ECOLOGICAL FOOTPRINT AS A METHOD FOR SOCIO-ECOLOGICAL SYSTEMS APPROACH

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This paper tries to elucidate the methods and work instruments used to simulation socio-ecological systems (CSE). Working of CSE may be described with specifically methods, using multi sector approach in which to be identifying common state variables of the system. Problems of modelling big systems are connected to hierarchical model structure, unless neglect the main variables, identify an integrated work method who will allow problem formalisation and use of quantifying tools in order to obtain data to estimate simulation results. This paper intent to develop a critic analyse for the three levels: model-method-instrument, regarding new approach of socio-ecological systems.

Keywords: ecological footprint, socio-ecological systems, economy, energy.

1. Introduction

New approach regarding simulation of complex systems tried to establish by top-down approach the hierarchy of such systems. Also, there are opinions of big system in witch human activity is analysed as a contextual component of ecosystems evolution, must be analysed no only by biunique influence between its subsystems, due to matter and energy flux, but also function of makes decisions that is administrative, juridical and political aspects also – formal informational flux. Such opinion considers these systems as socio-ecological systems (CSE). Simulation CSE problem rest usually: identify significant variables in dynamic process; establish an interdisciplinary working accepted method and using standard instruments for input and output quantification.

2. Simulation of socio-ecological systems

Simulation of socio-ecological systems (CSE), considered big system, is based on hypotheses limited to possibilities of formalisation made by domains that studies these systems. So, CSE may be approach by considered ecological, socials, and techniques components (in general sense). Regarding the ecology and social sciences (economic and social sense). It existed concerns for functional relations formalisation between system elements. Regarding technical systems (industrial and energetic) it be considered accounts relations for input (resources)

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or output (emissions) or both, for minimal purpose of managerial requests generated by public and political constrained.

Regarding technical aspects of CSE simulation these are in fact critical theories which discuses the problem of macroeconomic equilibrium, from the thermodynamic imposed laws. So, the technical formalisation of big systems cannot be extra posed at socio-economic systems, but only sub summed of their integrated systems.

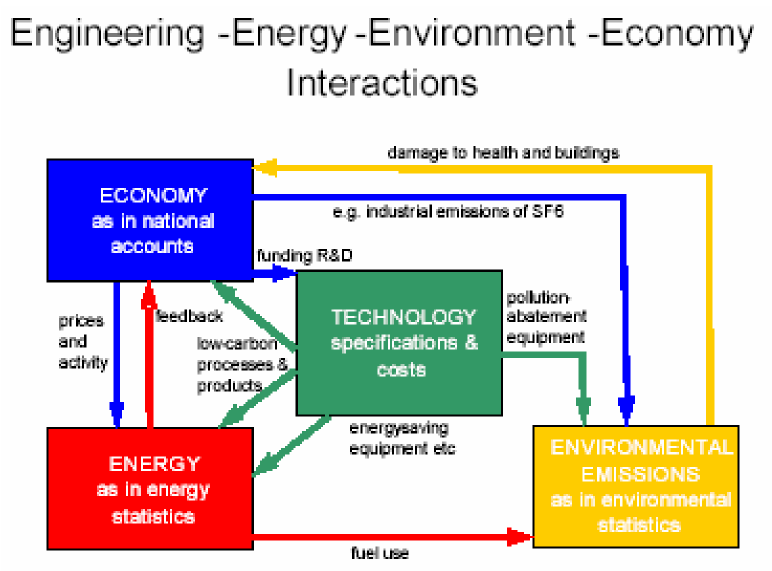

Fig. 1. Energy economy engineering and environment model.

Practical all the known and accepted models to ground the decision process are elaborated from top to down. Also, the models including technical components have evolution by the energetic block to the industrial (great industries) and completion by diffuse aspects of energy farms consumption. Addition of energetic block initial was made by distinct model with results in economical models. By introducing this block in the economic model, it prove on one hand the non-linear equations of model that optimised the energetic system in offers terms, has bad expectations for request function, corresponding to macroeconomic model. So, in macroeconomic equilibrium the results are unexpected. On the other side, energetic offer function is no dependent only by technology, the access to resources or costs, depend also by the interest rate and by incomes level. In present, separated approach of energetic and industrial blocks is recommended, plus environment components block connected to the climate changes. A global chart of such model it presents in figure 1 (Univ. Cambridge

UK-2005) and it is an economical treatment of dependence between energy-economy-engineering-environment. Specific literature present that a complex simulation of CSE will content equations witch in accounts terms of energetic, industrial, environmental and social blocks, all connected to a macroeconomic dynamical model. Such complex model is proposed by the Millennium Institute of USA (2005) working as connected modules of a specialised software in dynamic simulation of systems, see figure 2. This model consist in economic model (with 2 parts – national costs and computation algorithm for industry, agriculture and services), production model (consist in industrial production of the up domains plus technological domain, renewable energy, urban unemployed and pollution domains of people, agriculture, energetic, environment, social, technologic, transport, global (with climate changes), water, forests, emissions with hot house effect, governmental (governmental consumption and investments).

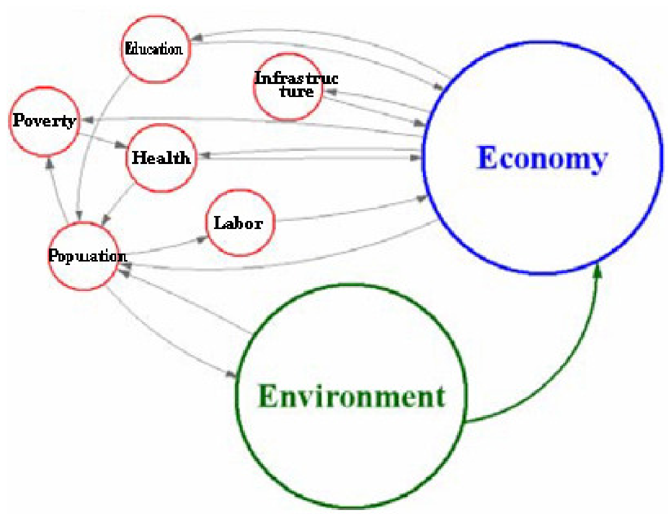

Fig. 2. People – Economy – Environment.

HIV-SIDA. This model has a great complexity and parts of approach from top to down. If this models has a rise complexity, their use is many difficult and the simulation scale introduce a certain suspicion in possibilities to obtain the macroeconomic equilibrium, main objective in sustainable politics.

3. The method of ecological footprint

The ecological footprint measures the quantities of natural resources that a person, a community or a country is used during a year. For this it is necessary to have statistical data regarding the level of consumption, which are transformed in equivalent ecological land average product and equivalent glossy water (surface), necessary to provide resources and to capitalize the waste product. Regarding global level, ecological footprint is the total sum of these areas, anywhere they are. In order to calculate the necessary of energy for ecological footprint, it can be estimated the value of surfaces area, which can produce the same energy request by consumption, but in biomass resources.

Elements of methodological calculation of ecological footprint:

From economical point of view, adding the internal consumption and reducing the export calculate national consumption level:

Consumption = production + imports – exports.

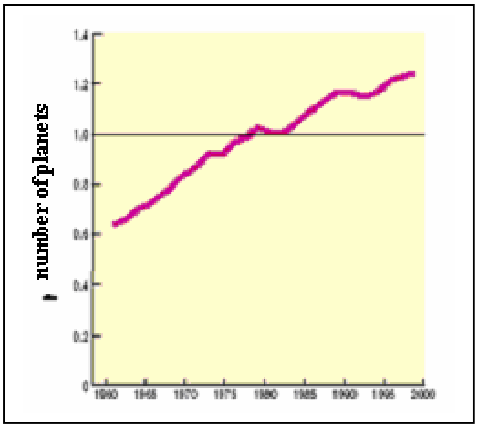

Fig. 3. The ecological footprint evolution versus planet capacity.

This equilibrium equation is calculated for 72 types of products. These products are quantified by average productive biological area. Some resources are elementary, the other are processed but derives from the first, all of them are finally calculated function of equivalent area surface. Regarding CO_2 emissions their total is divided by forest absorption capacity. Therefore, ecological footprint is the sum of necessary surfaces to provide primary internal consumption of energy, but also the space for infrastructure. In present, biosphere contents 10,8 billion ha biological productive area that is a quarter from the earth surface. From this area 2,3 billion ha are glossy water surface. Taking in consideration that the earth population is approximate to 6 billion people, to each person correspond 1,9 ha area. In the 2000-year, people from Africa and Asia have less that de 1,4 ha in the west of Europe approximate to 5 ha, in SUA 9,6 ha. Consumption in average was 2,3 ha per person, therefore with 20% over biologic productive capacity of earth. In conclusion, population exceeds the earth capacity to assure renewable resources. In this case available forests, fertile earth or fish stocks will disappeared. The same situation is with the CO_2 atmospheric emissions.

In this context is necessary to define the components of ecological footprint, so that to find solutions to reduce the resources consumption. The most important elements of ecological footprint and their influence will be presented below.

➢ **Foods**: Surface necessary for harvest, animals breeding, water resources for fish, also the necessary energy for industrial processes and transport.

➢ **Goods consumption and services**: The necessary requires by the standard of live in the country for which is calculated the ecological footprint. In this category is including the goods consumption, but also pollution water treatment, health, education, and telecommunication.

➢ **Transport:** Include all aspects of mobility including infrastructure, energy, transports- their consumption and maintenance.

➢ **Dwelling:** Refer to the inhabited spaces, therefore energy and necessary resources for their building.

➢ **Necessary of energy**: That means the proper consumption of energy. Any method of energy production has it proper ecological footprint for construction and exploitation. Regarding ecological footprint evaluate for energy consumption it calculate necessary of biological productive which will produce the same energy using solar radiation. More precision, considering biomass produced by flora and using relation of conversion for biomass in fuel: ethanol and methanol. So, it can establish the quantity of energy Joule/ha and year/ha for a given land surface.

➢ **Demurrage:** Ecological footprint is variable from country to country by economic specify, local consumption tradition, technology efficiency. This parameters depend by clime, global heat, style of dwellings building, transport.

➢ **The income:** Big income are correlated with big ecological footprint cause to rising the goods consumption and services, including governmental expenses In physical terms and correlating with farms level a big ecological footprint guide to a big farm with rise mobility area regarding means of transport.

➢ **Pollution:** Ecological footprint contents only aspects regarding consumption resources and waste products, which can be sustainable (supported by the regenerated capacity of the environment).

A great progress was made by treatment from bottom to top of the lasting development, once of ecological footprint calculation, by national accounts of consumption give in average productive area. Not even ecological footprint are presented sufficient reasons for itself consideration in the decision process. The purpose to simulate socio ecological complex is to identify decisions that may possible the system sustainability, but quarantine macroeconomic equilibrium. A solution will be to coupling ecological footprint by environment management methods, used to quantify the processes and analyse the results with the support capacity of ecological systems.

This bottom to top analyses makes connection between socio-economical aspects and development limits (economical aspects) using technical specific procedures (technical aspects).

4. Instruments for the environment management

By bottom to top approach is known by using instruments for environment management. This instruments were development to be part of studies that evaluate the investment impact and than were standardized (Life Cycle Assessment). But results obtained by using these working instruments is not general, cause to the country itself technical settlements regarding the environment indicators. In present instruments as Environmental Audit, Environment Impact Assessment, etc., have possible the forward in consideration many variables in working simulation of socio-ecological complex.

Life cycle assessment:

Life cycle assessment is an objective process for establish the level of environment solicitation by manufacturing a product, process or activity, quantifying the energy and materials used, also the waste products send to environment; establish the impact of these primary matter consumption, of energy and waste products emission about the environment quality have the purpose to identify and than to apply these measure with a minimum negative effect. Life cycle assessment include the process of the analyse of a product, process or activity life cycle, starting from the extraction of primary matter, manufacturing, transport and distribution, use and re-use, maintenance recycle and final manufacturing as waste products by controlled deposit in waste hollow, cremation, etc.

Conversion parameters:

These are necessary for unitary quantify of the dimensions taking account in decision process.

- **Consumption of energy**: Dimension unit convenient are megaJoule for quantify the energy consumption. This dimension unit considered both thermal and electric consumption energy. For the purpose to reduce in the future the consumption of energy it take account by the consumption purpose- in manufacturing, transport, etc., also it take account by the obtaining source (oil, natural gas, nuclear, etc) with different environment impact.
- **Solid waste products**: For different type of these solid waste products the equivalent dimension may be their volume (calculated function of specific mass) and the area affected at their checked lay (in waste hollow). This method is for no dangerous waste products.
- **Pollute emissions:** The principal problem in emission equivalents is their different nature. It developed many methods that integrate their heterogeneous patterns: *the method of critical volume*, that considers a theoretical critic volume of toxic emissions, calculated as ratio between the given and the maximum concentration for working places; *the cumulus effect method* that considers the effects of different emissions about the environment. For example it can establish

different list of gas responsible for hothouse effect, degradation the ozone layer or acid rains. This method is as target to follow for improvement measures of ecological profile for a product.

➢ **The level of the environment loading**: There are methods for quantifying the inputs and outputs in a list of life cycle analyse. Analysed results have a series of dimensions that transform the above data in values to point the loading level of environment; for example define a "eco factor" (EF) by Swiss model:

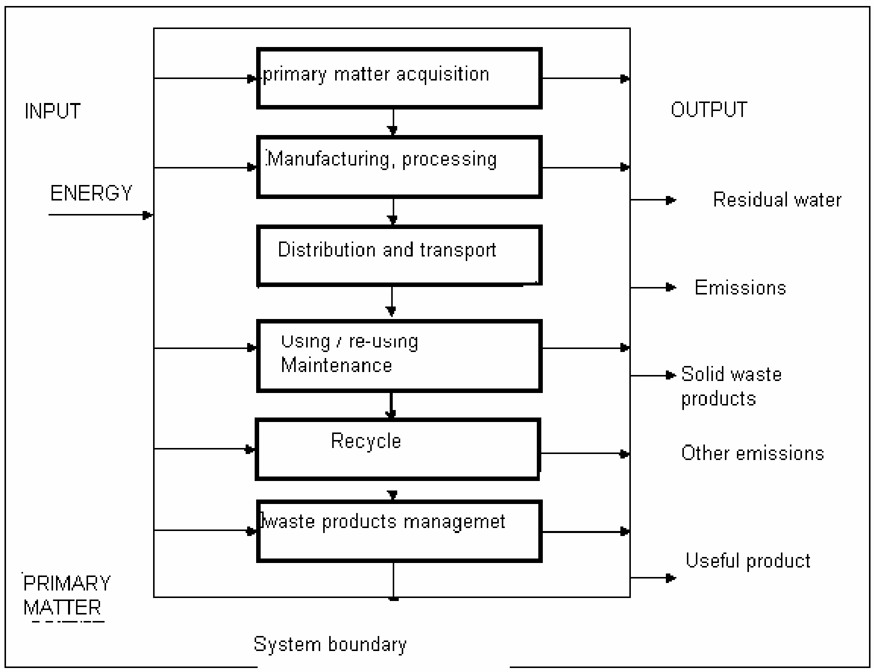

Fig. 4. Life cycle plan.

5. Conclusions

Necessity of the assessment the effects of the decision process has request the quantifying and unifying the flux, preferring top to down analyses, where monetary aspects have prevailed. However, since present, are not known and not accepted methods that satisfy the assessment necessity of publicly political effects regarding socio ecological complex. In this context, the solutions for supporting decision are limited to orientated models of socio ecological complex (models build on economical principles) or to environment management methods (like known from the Life Cycle Assessment, The Environment Survey, Assessment of Impact etc.).

As longer as the model has a higher complexity, so their use become more difficult and simulation at a big scale induce a certain suspicion degree regarding macroeconomic equilibrium, central object of sustainable politics. A step forward was made in a bottom up approach of durable development politics, by calculating ecological footprint, realised throw a national accounts of consumption on average productive area. In conclusion, not even ecological footprint cannot present enough arguments to take in consideration the decision process itself. The reason of this is due to the purpose of socio ecological complex simulation is to identity decisions for the sustainability of these systems, but in macro economical equilibrium context, a little less considering the durable aspect of environment.

In present, Life Cycle assessment – known as working method of years ’90 in environment management –represent an alternative to areas approach of decision process.

However is known that, this assessment instrument can provide opposite results, even in similar products or processes, because a missing of a methodology; so, there is a danger of limited trust in conclusions obtained by this way.

As a conclusion of previous paragraph, the public political approach can be made either top-down or bottom-up. Cause to diversity of the proposed models, it results that by rising their complexity imply a reduction of the trust level in proposed solutions. Also, it is useful to elaborate calibrated models based on case studies, for public political approach. These case studies must be builds using bottom-up method of socio ecological footprint.

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