

SIG/Platform for (Nonlinear) System of Accounts for Global Entropy Production, SAGE-P

R&D for the Balance Sheet Algorithm of Complex System's Production (inflow), Consumption (outflow) and Capital (stock) of any well-defined Low Entropy Fund (LEF) *available for Human Consumption.*¹

Objective: to create an open access platform for (nonlinear) accounting algorithms enabling the construction of the LEF for any well-defined dynamical economic, social and natural systems (see **Appendix I**). The central idea is the seamless mapping of ordinal-valued objects/function upon any well-defined topographical domain space of the **Econosphere**, where values are *conserved-in-exchange* or *prices*, the **Sociosphere**, where values are *conserved-in-use* or *participation rates* and the **Ecosphere**, where values are *conserved-in-themselves* or *existential*, (Friend, 2016).²

Unique to SAGE-P is the discovery of algorithms of entailment which enables the matrix mapping of **propositional logic**, (i.e., qualities of the accounting objects/functions measured in ordinal values) on **empirical evidence**, (i.e., quantities of the accounting objects/functions measured in cardinal values).³ The analysis of qualities permits the development of a hierarchical-structured value system: objects/functions *conserved-in-existence* > *conserved-in-use* > *conserved-in-exchange*. The accounts, and thus the algorithms employed, are set-theoretic nested structures.

The universal set, the **Planet-Earth**, solar energy inflows, heat dissipation outflows, → the LEF's belonging to the (€) of the **atmosphere, lithosphere and hydrosphere**. The largest sub-set are the accounts of the LEF's belonging to the (€) of the **Ecosphere** → the LEFs belonging to the (€) of the **Sociosphere** → the LEF's belonging to the (€) of the **Econosphere**.

The balance sheet of the LEFs are in any point in time:

- (i) **Sustainable + growth of LEF** (t+n): **inflow**, (i.e., production) > **outflow**, (i.e., consumption) @ some well-defined period of time;
- (ii) **Sustainable + steady-state of LEF** (t+n): **inflow = outflow** @ some well-defined period of time;

¹ The concept of the LEF is inspired by Georgescu-Roegen's "The Entropy Law and the Economic Process," (1971). The Algorithms of any well-defined complex system may be represented by the boundary conditions of the *Entropic Process*. G-R refers to the analytics of a 'partial processes' described by the *inflows*, (production), the *outflows*, (consumption) and the *stock* (capital) in any well-defined LEF, (see Chapter IX: The Analytical Representation of Process and the Economic Production).

² Ordinal values concern analysis and ranking of the qualitative properties of the accounting objects/function. While certain qualities can be measured on scales of intensity, hardness, durability and so forth, abstract qualities, such as taste, are subject to the sensitivity and knowledge of the observer, and may be defined in context of institutional and cultural values, or superficially in the political discourse. Further, ordinal valuation, while prevalent in the social sciences, are of increasing concern to the hard sciences with respect to 'uncertainty,' in empirical evidence, and in some cases politicization. Nonlinear accounting, in the strict sense, are based on Bayesian methods to predict the next event in the statistical time series,. For a well-argued position on uncertainty in science and the political process see Funtowicz & Ravetz, (1991) "*Uncertainty and Quality in Science Policy*."

³ Entailment is a system property of state, and change of state, of a complex hierarchical structure. A property distinguishable in the following descriptive categories: (a) material state entailed by the formal conservation laws of nature, (b) the state of individual species and communities entailed by the evolutionary rules embedded in the genome, (c) present-day state of social organizations, technology, and know-how entailed by the human historical-cultural experience and (d) the state of the environment entailed by recent-past human and natural activities and accidental events. G.E. Moore, (1923) proposed that "entailment" included a condition of relevance to any implied logical proposition where p implies q, and q implies p. This condition held if, and only if, q can be logically deduced from p. It was viewed by some logicians that by linking meaning to these two propositions, i.e., relevance condition, avoided paradoxes in logical implications. The entailment property of the phenomenal world of cause and effect, i.e, events, thus require that when p is a presumed cause and q a presumed effect, the explanatory variables must be both coherent with respect to context and relevance. It should be noted that entailment is an implicit property of the Aristotelian hierarchy of causal relationships, (i.e., material, efficient, formal, and final), Rosen 1985.

(iii) **Unsustainable + degrowth of LEF** (t+n); **inflow < outflow @** some well-defined period of time.

While the policy of sustainability are subject to the local state, and change of state, conditions, the universal policy criteria of minima/maxima of per capita: (a) consumption, (b) production, and (c) capital:
 (a) reduce to a minimum the socially-acceptable rate of *entropy production per unit of product consumed* ;
 (b) increase to a maximum the socially-acceptable rate of *entropy efficiency per unit of product produced*;
 (c) max. *entropy efficiency* → LEF → min. *entropy production*.

Political Argument.⁴

The profit/loss balance-sheet accounts of the double entry bookkeeping, (i.e., credits = debits and assets = liabilities) worked well when the Earth's LEF replenished at its rate of consumption, albeit at a high cost of wild-life habitat. Following the Second World War, and experience of the collapse of capitalism in the 1930's, Governments intervened in the social and economic planning of the Nation-state. For this to happen, there was a requirement for a reliable, timely and comprehensive system of Government Statistics. This was the task of UN Statistical Division.⁵ Currently, the UN is redefining Government Statistics entailed in holistic measures of state, and change of state, of the natural environment, (see **Appendix IV: UN Conference on Environment & Development, Rio de Janeiro, Brazil, 3 to 14 June 1992, Agenda 21 – Chapter 40: INFORMATION FOR DECISION-MAKING**).

The System of National Accounts (SNA) were developed as a quantitative database to measure the day-to-day performance of the economy as well as budgetary capacity to improve the social well-being of Society.⁶ By the 1970's following the UN Conference of Human Environment, (Stockholm 1972), the question of subtracting from GDP pollution and clean-up costs arose in the public discourse. While the valuation of a net-GDP had high currency in political debates at the time, the question of methods to subtract asset loss in the System of National Accounts, (SNA) was beaten back by the national accountants on the grounds of defining a negative 'product,' (i.e., at what point is the inflection of a negative return?). And even if defined, the National Accountants had no reliable, and independent method, to measure the negative sign of GDP, (Friend, 2000).⁷

⁴ Kenneth Boulding (1949) political argument:

I shall argue that it is capital stock that we derive satisfaction, not from additions to it (production) or subtractions from it (consumption): that consumption far from being a desideratum, is a deplorable property of the capital stock which necessitates the equally deplorable activities of production: and that the objective of economic policy should not be to maximise consumption or production, but rather minimise it, i.e. to enable us to maintain our capital stock with as little consumption and production as possible. It is not the increase in consumption or production that makes us rich, but the increase in capital, and any invention which enables us to enjoy a given stock of capital and a smaller amount of consumption and production, out-go or income, so much the gain

⁵ The United Nations **Statistics Division** is committed to the advancement of the global **statistical** system. We compile and disseminate global **statistical** information, develop standards and norms for **statistical** activities, and support countries' efforts to strengthen their national **statistical** systems, <https://unstats.un.org/home/>.

⁶ Note the politics of advanced industrial Nations where(a) growth in the (material) GDP is inextricably coupled with (b) growth in the human welfare function. Kenneth Boulding presciently observed this as the Catch 22, (see footnote 3). Predating was John Stewart Mill (1985) observation:

If the earth must lose that great portion of pleasantness which it owes to things that the unlimited increase in wealth and population would extirpate from it, for the mere purpose of enabling it to support a larger, but not a better or happier population. I sincerely hope, for the sake of posterity, that they will be content to be stationary, long before necessity compels them to it.

⁷ In effect, GDP was reduced to an economic performance indicators, and the well-being aspect was purely related to per capita income growth. Net-valuation was politically-satisfied with the polluter-pays-principle enacted to absorb clean-up costs, and pollution mitigation, by the producer, (i.e., not the consumer). Ironically the extra cost on the production function increased the value-added to GDP, or was exported to other countries. Whether latter added to, or subtracted from, GDP depends on the balance-of-trade with the exported country. Note that GDP is the 'domestic product,' and thus excludes the net-value inflow/outflow of foreign investments.

The term Sustainable Development (SD) came into vogue following the Report of the World Commission on Environment and Development "Our Common Future," (1987).⁸ The 1992 UN Conference of the Environment provided, what was believed to be an 'expert' road-map for Sustainable, referred to Agenda 21, (See Appendix IV, Chapter 40: INFORMATION FOR DECISION-MAKING).

Academic Argument

While the notion of sustainable systems of production, consumption and capital was well articulated in the discourse of governments, business and academia, including capital investments in clean energy and large-scale conservation projects, the global momentum of material/energy consumption continued to accelerated towards the limits of the Planetary LEFs available for human consumption. Initially, the project of sustainability were well-identified to particular processes and activities, referred to as unsustainable, but with right policies these practices could be 'modified,' 'replaced or 'fazed-out. This naive view "to think Globally, but act locally" is no longer tenable. The concept of sustainable systems is being reframed to human adaptation to climate change, and more generally to the factors which describe the emergent Anthropocene.

The SIG will offer a complex systems analytical frame for identifying not only the limit functions of the Planet Earth, but well-defined 'Entropic Processes' to describe the real-World evolutionary processes over space-time.⁹ The focal point are algorithms of the state, and change of state, of the Entropic Process defined in the category set of *Ecosphere [Sociosphere (Econosphere)]* expressing, where feasible, the emergent properties of dissipative structures far from equilibrium such as, for example, human adaption to climate change, (Prigogine, 1997).

While the equalities of the linear accounts are well-defined in the bookkeeping of legally-defined entities, the real-world upon which they operate are fundamentally non-linear, complex, entropic processes, described in the language of System Sciences.

The purpose of the platform is to translate the current accounting practice, in particular the balance-sheet of the Governments and business-enterprise, into the more precise language of the Second Law of thermodynamics. The ontological/epistemological framework for such balance sheets can be found in G-R Flow-Fund Model, where production accounts, (i.e., negentropy), are inflows to, consumption accounts, (i.e., entropy) are outflows from, any well-defined stock of the Low Entropy Fund (LEF) available for human consumption (Georgescu-Roegen, 1971). The LEF identified with any well-defined entropic process can, in any point in time, be in a '*sustainable surplus state*:' net-valued LEF >1, a '*unsustainable deficit state*:' net-valued LEF < 1, or a '*sustainable steady state*:' net-valued LEF = 1.

The suggested Platform Categories, (i.e., topological domain spaces), are well-defined in the mathematics, logic and one-to-one correspondence mapping of applied Category Theory, (Lawvere, and Schanuel, 1997). Central, is pluralism of values mapped on the accounting objects and functions well-identified in the emergent disciplines of Ecological Economics and General Systems Sciences, (Boulding, 1949, Bertalanffy, 1973, Daly and Cobb, 1989, Rosen, 1991, Friend 2016).

⁸ Colloquially referred as the Brundtland Report, after the chairperson Gro Harlem Brundtland, ex-Labour Prime Minister of Norway.

⁹ Alfred Marshall (1920) wrote: The Mecca of the economist lies in economic biology rather than economic dynamics. But biological conceptions are more complex than those of mechanics; a volume on Foundations must therefore give a relatively large place to mechanical analogies; and the frequent use of the term "equilibrium," which suggests something of a statical analogy. This fact, combined with the predominant attention paid in the present volume to the normal conditions of life in the modern age, has suggested the notion that its central idea is "statical," rather than "dynamical." But in fact it is concerned throughout with the forces which cause movement: and its keynote is that of dynamics, rather than statics.

SAGE-P, while still in the development stage, represents a formalized convergence of information on the quantitative/qualitative state, and change of state, of the topological domain spaces of: (A) *Econosphere* where values of objects/functions are *conserved-in-exchange*, (B) *Sociosphere* where values of objects/functions are *conserved-in-use*, (C) *Ecosphere* where values of objects/functions are *conserved-in-themselves*, The hierarchical structure of Categories may be represented in the following set theoretic structure: $C[B(A)]$.

Platform Development: in its early stage, would be an effective depository (or library) of peer-reviewed research papers, conference presentations and reference library germane to nonlinear accounting methods. However, the focus on methods, the collaboration among researchers could expand into funded case studies of nonlinear accounting methods to specific enterprises and/or industries. The goal, even at this early stage, is for Business Schools to offer courses to students in the theory and practice on nonlinear accounting.

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APPENDIX I

Platform Proposal: Research on Nonlinear Accounting of Complex Systems.

Proposal: Webpage for “Research on Nonlinear Accounting Methods”

Objective: To create an open access web-page for research inquiries into the theory and application of nonlinear accounting methods for governments, business and institutions.

Purpose: The traditional practice of accounting is a double entry bookkeeping of well-defined objects and functions where the inflows (e.g., revenue) = outflows (e.g., expenditure). This provides a decision-maker with a year-end balance sheet of surplus (e.g., profit) and/or deficit (e.g., debt). While the processes described by the accounts are well-defined social and economic structures with legally defined boundary conditions, the real-world upon which these artificially structured equilibrium state systems operate, are fundamentally non-equilibrium state systems describable in the language of nonlinear dynamics. The purpose of the web-site is to translate the current linear methods into the accounting language of entropic processes, (Georgescu-Roegen, 1971).

Location: The Web-page needs to be constructed in a rigorous academic environment upon a trans-disciplinary platform. Ideally this would be a university or research institution. The reason it is trans-disciplinary is that these accounts are only well-defined in complex systems science and multi-dimensional statistics, (i.e., economic, social, demographic and ecological); the latter being the feedstock algorithm (i.e., big data) and the former defining the structural algorithms, (i.e., thermodynamic open systems). Inter alia, are the well-defined boundary conditions which distinguish the stock/flow accounting entities. The other considerations are how these non-linear accounts are used in practice. This is why the platform cannot be housed in, or maintained by, a single academic department. The end-product is holistic and unique. Nonlinear accounts present a formalised, well-integrated, information system on the quantitative/qualitative state conditions of any well-defined economic system, social system, and ecological system. This is represented matrix of a hierarchical-structured value in the following order: *Ecosphere* [*Sociosphere* (*Econosphere*)]

Stages: The site, in its early stage, would be a depository for (or library) of research papers, and published articles, germane to the topic of nonlinear accounting. However, with its particular focus on, and an interest in methods, it could evolve into site for collaboration among researchers of nonlinear accounting. While accounting methods in themselves are generic, the interests may be more special and subject oriented. Thus the site would include: (a) theoretical foundations for nonlinear accounting, (b) accounting objects and functions specific to transaction values of government, business and institutions, (c) non-linear accounts design for specific policy objectives, such as: sustainability, addressing climate change and the qualitative states of the human welfare function and (d) measurement of GDP, redefined as Gross Domestic *Entropy* Production, (GDeP).

Funding: While the site itself should be housed in an academic institution, the outside interest may be of sufficient value to attract public or private investment, even that of well-funded NGOs.

Plea for Suggestions: Initial name for web site or project? Institutions or individual people to approach who might be interested in managing such a web site?

APPENDIX II

Special Integration Groups (SIG) on Nonlinear Accounting

The focus of the Special Integration Groups (SIG) is the potential for Groups congregating in designated sessions at an annual meeting may be placed into one of three categories:

- SIGs represented in Council, that have been ratified by the Board of Directors, and have scheduled at least one paper session within the past two annual meetings;
- Exploratory Groups, which typically convened at an annual meeting. They may come together only once or twice and then disband, or they may self-organize for later formal recognition as a Special Integration Group. A SIG chair has voting authority as a member of the ISSS Council, whereas Exploratory Groups are not represented in Council; and
- Coordinated sessions, which share in an Annual Meeting, but may have organizational affiliations independently of the ISSS.

Note: at this point SIG/SAGE-P is open-ended with respect to the above options.

The first option is that SIG/SAGE-P be formally ratified by the Board of Directors requiring, *inter alia*, signature-support of at least 17 members of ISSS.¹⁰

The second option is that SIG/SAGE-P be considered as an ‘exploratory group’ for “... later formal recognition as a Special Integration Group.”¹¹

The third option is that SIG/SAGE-P be affiliated with ISSS, but organizationally a separate entity.¹²

1. SIG/SAGE-P: Object and Purpose.

Theoretical: Application of the Second Law of thermodynamics to measure the State, and change of State, of any well-defined I/O accounts of the Low Entropy Fund, (LEF) available for human consumption. The objective function, or policy, is to increase to a maximum the entropy efficiency per unit of inflow, and decrease to a minimum the entropy production per unit of outflow, of any well-define LEF.

¹⁰ SAGE-P is inspired, and in various degrees influenced, by the work of the following past president of ISSS: Kenneth Boulding, 1957, 58, Robert Rosen, 1980. Ilya Prigogine, 1988, Howard Odum, 1991 and Timothy Allen, 2007.

¹¹ The ‘exploration’ option may be attractive to the members of the Group who feel uncertain of the feasibility of applying the Second Law of thermodynamics to the accounts of production (i.e., neg-entropy), consumption, (i.e., entropy) and capital (i.e., Low Entropy Fund available for human consumption) . However, the following papers/workshops have been presented at the ISSS’ 2016 Conference, Boulder, Colorado: *The System of Accounts for Global Entropy Production, (SAGE-P): Nonlinear Accounting of Gross Domestic Product (GDP) described by the topological domain spaces (TDS) of the nested Ecosphere [Sociosphere (Econosphere)]*. ISSS’ 2017 Conference, Vienna Austria: *Entropy: The Mirror Image of GDP or Entropy Efficiency Measure of Sustainability*. and ISSS’ 2018 Conference, Corvallis, Oregon: *The System of Accounts for Global Entropy Production, (SAGE-P): A Thermodynamic Measure of Sustainability*.

¹² The other key affiliates are: (a) Ecological Economists, (i.e., ISEE and Chapters), (b) Sustainable Business Enterprises, (i.e., BS-Lab., Italy) and the Degrowth Movement,(i.e., Paris 2008, Barcelona 2010, Venice 2012, and Budapest, 2016).

Research & Development: Design of the accounts of Entropy Production specific to any well-defined LEF, I/O matrix, such as:

- (a) **Planetary-LEF:** System Accounts for Global/Entropy Production, (**SAGE-P**), (e.g., Climate Change);
- (b) **Nation-LEF:** S. of A. for National/Entropy Production, (**SANE-P**), (e.g., GDP);
- (c) **Urban-LEF:** S. of A. for Municipal/Entropy Production, (**SAME-P**), (e.g., Mega-cities);
- (d) **Business-LEF:** S. of A. for Business-enterprise/Entropy Production, (**SABE-P**), (e.g., Multi-national Enterprises);
- (d) **Governing-LEF:** S. of A. for Public-administration /Entropy Production, (**SAPE-P**), e.g., Public Accounts);
- (e) **Security-LEF, Military, Police, Private:** S. of A. for Security/Entropy Production, (**SASE-P**), (e.g., Defence);
- (f) **Knowledge-LEF, Education and R&D:** S. of A. for Education/Entropy Production, (**SAEE-P**), (e.g., Primary, Secondary, Tertiary Edu.);
- (g) **Health-LEF:** S. of A. for Health/Entropy Production, (**SAHE-P**), (e.g., Potential loss-of-life);
- (h) **Population-LEF:** S. of A. for Demographic/Entropy Production, (**SADE-P**), (e.g., Census);
- (h) **Technology-LEF:** . S of A. for Technological/Entropy Production, (**SATE-P**), (e.g., Transport Infrastructure);
- (i) **Hydro-carbon-LEF:** S. of A. for Non-renewableEnergy/Entropy Production, (**SANEE-P**). (i.e., Carbon Footprint);
- (j) **Solar,Wind, Hydro, Bio fuel -LEF:** S. of A. for Renewable Energy/Entropy Production, (**SARE-P**) (e.g., ratio of renewable to nonrenewable energy production) ;
- (l) **X,Y,Z -LEF:** S. of A. for X,Y,Z/Entropy Production, (**SAXYZE-P**), (e.g.,ratio of entropy efficiency in the x,y,z, input vector over entropy production in the x,y,z output vector).¹³

Applications;

- (i) Produce an integrated system of accounts of the inflows to, the outflows from, any well-defined stock of a Low Entropy Fund (LEF) available for Human Consumption.
- (ii). From equilibrium accounting of the double entry bookkeeping, (i.e.,inputs = outputs) to disequilibrium accounting of the double entry bookkeeping, (i.e.,inputs \neq outputs).

2. Proposed at the ISSS Conference;

- (i) Fit with Complex System Science Theory and Practice
- (ii) Instrumental means to measure the value of the research projects and outcomes (to be completed)

3. Presentation at NCSE 2009 Conference “Sustainable Infrastructure & Resilience

- (i) Response of the researcher (to be completed)

¹³ Entropy efficiency/entropy production measurement are exclusive to objects/functions subject to the Second Law of thermodynamics. Abstract objects, like knowledge and know-how, while not directly subject the Second Law, entail various degrees of entropy production in transmission and storage. Abstract objects, like money, are entangled in physical objects, and may fluctuate in value.

A Special Integration Group is not a Special Interest Group. See [Special Integration Groups Purpose](#). Special Integration Groups may jointly focus on common interests (at a distance) over the year, and/or join in formal discussion at the annual meeting. Groups congregating in designated sessions at an annual meeting may be placed into one of two categories:

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- Coordinated sessions, which share in an Annual Meeting, but may have organizational affiliations independently of the ISSS.

For more information on SIGs, consult the [ISSS Bylaws](#).

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Active SIGs represented in Council

Please contact the following SIG chairs for further information and any questions you may have about their work or submitting a paper in the Annual Meeting.

4.10 Special Integration Groups (SIGs). The Society encourages the formation of Special Integration Groups (SIGs) composed of persons interested in promoting a particular subset of the Society's purposes and objectives. To be authorized by the Board of Directors, at least twelve Society members in good standing shall petition the VP for Administration. The SIG chairperson or a designee shall be a full member of the Council if the SIG has organized at least one papers session (or the equivalent), at each of the Society's last two annual meetings. SIGs are encouraged to conduct meetings with Society chapters and other SIGs in addition to their annual meeting participation.

A **Special Interest Group (SIG)** is a community within a larger organization with a shared interest in advancing a specific area of knowledge, learning or technology where members cooperate to affect or to produce solutions within their particular field, and may communicate, meet, and organize [conferences](#). The term was used in 1961 by the [Association for Computing Machinery](#) (ACM), an academic and professional computer society.^[1] SIG was later popularized on [CompuServe](#), an early [online service provider](#), where SIGs were a section of the service devoted to particular interests.

Appendix III

Panel: The RIO Declaration and the Agenda 21: transdisciplinary conversations about Entropy Accounting of the Agenda 21⁺²⁰.

The Agenda 21 assumed sustainable development (SD) as the norm in the public discourse long-term future development of Nations, providing the road map for effective policies towards conservation, and the sustainable management of economic, social, human and natural capital. While ill-defined in the formal sense of limit functions, (i.e., rates of replenishment of consumed stocks) and efficiency criteria (i.e., maximum enjoyment per unit of consumed stocks), normalizes SD as an *objective function* for governance, along with other high order ethical issues, like the equitable distribution of wealth. Nonetheless, there is the logical disconnect between the pragmatism of the 'Action Plan' and the higher order ethics of the 'Rio Declaration.' The result: non-integrability of the higher order *formal causes*, (i.e., socio-political statements), with the lower order *material causes*, (i.e., techno-scientific statements) of the Agenda 21.¹⁴

The question for the Panel is how to integrate harmoniously the disjunctive *material/efficient causes* with the higher order ethical standards of *formal/final causes*. The template for this 'conversation' is the reconciliation of the RIO Declaration's Principles 1,3,7, and 8 and the Agenda 21⁺²⁰

(i) **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, (i.e., the social ethics of harmony of Man & Nature expressed as the global economy being a proper subset of the global ecosystem):*

(ii) **Principle 3:** *The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations, (i.e., the social ethics of intergenerational equity expressed as a global non-declining human welfare function);*

(iii) **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, [i.e., the environmental ethics of the conservation,*

¹⁴ Aristotle in the reasoning of why things happen, identified four types of causes, (1) *material*, (2) *efficient*, (3) *formal* and (4) *final*. While the Aristotle framed causes in a philosophical discourse, we shall apply the four causes analytically within the following set-theoretic structure: *final {formal [efficient (material)]}*. The *material-cause* is simply observed in the first instance, (e.g., tree falling). The *efficient-cause* is the immediate agent of the *material cause*, (e.g., the man with the saw). The *formal-cause* is the intermediary agent of the *efficient-cause*, (e.g., forest industry). The *final-cause* assumes socio-political objectives of the Nation-state, (e.g., the regulatory regime to achieve the objectives of sustainable forestry production).

protection and restoration of the Earth's ecosystem expressed as a shared (international) responsibility to maintain (and enhance) local, regional and global ecosystem functions];

(iv) **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,* [i.e., the socio-economic ethics of the consumption of economic, social and natural capital, expressed as a global Pareto optimum, (sum positive) state. This may be reduced to a set of policies with respect to: (a) 'degrowth' in material consumption of high (money) income societies and (b) reduction in fertility rate of low (money) income societies].

The Agenda's 'action plan', while sensitive to social and economic differences in regions and national states, failed to define:

(a) a Universal Domain Set of objects and functions for the whole Planet as *per* habitat for seven and a half billion *Homo sapiens*;

(b) a common metric¹⁵ enabling the distinction to be made among value systems as per: (i) *economic values* conserved-in-exchange, (ii) *social values* conserved-in-use, and (iii) *ecological values* conserved-in-themselves, (i.e., intrinsic), and;

(c) an accounting method for the ordinal valuation of *objects* and *functions* to support the protocols for the conservation, protection and restoration of (global) ecosystem functions.

The discourse for the panel is the means by which we may apply the Second Law of thermodynamics to the Agenda 21, 'action plan.' Proposed for this objective is the System of Accounts of Entropy Production, (SAGE-P) described in the following topological domain spaces:

(A) the Econosphere: the accounts of the inflows, outflows, and balances of the economic process described by 'economic statistics;'

(B) the Sociosphere: the accounts of the inflows, outflows, and balances of the social/ demographic process described by 'social and demographic statistics;'

(C) the Ecosphere: the accounts of the inflows, outflows, and balances of the global ecosystem described by 'environmental and natural resource statistics.'

The accounts describe, a nested, ordinal-valued, mapping of objects and functions in the domain space as follows: $C \longrightarrow [B \longrightarrow (A)]$ & $C \longleftarrow [B \longleftarrow (A)]$

The Panel of six, while still T.B.A, will be transdisciplinary. A slide presentation of SAGE-P will precede the panel discussion.

From: Anthony Friend <afriend@sympatico.ca>

¹⁵ The common metric proposed in the G-R Flow-Fund Model is the rate of entropy production per unit of production, and the rate of entropy efficiency per unit of production.

Saturday, June 1, 2019

Subject: Panel: The RIO Declaration and the Agenda 21: transdisciplinary conversations about Entropy Accounting of the Agenda 21+20.

Date: 23 November, 2011 3:50:57 PM EST

To: Clive Spash <Clive.Spash@csiro.au>, Richard Norgaard <norgaard@violet.berkeley.edu>, Kozo Mayumi <mayumi@ias.tokushima-u.ac.jp>, Mario GIAMPIETRO <giampietro@liphe4.org>, Joe Mourad <kjm57@georgetown.edu>, michele friend <micheleifriend@gmail.com>, Herman Daley <hdaley@umd.edu>
Cc: info@isee2012.org

Dear Colleagues:

This is an invitation to join me on a Panel to discuss the radical idea of an 'entropy accounting' of the Agenda 21, (see attachment). Since I shall be occupy the chair, there are six vacant seats left on the Panel. (An extra chair could be provided if everyone accepts). I had also proposed short slide presentation to precede the Panel discussion.

Kozo Mayumi, taking the G-R Flow-Fund Model of the 'entropic process,' had the brilliant idea of reducing the indicator of SD into a single, and ultimately iconic number, representing some **socially acceptable rate of entropy production**. Thus, by a stroke of a pen, the concept of sustainability is removed from its *posteriori* low order cost equations of 'economics' and placed in the *a priori* high order ethics assumed in 'social values.' Kozo's SD Number could be a useful starting point for the Panel discussion linking the ethical principles of the RIO Declaration with the pragmatism of the Agenda 21.

I have suggested below four primary questions for the Panel. Nonetheless, this being a under the Conference Thematic 4: Methodological Challenges, and the sub-theme "Economics and Ecology: transdisciplinary conversation," the discussion may, as it should, follow its own course.

1. Given that the RIO Declaration of 1992 established the concept of SD among States, did social sciences fall short of a compelling intellectual foundation for normalising SD in the socio-political decisions? This may be contrasted with the natural science's analysis of the Earth's limit functions (i.e., Tragedy of the Commons) and the response to the degradation of ecosystem functions, (i.e., UN Biodiversity Strategy).
2. Given that the Categories of Agenda 21 (i.e., 40 chapters) assume complex, interconnected, processes, where the whole > the sum of the parts, implies that while each category may be assessed 'sustainable,' but the whole is not. Therefore, is there a need to rewrite the Agenda 21 into a Category Set Theoretic Structure in Topological Domain Space, TDS?
3. Is the neoclassical formula of a (global) non-declining welfare function, assumed under the rules of conservation of (inclusive) capital, theoretical sound? Does the argument of weak sustainability, a necessary condition, (i.e., equivalences in the qualitative properties of economic, social and ecological objects and functions) contradict the Second Law of thermodynamics? Can one argue that a global non-declining welfare function rewritten in the meta-language of the G-R Flow-Fund Model is theoretically sound?
4. Given the current state of computerised data, and its automated systems of data processing, storage and retrieval, is it feasible to construct the requisite databases and the complex, nonlinear, algorithms of SAGE-P?

The latter assumes accounting values derived from a hierarchical mapping of 'entropic processes' on three Category Sets defined by TDS in the form: $C \rightarrow [B \rightarrow (A)]$:

Where:

- (A) Econosphere: represent object and function values conserved-in-exchange;
- (B) Sociosphere: represent object and function values conserved-in-use, and;
- (C) Ecosphere: represent object and function values conserved-in-themselves (intrinsic).

I shall seek funding from the Canadian Organizing Committee for RIO+20, in order to defray the travel and per diem costs of the more impoverished members of the Panel.

Cheers, Anthony Friend

Anthony Friend, afriend@sympatico.ca

Appendix IV

UN Conference on Environment & Development Rio de Janeiro, Brazil, 3 to 14 June 1992, Agenda 21 – Chapter 40

INFORMATION FOR DECISION-MAKING

40.1. In sustainable development, everyone is a user and provider of information considered in the broad sense. That includes data, information, appropriately packaged experience and knowledge. The need for information arises at all levels, from that of senior decision makers at the national and international levels to the grass-roots and individual levels. The following two programme areas need to be implemented to ensure that decisions are based increasingly on sound information: a. Bridging the data gap; b. Improving information availability. PROGRAMME AREA SA. Bridging the data gap Basis for action

40.2. While considerable data already exist, as the various sectoral chapters of Agenda 21 indicate, more and different types of data need to be collected, at the local, provincial, national and international levels, indicating the status and trends of the planet's ecosystem, natural resource, pollution and socio-economic variables. The gap in the availability, quality, coherence, standardization and accessibility of data between the developed and the developing world has been increasing, seriously impairing the capacities of countries to make informed decisions concerning environment and development.

40.3. There is a general lack of capacity, particularly in developing countries, and in many areas at the international level, for the collection and assessment of data, for their transformation into useful information and for their dissemination. There is also need for improved coordination among environmental, demographic, social and developmental data and information activities.

40.4. Commonly used indicators such as the gross national product (GNP) and measurements of individual resource or pollution flows do not provide adequate indications of sustainability. Methods for assessing interactions between different sectoral environmental, demographic, social and developmental parameters are not sufficiently developed or applied. Indicators of sustainable development need to be developed to provide solid bases for decision-making at all levels and to contribute to a self-regulating sustainability of integrated environment and development systems. Objectives.

40.5. The following objectives are important:

- a. To achieve more cost-effective and relevant data collection and assessment by better identification of users, in both the public and private sectors, and of their information needs at the local, provincial, national and international levels;
- b. To strengthen local, provincial, national and international capacity to collect and use multi-sectoral information in decision-making processes and to enhance capacities to collect and analyse data and information for decision-making, particularly in developing countries;
- c. To develop or strengthen local, provincial, national and international means of ensuring that planning for sustainable development in all sectors is based on timely, reliable and usable information;
- d. To make relevant information accessible in the form and at the time required to facilitate its use.

1. Activities: Development of indicators of sustainable development

40.6. Countries at the national level and international governmental and non-governmental organizations at the international level should develop the concept of indicators of sustainable development in order to identify such indicators. In order to promote the increasing use of some of those indicators in satellite accounts, and eventually in national accounts, the development of indicators needs to be pursued by the Statistical Office of the United Nations Secretariat, as it draws upon evolving experience in this regard. b. Promotion of global use of indicators of sustainable development

40.7. Relevant organs and organizations of the United Nations system, in cooperation with other international governmental, intergovernmental and non-governmental organizations, should use a suitable set of sustainable development indicators and indicators related to areas outside of national jurisdiction, such as the

high seas, the upper atmosphere and outer space. The organs and organizations of the United Nations system, in coordination with other relevant international organizations, could provide recommendations for harmonized development of indicators at the national, regional and global levels, and for incorporation of a suitable set of these indicators in common, regularly updated, and widely accessible reports and databases, for use at the international level, subject to national sovereignty considerations.c.Improvement of data collection and use

40.8. Countries and, upon request, international organizations should carry out inventories of environmental, resource and developmental data, based on national/global priorities for the management of sustainable development. They should determine the gaps and organize activities to fill those gaps. Within the organs and organizations of the United Nations system and relevant international organizations, data-collection activities, including those of Earthwatch and World Weather Watch, need to be strengthened, especially in the areas of urban air, freshwater, land resources (including forests and rangelands), desertification, other habitats, soil degradation, biodiversity, the high seas and the upper atmosphere. Countries and international organizations should make use of new techniques of data collection, including satellite-based remote sensing. In addition to the strengthening of existing development-related data collection, special attention needs to be paid to such areas as demographic factors, urbanization, poverty, health and rights of access to resources, as well as special groups, including women, indigenous peoples, youth, children and the disabled, and their relationships with environment issues.

2. Improvement of methods of data assessment and analysis.

40.9. Relevant international organizations should develop practical recommendations for coordinated, harmonized collection and assessment of data at the national and international levels. National and international data and information centres should set up continuous and accurate data-collection systems and make use of geographic information systems, expert systems, models and a variety of other techniques for the assessment and analysis of data. These steps will be particularly relevant, as large quantities of data from satellite sources will need to be processed in the future. Developed countries and international organizations, as well as the private sector, should cooperate, in particular with developing countries, upon request, to facilitate their acquiring these technologies and this know-how.e.Establishment of a comprehensive information framework.

40.10. Governments should consider undertaking the necessary institutional changes at the national level to achieve the integration of environmental and developmental information. At the international level, environmental assessment activities need to be strengthened and coordinated with efforts to assess development trends.

3. Strengthening of the capacity for traditional information

40.11. Countries, with the cooperation of international organizations, should establish supporting mechanisms to provide local communities and resource users with the information and know-how they need to manage their environment and resources sustainably, applying traditional and indigenous knowledge and approaches when appropriate. This is particularly relevant for rural and urban populations and indigenous, women's and youth groups. Means of implementation a.Financing and cost evaluation.

40.12. The secretariat of the Conference has estimated the average total annual cost (1993-2000) of implementing the activities of this programme to be about \$1.9 billion from the international community on grant or concessional terms. These are indicative and order-of-magnitude estimates only and have not been reviewed by Governments. Actual costs and financial terms, including any that are non-concessional, will depend upon, inter alia, the specific strategies and programmes Governments decide upon for implementation.

4. Institutional means

40.13. Institutional capacity to integrate environment and development and to develop relevant indicators is lacking at both the national and international levels. Existing institutions and programmes such as the Global Environmental Monitoring System (GEMS) and the Global Resource Information Database (GRID) within UNEP and different entities within the systemwide Earthwatch will need to be considerably strengthened. Earthwatch has been an essential element for environment-related data. While programmes related to development data exist in a number of agencies, there is insufficient coordination between them. The

activities related to development data of agencies and institutions of the United Nations system should be more effectively coordinated, perhaps through an equivalent and complementary "Development Watch", which with the existing Earthwatch should be coordinated through an appropriate office within the United Nations to ensure the full integration of environment and development concerns.

5.) Scientific and technological means

40.14. Regarding transfer of technology, with the rapid evolution of data-collection and information technologies it is necessary to develop guidelines and mechanisms for the rapid and continuous transfer of those technologies, particularly to developing countries, in conformity with chapter 34 (Transfer of environmentally sound technology, cooperation and capacity-building), and for the training of personnel in their utilization. e.Human resource development.

40.15. International cooperation for training in all areas and at all levels will be required, particularly in developing countries. That training will have to include technical training of those involved in data collection, assessment and transformation, as well as assistance to decision makers concerning how to use such information. f.Capacity-building

40.16. All countries, particularly developing countries, with the support of international cooperation, should strengthen their capacity to collect, store, organize, assess and use data in decision-making more effectively.

6. Improving availability of information, Basis for action.

40.17. There already exists a wealth of data and information that could be used for the management of sustainable development. Finding the appropriate information at the required time and at the relevant scale of aggregation is a difficult task.

40.18. Information within many countries is not adequately managed, because of shortages of financial resources and trained manpower, lack of awareness of the value and availability of such information and other immediate or pressing problems, especially in developing countries. Even where information is available, it may not be easily accessible, either because of the lack of technology for effective access or because of associated costs, especially for information held outside the country and available commercially.

Objectives

40.19. Existing national and international mechanisms of information processing and exchange, and of related technical assistance, should be strengthened to ensure effective and equitable availability of information generated at the local, provincial, national and international levels, subject to national sovereignty and relevant intellectual property rights.

40.20. National capacities should be strengthened, as should capacities within Governments, non-governmental organizations and the private sector, in information handling and communication, particularly within developing countries.

40.21. Full participation of, in particular, developing countries should be ensured in any international scheme under the organs and organizations of the United Nations system for the collection, analysis and use of data and information. Activities a.Production of information usable for decision-making.

40.22. Countries and international organizations should review and strengthen information systems and services in sectors related to sustainable development, at the local, provincial, national and international levels. Special emphasis should be placed on the transformation of existing information into forms more useful for decision-making and on targeting information at different user groups. Mechanisms should be strengthened or established for transforming scientific and socio-economic assessments into information suitable for both planning and public information. Electronic and non-electronic formats should be used.

7. Establishment of standards and methods for handling information

40.23. Governments should consider supporting the efforts of governmental as well as non-governmental organizations to develop mechanisms for efficient and harmonized exchange of information at the local, national, provincial and international levels, including revision and establishment of data, access and dissemination formats, and communication interfaces.

8. Development of documentation about information

40.24. The organs and organizations of the United Nations system, as well as other governmental and non-governmental organizations, should document and share information about the sources of available information in their respective organizations. Existing programmes, such as those of the Advisory Committee for the Coordination of Information Systems (ACCIS) and the International Environmental Information System (INFOTERRA), should be reviewed and strengthened as required. Networking and coordinating mechanisms should be encouraged between the wide variety of other actors, including arrangements with non-governmental organizations for information sharing and donor activities for sharing information on sustainable development projects. The private sector should be encouraged to strengthen the mechanisms of sharing its experience and information on sustainable development.

9. Establishment and strengthening of electronic networking capabilities

40.25. Countries, international organizations, including organs and organizations of the United Nations system, and non-governmental organizations should exploit various initiatives for electronic links to support information sharing, to provide access to databases and other information sources, to facilitate communication for meeting broader objectives, such as the implementation of Agenda 21, to facilitate intergovernmental negotiations, to monitor conventions and efforts for sustainable development to transmit environmental alerts, and to transfer technical data. These organizations should also facilitate the linkage of different electronic networks and the use of appropriate standards and communication protocols for the transparent interchange of electronic communications. Where necessary, new technology should be developed and its use encouraged to permit participation of those not served at present by existing infrastructure and methods. Mechanisms should also be established to carry out the necessary transfer of information to and from non-electronic systems to ensure the involvement of those not able to participate in this way. e. Making use of commercial information sources.

40.26. Countries and international organizations should consider undertaking surveys of information available in the private sector on sustainable development and of present dissemination arrangements to determine gaps and how those gaps could be filled by commercial or quasi-commercial activity, particularly activities in and/or involving developing countries where feasible. Whenever economic or other constraints on supplying and accessing information arise, particularly in developing countries, innovative schemes for subsidizing such information-related access or removing the non-economic constraints should be considered.

10. Means of implementation: Financing and cost evaluation

40.27. The secretariat of the Conference has estimated the average total annual cost (1993-2000) of implementing the activities of this programme to be about \$165 million from the international community on grant or concessional terms. These are indicative and order-of-magnitude estimates only and have not been reviewed by Governments. Actual costs and financial terms, including any that are non-concessional, will depend upon, inter alia, the specific strategies and programmes Governments decide upon for implementation. b. Institutional means

40.28. The institutional implications of this programme concern mostly the strengthening of already existing institutions, as well as the strengthening of cooperation with non-governmental organizations, and need to be consistent with the overall decisions on institutions made by the United Nations Conference on Environment and Development. c. Capacity-building.

40.29. Developed countries and relevant international organizations should cooperate, in particular with developing countries, to expand their capacity to receive, store and retrieve, contribute, disseminate, use and provide appropriate public access to relevant environmental and developmental information, by providing technology and training to establish local information services and by supporting partnership and cooperative arrangements between countries and on the regional or subregional level. d. Scientific and technological means