Accounting for Sustainable Development of Socio-Economic and Environmental Systems

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Sustainability and Human Development

Human development derives from our ability to use a stock of assets that sustain a flow of goods and services to develop and maintain the capacity to satisfy our needs and aspirations *as a society* (Sen, 1998). Account-keeping of income, money, commodity and asset stocks and flows attempts to measure their availability and growth, within certain boundaries of time and space. In the framework of sustainability the main practical purpose of these accounts is to serve as a guide for prudent decision-making: they are indicative of the amount of goods and services that can be devoted in the present to satisfy needs and aspirations, without negatively affecting the asset base which will support the capacity of future generations to satisfy their needs and aspirations. Yet the satisfaction of individual and social needs and aspirations is subject to varying degrees of uncertainty, as it is the result of the complex – and sometimes unknown and unpredictable – interaction of social, technical, economic and environmental possibilities and constraints in a given context. Consequently sustainability is the dynamic capacity of a society to respond adaptively in order to maintain itself in a position that will warrant its capacity to satisfy its present and future needs and aspirations, even in the face of major or cumulative shocks such as climatic change, war, pestilence, erosion, or generalised economic failure (Boulding,1966; Norgaard,1988, Pearce,1988, Daly,1988; Pearce *et al*, 1989; Daly;1989; Folke and Kaberger,1992).

Environmental Degradation and Human Deprivation

Accounting for economic stocks and flows therefore supplies an important measure of sustainability: the possibilities of a community to deal with shocks and uncertainty increase with the size and diversity of the stream of goods and services that sustain their capacity to manage and transform their social, technical, economic and environmental potentials and constraints. Made assets ($\mathbf{K_m}$) such as machinery, infrastructure, factories and technology, are critical for economic growth and sustainability precisely because they contribute positively to increase the amount and diversity of goods and services at our disposal. At the same time, the natural environment also represents a stock of assets ($\mathbf{K_n}$), which are source of a stream of goods and services also critical for human activity: they supply both non-renewable resources such as oil and ore, and renewable natural resources (ecosystem based) such as biomass, soil, genetic diversity and water, among others. They also provide services such as maintenance of the composition of the atmosphere, of climate, the operation of the hydrological cycle including flood control and drinking water supply, waste assimilation, recycling of nutrients, regeneration of soils, pollination of crops and maintenance of a vast genetic library (EHRLICH,1989; DE GROOT,1992).

Much of the debate about sustainability is centred on determining the most sustainable combination of $\mathbf{K_m}$ and $\mathbf{K_n}$ in the economy. However policy predominantly based on accounting of economic stocks and flows has an inbred bias against $\mathbf{K_n}$. Since goods and services obtained from $\mathbf{K_m}$ tend to have a more income elastic demand than that of $\mathbf{K_n}$, and therefore a greater capacity to generate growth as measured by these accounts, policy goals tend to establish conditions which favour maximised returns to $\mathbf{K_m}$. The resulting production functions for activities which require labour as well as natural resources and services as inputs, tend to integrate these factors in an exploitative manner (i.e. their factor costs are not completely covered). Thus $\mathbf{K_m}$ accumulation is "traded off" for depletion of $\mathbf{K_n}$ and constraints on the potential development of human capacities in different cultural, social and environmental contexts.

For many this trade off is desirable to increase the value of the overall capital stock available for income generation. Therefore they consider it the optimal path of accumulation in the present as well as for warranting sustainability for future generations. As long as $\mathbf{K_m}$ continues to increase intensity and efficiency in the use of energy and information, future needs of the coming generations can be satisfied, even in the face of a decreasing $\mathbf{K_n}$ base [1] (MORTON,1994).

Yet the fact that $\mathbf{K_n}$ and $\mathbf{K_m}$ are not perfectly substitutable, and the possibility that irreversible damage may affect the $\mathbf{K_n}$ which provides services like the protection offered by the ozone layer, or the climatic regulating functions of phytoplankton, or the watershed protection by forests, seriously undermine the long term sustainability of the present path of $\mathbf{K_m}$ accumulation based on optimal substitution or depletion of $\mathbf{K_n}$ Since it is not clear that this path will contribute to enhance the capacity of future generations to respond adaptively to major or cumulative shocks, there is a growing consensus among both ecologists and economists that maintaining the total $\mathbf{K_n}$ stock at or above its current position is

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[1] The consistency of the present value criterion which supports the common notion of discounting the future in some fashion, also rests largely upon this assumption. Present value is considered a complete criterion because in the context of a "free market", it is a sufficient prescription for allocating efficiently resources and services over time, as long as subsequent generations continue to use the same optimal accumulation path. To maximise present utility, the present value criterion therefore requires future generations to adopt and follow the presently defined accumulation path. See PAGE,1977; AYRES,1978

a central condition for sustainability [2]. (PEARCE,1988; TURNER,1988; PEARCE *ET AL*,1989; CONSTANZA AND DALY, 1992; FOLKE AND KABERGER, 1992).

WHAT TO ACCOUNT FOR?

In an age of continuous economic expansion and globalisation, in which markets have become the predominant mechanism for informing and expressing a large part of the decisions regarding the use and combination of $\mathbf{K}_m$ and $\mathbf{K}_n$ as well as income derived from these assets, sustainability cannot be properly considered outside the market. In a market environment decisions and learning are coordinated in a decentralised fashion. Therefore to be effective, sustainable development policies must be supported upon conceptual models that account for how a socio-economic and environmental system functions in a given market context, and allow for simulations of how it may respond in this context under different conditions in the future.

A conceptual model is a simplified representation of a system of some nature, which has to be clearly identified and related with the values and intentions of the people involved in steering or operating within it[3]. In a first approach, a system represented by a model is not easily delimitated in time nor space, and it is

[2] Underlying the neo-classical concept of *production function* is the notion of *substitutability*: a given product or set of joint products can be obtained from a variety of different combinations of inputs, and one such combination will turn to be optimal under a given objective function and a set of relative factor costs. However all inputs are not perfectly substitutable: they can be complementary (synergistic), competitive (antagonistic) or fixed. There is no possibility of substitution between complementary inputs because neither is of any use without the other (i.e. petrochemical complex and oil). Competitive inputs are those such that the degree of possible substitution has no *a priori* technological limit: in principle one factor may completely replace the other (i.e. labour and capital). Fixed inputs are those such that the application of other factors can only eliminate marginal wastage: there is a definite physically determined lower limit that can only be approached asymptotically. See AYRES, 1978: 39.
The *polluter pays principle* ultimately operates within the framework of optimisation as a tool for allocating pollution, and is therefore useless as a sustainable management principle. Daly's famous analogy with the "plimsoll line" clearly illustrates this: Suppose that the load that a boat carries is to be maximised. If all the load is placed in one corner the boat will capsize or sink. Thus it is necessary to evenly spread out the weight. A pricing system can be a useful allocative tool for this purpose: the higher the water line in any corner of the boat, the higher the price of putting another unit of weight in that corner, and the lower the waterline the lower the price. However the cumulative and incremental use of this allocative tool ultimately leads to continue adding weight (- *pollution* -) and distributing it equally until the optimally loaded boat (- *life support systems* -) sinks (- *breakdown* -), optimally to the bottom of the sea. See DALY, 1984; and FOLKE and KABERGER, 1992.

[3] "'Steering' here means any deliberate action that is based on information which is carried out to influence the course of developments." See MUSTERS C. *ET AL* 1998.

difficult to select which are the significant characteristics which have to be taken into account by the 'variable set' of the model[4] (See box).

What variables need to be accounted for in order to properly model sustainable development? When striving for the sustainable development of a given socio-economic and environmental system, policy must identify the variables by which that system can be steered. Systems can be steered by controlling the streams of energy, materials of information to which its borders are open or closed: i.e. by manipulating import taxes. On the other hand, systems can also be steered by changing their subsystems or the relationships between them: i.e. production patterns and income distribution. (MUSTERS *ET AL*, 1998)

However as globalisation expands and socio-economic and environmental systems grow more open, their streams of input and output are increasingly stimulated or constrained by decisions which respond to higher hierarchy levels than the systems at hand to be steered by policy makers: i.e. the amount of oil that a country exports will depend on oil prices that are influenced by the OPEC. Therefore accounting for the *flow* of commodities and money within a particular system, may be an efficient way of describing the system as well as the important relations between its various elements and the system's context. Yet as these flows are increasingly beyond the control of policy instruments available in peripheral regions and countries, policy makers in these contexts have little room for manipulating the constraints or possibilities related with these flows. They can use their accounting for descriptive or predictive purposes, but they can hardly affect or use them as 'steering variables'.

Consequently policy instruments designed to steer socio-economic and environmental systems have to focus on controlling, changing or constraining the *number, relative spatial and temporal position of its subsystems and the relations between them*, within the constraints laid upon the system by its context. In the framework of sustainability, accounts should be structured primarily in order to assess not only the system's financial position by means of its balance of payments, but also the social and environmental position of its network of subsystems by means of corresponding 'balances' based on *non-monetary* indicators, in recognition of the fact that *not all values* are informed or expressed by markets. In this context, accounts should aim primarily to contribute to more responsive and accountable government, by supporting scrutiny of how public policy decisions affect the present day 'position' of different interest groups, as well as their local, social, cultural and life-support systems.

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4 "Socio-environmental systems are open systems, with numerous relations to other systems. All possible relations between the various elements of the system and the systems context can never be fully described. And even if they could, the amount of data would be so large that it could not be discussed or dealt with without information reduction" Ibid.

CONDITIONS FOR MODELLING SUSTAINABLE DEVELOPMENT *

The 'variable set' defined to model a socio-economic and environmental system must include two kinds of variables: *functional* – its inputs and outputs –, and *structural* – the relations that take place within it as a network of subsystems. There are several implications related with this manner of describing and modelling a socio-economic and environmental system:

- ☑ To be operative, variables used in a conceptual model need to define 'observation sets'. These are defined by indicators, which express a set of states or 'positions' which the system under discussion may have. The values of the set of indicators in a given moment, have to be calculated by relating certain attributes which are selected as most significant for a given set of values and policy objectives. Therefore indicators used to describe a socio-economic and environmental system have to include *spatial location* as an attribute necessary to map the position and relationship of structural variables such as production patterns, income distribution, poverty, available natural resources, and environmental constraints, among other.
- ☑ Socio-economic and environmental systems are always in flux: the development of a system can be regarded as the movement from one state or 'position' of the system to another. A given state or position of the system can be regarded as a point in the multidimensional space, of which the selected 'variable set' are the dimensions and the values of the indicators, the coordinates. Each variable of the system can have a certain, limited range of values, and likewise, the system can only have a certain limited combination of values for all its variables. The set of possible states or positions that can be found in a system in this multidimensional space, can be expressed as the *'phase space'* which defines that particular system. Any observation set that lays outside of the phase space of the system, is considered to belong to another system
- ☑ Uncertainty related with the complex interaction of social, technical, economic and environmental possibilities and constraints in any given context, derive from the fact that socio-economic and environmental systems are subject to unpredictable behaviour and unknown changing phase spaces. The values and constraints which determine the orientation in which such a system is to be steered by policy makers, define a 'phase space' which has to be acceptable for the people involved in the system as well as those outside it, both in the present and the future.
- ☑ A further condition of sustainability of a given steering orientation is that it should not trigger uncontrollable processes in other systems, so that steering of those systems is frustrated. This condition stresses the importance of taking the interests of other constituencies into consideration, people living elsewhere in other systems as well as future generations. This ultimately means that no externalities are allowed. However as this condition does not hold everywhere, particularly in the context of peripheral countries and regions, not all parts of the world at present are equally suitable to be defined as socio-economic and environmental systems in which sustainable development policies can be applied successfully.

☑ Another condition for sustainable development is the possibility of a permanent political exercise in search of social agreement on the values of the system, its goals, the chances of realising them, their relative importance, the choices to be made and measures to be taken. Thus in order to promote a favourable environment for this perennial political process as well as for defining and examining the relevant information in regards with the impact of the resulting decisions and measures, socio-economic and environmental have to be defined as explicitly as possible. To do so, four iterative steps are suggested by MUSTERS *ET AL*, 1998 :

i. identification of the socio-economic and environmental system, that is, locating it concretely in time and space in the biophysical world, defining its socio-cultural, economic and ecological values, and the level of scale in which the system allows for its development to be steered;
ii. assessment of the people involved with the socio-economic and environmental system now and in the future: this includes those directly involved, i.e. all persons or systems that are affected – positively or negatively – by the 'values' of that system, that is the input or output of the system and its structure; also, those indirectly involved, i.e. people and systems not affected directly by the system's inputs or outputs, but related with its context in higher or lower hierarchic scales.
iii. delimitation of the outer boundaries, the level of resolution of the information and the boundaries of the context to which the socio-economic and environmental system belongs.
iv. description of *a)* the number, relative spatial and temporal position, inputs and outputs of the subsystems; *b)* the valuable characteristics of the system to those directly involved with it and which clearly make the *phase space* of the system acceptable to them; *c)* the natural characteristics and regulations of higher scales systems, as well as the possibilities of change constrained by the network of subsystems; and *d)* the set of rules which govern the system's structure and operation, as functions of its input, output and relative position within certain constraints.

Accounting for Sustainable Development of Socio- Economic and Environmental Systems

As stated in the beginning, sustainability is the dynamic capacity of *a society* to respond adaptively in order to maintain itself in a position that will warrant its capacity to satisfy its present and future needs and aspirations, even in the face of major or cumulative shocks such as climatic change, war, pestilence, erosion, or generalised economic failure. Consequently the values and constraints that determine the orientation in which such a system is to be steered, must be closely linked to a political process in perennial search of social agreement about the values of the system, its goals, the chances of realising them, their relative importance, the choices to be made and measures to be taken, and their consequences for the people involved in the system as well as those outside it, both in the present and the future. Additionally, decisions and measures should take into consideration the interests of other constituencies and keep track of impacts on other systems, in order to avoid triggering uncontrollable processes that may frustrate steering of those systems.

Therefore understood as a dynamic capacity to respond adaptively as a socio-economic and environmental system, sustainability brings with it the responsibility of up-keeping feedback about decisions and measures taken, in order to learn in a decentralised manner but also sensitive to particular systems and contexts. This means that sustainable development requires, additionally to markets, instruments which permanently inform, support and express collective agreements and arrangements in regards to what is considered acceptable in terms of the social and environmental state or 'position' of its network of subsystems. It also implies that sustainable development involves developing a socio-economic and environmental system's capacity for self-control by means of mechanisms capable of clarifying our responsibility for what happens in our vital surroundings, as well as for the collective satisfaction – or dissatisfaction – with it.

At what 'level of hierarchy' can these instruments be designed? Certainly it has to be at a level at which institutional subsystems be steered to harness appropriate knowledge, inputs and organisation forms in order to capture the gains derived from the management of the socio-economic and environmental system (NORGAARD, 1988). Therefore conditions for sustainable development of a system necessarily imply i) the identification of the system; ii) assessment of the people involved with it, iii) delimitation of the system's boundaries; and its description, as discussed in the box above. It will also require political agreement and institutional arrangements that allow for setting and enforcing macro-environmental standards such as land use zoning criteria and ambient environmental quality standards for air, water and land, among others. For their operation, monitoring systems will have to be developed in order to keep track of the behaviour of indicators set to measure levels of intensity of human influence appropriate to social and environmental conditions of the system (i.e. $\mathbf{K_m}$ inputs/ $\mathbf{K_m}$ outputs in monetary and caloric terms, pollutant levels of incoming and outgoing atmospheric, water and soil flows, [5] changes in the stock of $\mathbf{K_n}$ in the system [6])

EPILOGUE: COLOMBIA'S UNSUSTAINABLE DEVELOPMENT PATH

In what regards to socio-economic modelling as well as to environmental legal and administrative framework, Colombia is generally recognised to have developed a state of the art instrumental capacity. The Departamento Administrativo del Planeación Nacional – DNP– as well as the Departamento Administrativo Nacional de Estadísticas – DANE – and the Banco de la República regularly produce statistics to feed social accounting matrices, and publish studies and public policy documents based on their analysis. DNP and the Contraloría General de la Nación – CGN – have also devoted in the past decade significant efforts to develop an environmental accounting system to complement national accounts.

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[5] In general pollution problems associated with elements and compounds related to hydrogen, carbon, oxygen, sodium, potassium, calcium, silicon, magnesium, aluminium and iron, give rise to environmental problems caused by quantitative excess and imbalances such as silting and erosion, soot and vaporised hydrocarbons, biological oxygen demand (BOD) and oil spills, but not from fundamental incompabilities. All of these problems are feasible to be reduced by a combination of technology and regulations applied to:

- ☑ agricultural and construction activities
- ☑ combustion of fossil fuels
- ☑ waterborne disposal of untreated or partially treated municipal sewage, food processing and pulp paper manufacturing effluent
- ☑ oil shipping and operating practices

Pollution problems involving elements such as nitrogen, sulphur, phosphorous and chlorine are pervasive and have uncertain impacts on life supporting systems because when associated with compounds with carbon, hydrogen and oxygen, they become extremely biologically active and sometimes have highly toxic and carcinogenetic effects. Dispersive and dissipative management of these elements increase possibilities of synergetic toxic effects which may affect and breakdown life supporting cycles, and create persistent stock pollutants (i.e. substances which have no counterpart degrader populations in the biosphere). All other elements -metal and non-metal- have toxic effects, some more than others. Efforts should be devoted to monitor the stock and flow of these elements within the productive circuit and the environment which contains it. See Ayres, 1978.

[6] Potential degradation of $\mathbf{K_n}$ can be easily observed by **1)** changes in the relative abundance of species; **2)** sensitive species begin to disappear and native species decrease; **3)** non-native species begin to colonise; **4)** biomass and cover begin to decrease; **5)** production begins to decrease; **6)** erosion begins to increase. See AYRES,1978; FORMAN AND GODRON,1984; KABERGER,1992; GEORGESCU-ROEGEN,1993

However by account of prestigious analysts such as Eduardo WIESNER (1997), public policy objectives related with economic growth, income distribution and unemployment have failed miserably, mainly because of an institutional context prone to benefit special interest groups granting special privileges and incentives through legislation and public expenditure, thus affecting adversely the achievement of public policy goals. In a brief commentary of WIESNER'S conclusions, Francisco GONZÁLEZ (1999) , head of the Measurement and Macroeconomic Projections Division of DNP, supports them with empirical data which show how expansionist fiscal policies over a period of 25 years have had little effect on goals related with economic growth, income distribution or unemployment. Could this be because policy simulation models of DNP are working with variables which cannot be steered at that level of hierarchy? Or maybe as a system Colombia is so 'open' – i.e. a system whose development is assumed to be controlled primarily by processes outside of the system –, that it cannot be treated as a socio-environmental system for sustainable development purposes? It seems as if sustainable development policy in Colombia needs to start by properly identifying its socio-economic and environmental system and context.

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