A) the *Econosphere:* values are *conserved-in-exchange* and represent the accounts of the inflows, outflows, and balances of the economic process described by 'economic statistics;'

(B) the *Sociosphere:* values are *conserved-in-use* and represent the accounts of the inflows, outflows, and balances of the social/demographic processes described by 'social and demographic statistics;'

(C) the *Ecosphere:* values are *conserved-in-themselves,* or *intrinsic* and represent the accounts of the inflows, outflows, and balances of the global ecosystem described by environmental spatial and volume statistics.

The mapping in the TDS is in the form: C ⟶ [B ⟶ (A)] and its inverse, C ⟵[B ⟵(A)].

The *entropy production* (i.e., consumption function) measures the rate of increasing 'disorder' in any material system and, when given a negative sign, or *neg-entropy production* (i.e., production function), measures the rate of decreasing 'disorder' in any material system.

The paper will elaborate on the accounting of entropy production within the conceptual framework of the System of Accounts for Global Entropy Production (SAGE-P). This will be demonstrated as feasible method of accounting within the contextual framework of information systems in the Digital World. The key elements being the linkage of space-time databases obtained from remote sensing platforms with the body of computable economic and social databases -the latter composed of individuals, households and communities, and the former of production, consumption and capital accumulation. The objective is to provide a reliable, and germane, continuous space-time database for both decision-makers and the public at large to assess, and evaluate, the distance between sustainable, and unsustainable, processes.

The template for the Panel Discussion is the empirical research which connects the normative principles of the RIO Declaration with applications of the Agenda 21. The Panel on the WAVE Project makes a similar claim on the research methodology to assess the gap between sustainable, and unsustainable, production, consumption and capital accumulation/decumulation systems. The difference, apart from the neoclassical theoretical constructs, is that the latter assumes ‘weak,’ and the former ‘strong,’ sustainability. The Panel will examine the similarities, complementarities and differences of these two global conservation accounts of sustainability.

While neoclassical reference point is towards a non-declining welfare function (or a global Pareto criteria) entailed by the conservation of inclusive capital (economic, social, human and natural), the ecological economics reference point is towards maintaining the qualities of human well-being and ecosystem health and integrity entailed by the conservation of the Planet’s ‘Low Entropy Fund,’ (LEF). Thus, the objective function of a ‘sustainable system’ is defined in the *‘entropy production accounts’* by the difference between rate of inflow, and the rate of outflow, of any well-defined LEF. The three states of sustainability can be defined as follows:

(i) Sustainable and growing = rate of inflow (production) > rate of outflow (consumption) of LEF.

(ii) Sustainable = rate of inflow (production) = rate of outflow (consumption) of LEF.

(iii) Unsustainable = rate of inflow (production) < rate of outflow (consumption) of LEF.

Equation (iii) applied to the TDS of the Ecosphere is the direct measure of the *ecological footprint.*

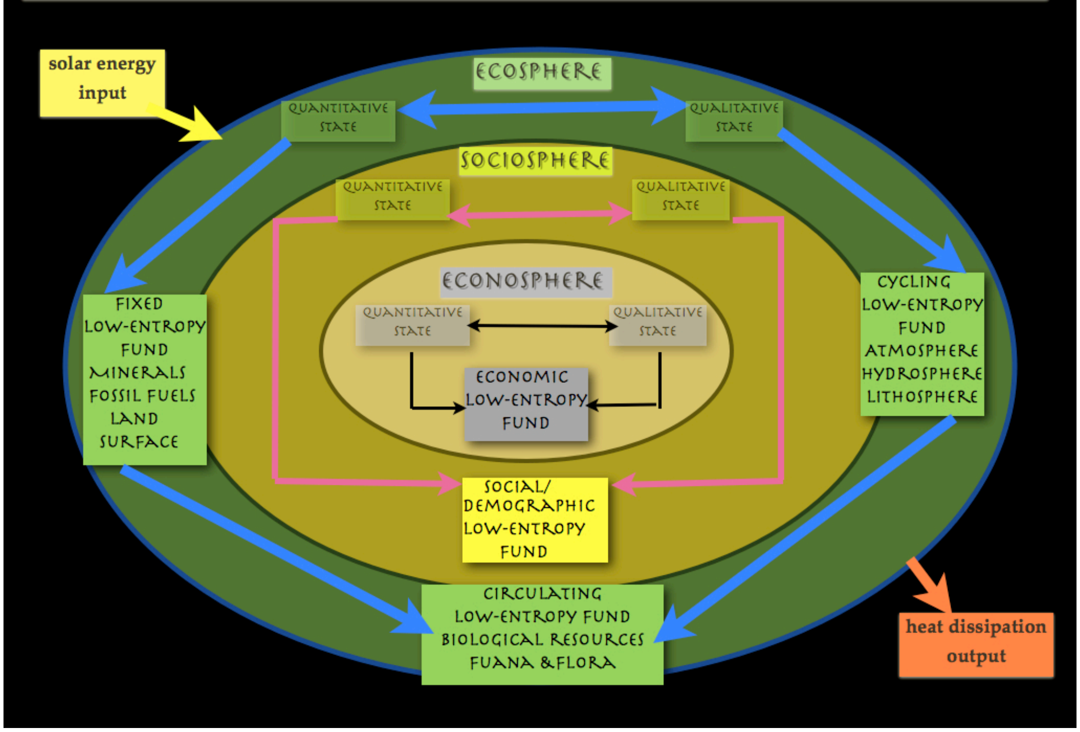

Figure 1a: Stock Data: Statistical Sets of the (low entropy) Fund measured in Quantitative (cardinal) & Qualitative (ordinal) States of the System

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