

# FROM GEORGESCU-ROEGEN'S BIOECONOMICS TO THE META-ANALYSIS OF THE SOCIOECONOMIC AND ENVIRONMENTAL METABOLISM

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***Abstract.** Implementing the bioeconomic program proposed by Georgescu-Roegen led to the meta-analysis construct for the socioeconomic metabolism subject to the laws of thermodynamics.*

*This paper presents the essence of Georgescu-Roegen's criticism of the neoclassical economics theory that led him to formulate the bioeconomic paradigm as an alternative to standard welfare economics.*

*We discuss the extension of Georgescu-Roegen's idea regarding the utility associated to leisure, extension done by Giampietro and Mayumi, to a method for multi-scale integrated analysis of the socioeconomic metabolism. According to Herman Daly, the adoption of the bioeconomic paradigm requires extremely important changes in the way the 'building blocks' of economics are assembled: the 'entropic flow diagram' replaces the 'circular flow diagram' and 'the natural resources and the environment' become the main point for the development of the theory. Therefore, the idea of 'continuous growth' would cease to be the main objective of economic policy while the progress of 'technology' is aimed to increase the efficiency of entropy flows. When the entropic conceptual framework is considered, improving or eliminating 'poverty' cannot be achieved without redistribution (only through growth), while the current model of 'development and modernization' associated with increasing and intensifying production and consumption must be replaced by a model that promotes maintaining the entropic flow, flow monitored by an index measured in the system of national income accounts.*

*Last but not least, the importance of institutions for the socioeconomic metabolism is contrasted to the theoretical foundations of welfare economics guiding current economic policies for development and poverty elimination.*

**Keywords:** *socioeconomic metabolism, bioeconomics, Georgescu-Roegen.*

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## 1. Introduction

Georgescu-Roegen is known, among many notable contributions, for the application of the second law of thermodynamics, the law of entropy, to analyze the economic process [1]. His visionary idea to build a sort of meta-economic analysis associated with the concept of socioeconomic metabolism subject to the laws of thermodynamics, led him to develop the flow-fund model and to sketch a bioeconomic program (having the role of transforming current human economy from destructive, at the level of the global integrated ecosystem, to long-term sustainable). Although during his lifetime (he died in October 1994) his bioeconomic program did not fully come to life, in the past fifteen years, his student Kozo Mayumi (Professor at Tokushima University, Japan) together with Mario Giampietro (Professor at Universitat Autònoma Barcelona, Spain) have developed a method for meta-analysis of economic, societal and ecosystem metabolism (Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism MuSIASEM) based on the ability of the bioeconomic concept “to integrate the representation of monetary flows with matter and energy flows. In this way, it provides a bridge between economic, ecologic, social and demographic analysis”. [2]

Georgescu-Roegen insisted on the conceptual difference between agricultural and industrial processes that cannot operate according to the same economic laws [3]. He conceived “the difference between the philosophy of the industrial town and that of the agricultural village” [4] in relation to two types of constraints, one corresponding to the “living Nature” impacting on *Homo agricola*, and the second one corresponding to the “inert matter” impacting on *Homo faber*. Consequently, in order to be appropriate, economic analysis should discriminate between the economic processes at a village level and at the urban, industrial level.

Unfortunately, the economic theory has embedded in its core the inaccurate assumption “that the peasant ...behaves irrationally” [5]. Almost fifty years ago, Georgescu-Roegen explained how, being guided by utility theory and rational-choice profit functions, economists came to this conclusion. Recent studies in the field of economic anthropology and other disciplines brought scholars to understand the importance for the economic process of institutional specificities in various societies (rural or urban, developed, transitional, or developing).

A simple example could prove to be thought-provoking about the implications of such a theoretical correction. In Romania, compared to 23% average EU-27 rural population [6], 45% of country’s population [7]

lives in rural areas (Table 1) and 35% of it is working for private agricultural businesses in rural areas compared to only 28% in 1989 [8].

**Table 1.**

*Rural and urban population in Romania 2007-2011*

	2007	2008	2009	2010	2011
% urban population	55%	55%	55%	55%	55%
% rural population	45%	45%	45%	45%	45%

For 2008, 2009 and 2010 data at July 1<sup>st</sup>, while for 2011, at January 1<sup>st</sup>.

**Source:** CNS-Statistical Yearbook of Romania 1990. The National Commission for Statistics.

The rest of the paper is organized as it follows: Section 2 lists some of the pervasive technicalities of the standard economic theory that invisibly guided the development of a global unsustainable and destructive lifestyle. Section 3 presents the transition from Georgescu-Roegen's flow-fund model, representing the economy as a metabolic system, to a new type of socioeconomic – environmental meta-analysis. Section 4 introduces the Georgescu-Roegen's sketch for a bioeconomic program conducive to a sustainable society; it also lists what would change in basic economic theory if that bioeconomic program would be adopted. Section 5 emphasizes that urban and rural economic processes do not have the same nature and their treatment in economic theory should be different to promote a safe and sustainable development. Section 6 conclusions.

## **2. Goergescu-Roegen's critique of standard economic theory**

In his introduction to *The Entropy Law and the Economic Process*, Georgescu-Roegen argued that the fundamental flaws involved in standard economic theory are the concepts of *Homo economicus* and the mechanistic structure of economics.

No science has been criticized by its own servants as openly and constantly as economics. The motives of dissatisfaction are many, but the most important pertains to the fiction of *homo economicus*. The complaint is that this fiction strips man's behaviour of every cultural propensity, which is tantamount to saying that in his economic life man acts mechanically. This is why the shortcoming is ordinarily exposed as the mechanistic outlook of modern economics [5].

Mechanics knows only locomotion, and locomotion is both reversible and quality less. The same drawback was built into modern economics by its founders, who, on the testimony of Jevons and Walras, had no greater aspiration than to create an economic science after the exact pattern of mechanics. [4](p. 1)

For half a century, Georgescu-Roegen produced sophisticated critics within the neoclassical theory and provided an outline of alternatives to standard welfare economics. He insisted on the importance of drawing explicit relevant analytical boundaries for the purpose of specific studies. Standard economics has been criticized for its *arithmomorphism*, meaning the characterization of economic behaviour as having a one-to-one association to the real numbers set. The alternative he proposed is to use what he calls the *dialectical* representation. Georgescu-Roegen argued that we need both concepts, arithmomorphic and dialectical, to study the economic process: some phenomena require a quantitative analysis, and others can only be understood using a qualitative approach, while others require them both.

In contrast with the approach of the new welfare economics (new welfare economics NWE) based on the laws of classical mechanics, Georgescu-Roegen [9] advocated a progressive approach based on the laws of thermodynamics. He pointed out that the economic process is one of qualitative change characterized by discontinuous leaps rather than by marginal changes:

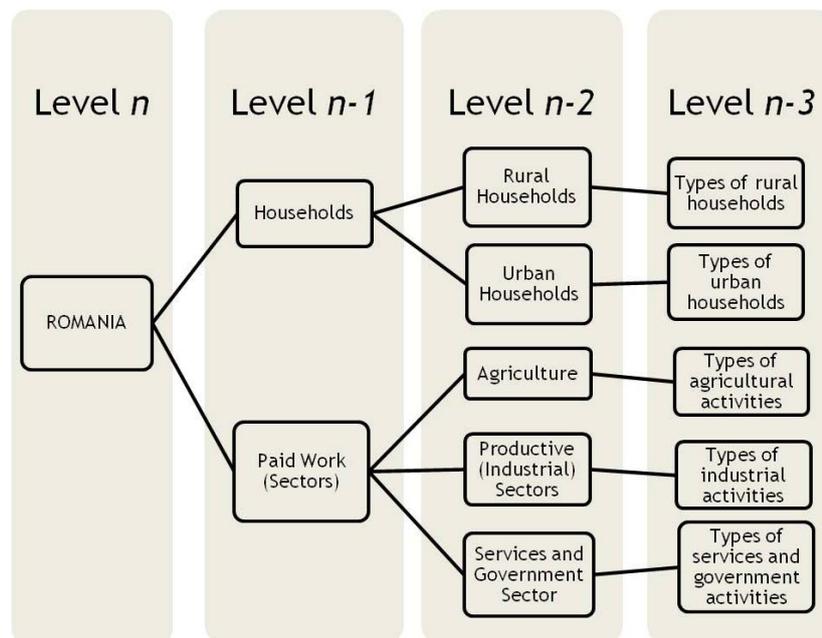
The usefulness of the analytical models that represent similes of actual processes (divested, however, of any qualitative change) cannot be denied. But what matters most in the case of evolutionary structures is the emergence of novelties, of qualitative changes. For these aspects we have no other solution than that of a dialectical approach, involving in particular structural changes. This means to use *words*, instead of numbers, for truly qualitative changes cannot be represented by an arithmomorphic model. [9] (p. 325)

### **3. The connection Georgescu-Roegen's bioeconomics — socioeconomic meta-analysis**

Giampietro and Mayumi, based on Georgescu-Roegen's idea of utility associated to leisure, have built a socioeconomic metabolism meta-analysis method. As a starting point they use the concept of metabolic systems [10]:

Systems able to use energy and material flows to maintain, reproduce and improve their own existing structures and functions. ... Human beings, societies and ecosystems are all metabolic systems. For this reason, the availability of energy and resources, together with know-how and technology, are key factors determining the feasibility and desirability of patterns of societal metabolism (p. 261).

Metabolic systems are a sub-class of the class of dissipative systems [11]. Moreover, life is characterized by self-organization of evolving dissipative systems in relation to multiple hierarchical levels and for different scales of space-time. Interpreting the economy at a macro-level, nationally and internationally, as a metabolic system, Georgescu-Roegen questioned the micro-foundation idea for macroeconomics. His mentor, Joseph Schumpeter (quoted by Georgescu-Roegen, [9], p. 326) states: “It is therefore misleading to reason on aggregative equilibrium as if it displayed the factors which initiate the change and as if disturbance in the economic system as a whole could arise only from those aggregates.” Consequently, the thermodynamic approach for economic processes involves describing the macro-economy using different time scales and interacting hierarchical levels of analysis. Figure 1 presents how the hierarchical meta-analysis can be represented for the socioeconomic metabolism (for simplicity, we do not include the environment):



**Figure 1.** MuSIASEM levels.

Envisioning socio-economic systems as metabolic systems allowed Georgescu-Roegen to create the 'flow-fund' model. The components of the model are 'funds' (elements whose identity remains unchanged during the economic process are defining the system in the model) and 'flows' (produced or consumed during the economic process; are defining the interactions of the system in the model). Flows are, among other, money, energy and materials flows. Related to the concept of 'funds', Giampietro, Mayumi and Sorman give more details: “model fund elements are metabolic converters; they must be able to maintain and reproduce themselves in order to keep their original identity. Thus fund elements entail (1) an overhead, for their maintenance and reproduction, (2) a definition of what should be considered as an admissible input – their identity entails that they can only metabolize a specified type of inputs – and (3) a set of biophysical constraints on the relative pace of conversion of metabolized flows. Their identity can be associated to an expected power level and efficiency of conversion.” ([2], p. 384)

Although the limited extent of this paper prevents us from presenting in more detail the structure and operation of the MuSIASEM model of meta-analysis, it is extremely important to introduce the basic terminology.

Table 2 presents a selection of the most important MUSIASEM intensive variables.

**Table 2.**

*MuSIASEM Intensive Variables*

<b>INTENSIVE VARIABLE</b>	<b>NAME</b>	<b>DESCRIPTION</b>	<b>UNIT</b>
EMR <sub>SA</sub>	Exosomatic Metabolic Rate for Societal Average	Amount of energy used per hour of human time for the whole society	MJ/hr; TET/THA
EMR <sub>HH</sub> , EMR <sub>PW</sub> (EMR <sub>AG</sub> , EMR <sub>PS</sub> , EMR <sub>SG</sub> )	Exosomatic Metabolic Rate for compartments (sectors) households and paid work (agriculture, industrial sectors, services and government)	Amount of energy used per hour in each sector	MJ/hr; ETi/HAi
ELP <sub>SA</sub>	Economic Labour Productivity	Amount of value-added produced per hour of human time for the whole society	Lei/hr; GDP/THA

$ELP_{PW}$ ( $ELP_{AG}$ , $ELP_{PS}$ , $ELP_{SG}$ )	Economic Labour Productivity for Paid Work compartment sectors (agriculture, productive sectors, service and government)	Amount of value-added produced per hour of work spent in each sector	Lei/hr; $GDP_i/H A_i$
$EI_{SA}$	Energy Intensity Societal Average	Energy Consumed per unit of value-added generated	J/Lei; $TET/GDP$
$EI_{PW}$ ( $EI_{AG}$ , $EI_{PS}$ , $EI_{SG}$ )	Energy Intensity for Paid Work compartment sectors (agriculture, productive sectors, service and government)	Energy Consumed per unit of value-added generated for each sector	J/Lei; $ET_i/GDP_i$
$EE_{SA}$	Energy Efficiency Societal Average	Economic productivity measured in energy terms	Lei/J; $GDP/TET$
$EE_{PW}$ ( $EE_{AG}$ , $EE_{PS}$ , $EE_{SG}$ )	Energy Efficiency for Paid Work compartment sectors (agriculture, productive sectors, service and government)	Amount of value-added produced per unit of energy consumed in each sector	Lei/J; $GDP_i/ET_i$

**Source:** FP7-SSH-2007-1 SMILE. (2009). Report of the Romanian case study, Deliverable 9, WP 3, pp. 6-7 online <http://www.smile-fp7.eu/deliverables/-SMILE%20D9%20Romanian%20case%20study%20report.pdf>

**Exosomatic** energy is the energy used by man outside his body (in the socioeconomic and environmental metabolism). The external metabolism complements the **endosomatic** metabolism that is associated with the energy processed within the human body.

**Human Activity:** is a set of *extensive variables* introduced by [13] to represent the number of hours the population under consideration consumes for performing tasks (**HA<sub>i</sub>**). Starting with the 'flow-fund' model, the MuSIASEM approach is centred on expressing quantities used *per hour* of human activity and not *per person* as in standard economic theory. Productive activities, consumption and leisure occupy all 8760 hours available to each person during a year (24 hours \* 365 days). Multiplied by the number of people in a country is the national fund of available time for one year. **Total Human Activity (THA)** corresponds to the entire

population (*level n*). At the next level (*level n-1*), time is divided between paid employment ( $HA_{PW}$ ) and household activities ( $HA_{HH}$ ). At the third level (*level n-2*), the time paid is divided between activities in different sectors: agriculture ( $HA_{AG}$ ), industrial production ( $HA_{PS}$ ) and business and government ( $HA_{SG}$ ). Time allotted to paid activities in each sector is the product of the number of workers in each sector and the number of hours worked per year:

**THA = Population \* 8760 (hours)**

**$HA_i$  = Persons in sector/type of household  $i$  \* number of hours per week corresponding to that activity \* number of weeks per year.**

**Saturation Index of Human Activity ( $SI_{HA}$ ):** is the share of total human activity (THA) spent for paid activities ( $HA_{PW}$ ):

$$SI_{HA} = HA_{PW}/THA.$$

**Energy Throughput:** set of *extensive variables* indicating the exosomatic energy (in **Joules/year**) consumed at each level ( $ET_i$ ). For level  $n$ , entire country, **Total Exosomatic Throughput (TET)** represents the final energy consumption (in Joules/year).

**Saturation Index of Exosomatic Energy Throughput ( $SI_{ET}$ ):** is the share of total exosomatic throughput (TET) consumed for paid activities ( $ET_{PW}$ ):

$$SI_{ET} = ET_{PW}/TET.$$

**Exosomatic Metabolic Rate (EMR):** is the exosomatic energy consumed for one unit of human activity. At level  $n$ , Exosomatic Metabolic Rate on Average for Society ( $EMR_{AS}$ ) is the ratio between TET and THA. Exosomatic Metabolic Rate for compartment/sector  $i$  ( $EMR_i$ ) for lower levels –  $n-1$ ,  $n-2$  and others – is the ratio between  $ET_i$  și  $HA_i$ .

This set of variables is extremely important since it allows for comparisons among various hierarchical levels of the same system or for the same level but for systems of different sizes. For example, it is possible to compare  $EMR_{AS}$  for USA to that of Cyprus, or among the  $EMR_i$  for different types of households, villages, or provinces independently of the relative size of the systems they belong to [14]:

$$EMR_{AS} = TET/THA$$

$$EMR_i = ET_i/HA_i$$

The concept of bio-economic pressure (PBE) gives access to the complex meta-analysis of societal evolution using MuSIASEM type scenarios based on:

The existence of a link between changes in the economic performance of an economy and changes in the metabolic pattern of society. An increase in the monetary flows within the economy having the goal of increasing the “enjoyment of life” of the members of a society induces, as a side-effect, an increase in the intensity of the throughputs of matter and energy per hour of labour in the “productive sectors” of the economy. The label “productive sectors” includes the primary sectors (agriculture, forestry, fisheries, energy and mining) plus the secondary sector (building and manufacturing). In plain terms this means that a richer society will demand more services and will work less because of ageing, increased education and leisure time. Facing these changes the productive sector must be able to supply a larger amount of products, energy and materials to the rest of society using only a very limited amount of work hours ([2] p. 382).

#### **4. Georgescu-Roegen’s bioeconomic program**

MuSIASEM – complex meta-analysis method for the economic process – is extended and improved by its creators Mario Giampietro and Kozo Mayumi [16] [17] [18] [2] [10] and an increasing number researchers, from all continents, apply it. As a result, economic thinking and practice constantly advance bringing to reality the bioeconomic program proposed by Nicholas Georgescu-Roegen more than 35 years ago.

Georgescu-Roegen’s 'minimal' bioeconomic program is presented, among others, by Gowdy and Mesner [18]:

1. The complete prohibition of weapons productions, thereby releasing productive forces for more constructive purposes;
2. Immediate aid to underdeveloped nations;
3. Gradual decrease in population to a level that could be maintained only by organic agriculture;
4. Avoidance, and strict regulation if necessary, of wasteful energy use;
5. Abandon our attachment to “extravagant gadgetry”;
6. “get rid of fashion”;
7. Make goods more durable and repairable;

8. Cure ourselves of workaholic habits by rebalancing the time spent on work and leisure, a shift that will become incumbent as the effects of the other changes make themselves felt. ([18] p. 151)

In his essay-obituary for the death of Georgescu-Roegen, Herman Daly [20] details what should be changed in introductory economics textbooks to be in line with the new paradigm proposed in *The entropy law and the economic process*. Daly's answers are another impetus for further analysis.

- (1) The '*circular flow diagram*' "representing the economic process as an isolated circular flow from firms to households and back again" should be substituted "with a different pre-analytical vision: namely, a diagram showing the entropic throughput in bold solid lines as a one-way flow from environmental sources, through firms and households, and back to environmental sinks. The circular flow would be depicted as a faint dotted loop from firms to households and back again. No economy can conceivably exist without the entropic flow, while it is easy to conceive of an economy with no circular flow – e.g., an economy of self-sufficient peasants engaging in no exchange." (p. 151)
- (2) "In the revised text the special topic chapters on *natural resources and environment* (usually tacked at the end of the book) would probably not exist because no longer be "special topics", but would be integrated into the very centre of economics." (p. 152)
- (3) On '*continuous economic growth (in real GNP)* as the norm of a healthy economy, and the main goal of economic policy' "The circular flow can theoretically grow forever because abstract exchange value (debt, purchasing power) has no physical dimension. But growth in the entropic flow encounters the physical barriers of depletion, pollution, and ecological disruption... in the new paradigm increasing depletion and pollution become expected, necessary consequences of economic growth, not surpassing externalities as viewed from the circular flow paradigm." (p. 152)
- (4) "*Technologies* that squeeze more welfare (more life enjoyment) out of a given entropic flow become more interesting than technologies that simply increase the volume of throughput. Our chapter on Technology will stress the point that the former

- technologies benefit the future as well as the present, while the latter benefit the present at the expense of the future.” (p. 152)
- (5) *Poverty* “In addition to highlighting *intergenerational conflicts*, our chapter on distribution would point out that the “miracle of compound interest” can no longer be appealed to as the way to grow everyone in the present generation out of poverty. *Growth* cannot for ever substitute for redistribution and population control in fighting poverty.” (p. 153)
  - (6) “...not hold out the vision of *development* as a worldwide generalization of the U.S. standard of living. ... The new concept of development would not be virtually synonymous with growth in real GNP as it is today, but would emphasize population control, limits to inequality in distribution, and production for sufficiency in basic needs. The idea that poor countries can simply grow their way out of poverty and debt by spinning their circular flows of exchange ever faster would itself be retired from circulation, along with other Ponzi schemes.” (p. 153)
  - (7) “National income accounting... would be expanded to include some measured index of the entropic flow.” (p. 153)

## **5. Institutions and economics**

Georgescu-Roegen [1] also insisted that economics is one of the social sciences and the economic process cannot be understood outside the social and institutional context, while the general equilibrium framework of neoclassical welfare economics was borrowed from classical [9]. Moreover, Georgescu-Roegen [6] pointed out that trying to build economics in a manner similar to classical mechanics has led to ignoring the endogenous nature of preferences:

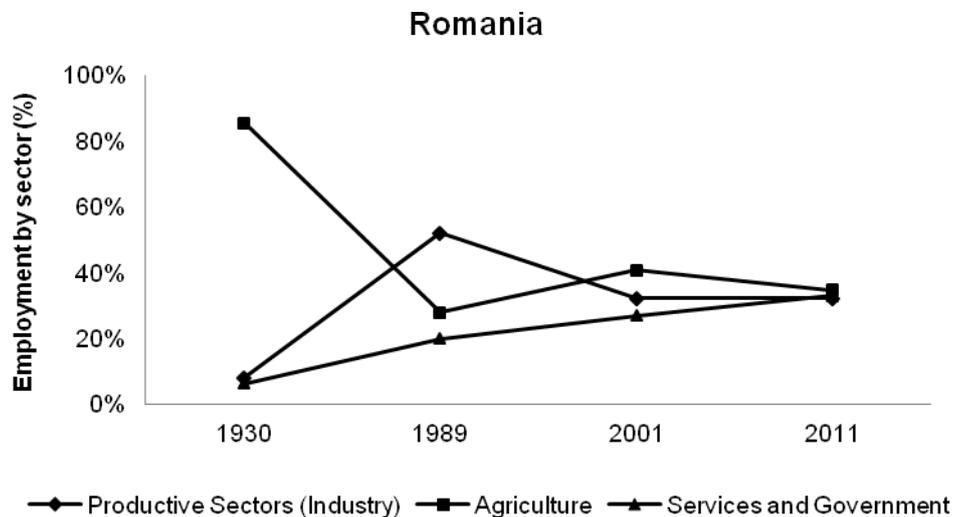
It is all right for physics to trust only what is amenable to sense-perception, i.e., only observables, because that is the sole contact we have with the outside world. It is equally understandable for physics to treat as fiction and view with mistrust the unobservable it had to invent in order to unify into one picture disparate observables and thus simplify its logical foundation. But there is absolutely no reason for economics to treat as fiction the very springs of economic action – wants, beliefs, expectations, institutional attitudes etc. For these elements are known to us by immediate acquaintance, that is, more intimately than any of the economic “observables” – prices, sales, production, and so forth. [14] (p. 119) The

obvious conclusion is that if economics is to be a science not only of “observable” quantities but also of man, it must rely extensively on dialectical reasoning. [14] (p. 120)

Georgescu-Roegen believed that neoclassical economics was formulated to describe the behaviour of Western cities and is not universally applicable. Therefore, development policies should be adapted to the situation. Even if his criticism was made, more than fifty years ago, targeting both Marxist and neoclassical economic theories [4], it is still accurate. None of these theories have taken into account the institutional differences between capitalist and non-capitalist (peasant) economies.

Development economics, making the best use of the standard economic toolbox to address the differences between developed and developing countries and to seek practical ways to enable and support the growth of the latter in order to raise the standard of living for so many people in need. After decades of efforts, the results are not as good as expected while the flaws in the theory can explain it.

One simpler but thought-provoking example is in Figure 2 – depicts the major structural changes that took place in Romania over the past eighty years. Only one variable is presented, the share of total population working in agriculture, industry, and services and government.



**Figure 2.** Occupied population by sectors in Romania 1930-2011.

**Source for 1930-2001 data:** Polimeni, R. I. & Polimeni, J. M. (2007). Multi-Scale Integrated Analysis of Societal Metabolism. *The International Journal of Interdisciplinary Social Sciences*, 2 (2), pp. 41-52.

**Source for 2011 data:** Statistics on the labour force survey in households (AMIGO).

Currently, one of the most politically charged issues, and not only in Romania but for the whole European Union, is rural development. Romania is only one of the Member States with a large and extremely vulnerable rural population. European Union basic principles such as promotion of social justice and protection, sustainable development, aiming at full employment and social progress, and a high level of protection and improvement of the quality of the environment, cannot be achieved if policies are designed based on a theory that is not universally applicable. Only perpetual post-factum policy corrections can be employed and no real pro-active policies.

## **6. Concluding comments**

Georgescu-Roegen's thermodynamic paradigm shift in economics gave birth to a new method of socioeconomic and environmental meta-analysis. The paper introduced the rationale and presented a brief overview of the related conceptual framework. The bio-economic paradigm promoted by Nicholas Georgescu-Roegen and the related method of multi-scale integrated analysis of societal and ecosystem metabolism (MuSIASEM) are presented. Also, it is argued why the concept of 'institution' (which at the macro-level becomes 'culture') is extremely important for the bioeconomic meta-analysis unlike for standard welfare economic theory that guided economic development and poverty eradication policies.

As a consequence, the discussion regarding household's (viewed as one of society's basic institutions) vulnerability, its evolution (and not only for the case of Romania) and the possible solutions could be centred on the socioeconomic and environmental meta-analysis integrating multiple aspects which are (or are lacking from) the foundation of economic theory that led to the modern lifestyle.

Unfortunately, modern lifestyle fights against nature and it is out-of-balance due to over-production and excessive consumption to conspicuous (useless) consumption. Moreover, the unsustainable socioeconomic system threatens to completely replace the traditional society that is sustainable, durable and provided during history a balanced and healthy way of life.

One outcome of the thermodynamic approach to economy is, among other things, the development of a society that encourages an agriculture integrated and in balance with the rest of the ecosystem (producing a minimal amount of waste) combined with the encouragement through education of a lifestyle that promotes a good health.

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