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The unsustainability of sustainability: a new perception of applied ecology against the granfalloon's mission

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Abstract

The unsustainability of sustainability wants to underline the improper and widespread use of a complex concept that cannot be trivialized through the proposal of technological solutions. Although technological solutions represent "comfortable" tools for social reassurance, the risk is a social drift generated by the phenomenon of the "granfalloon". Behind the technological solutions there are new market proposals, which have nothing to do with the real resolution of the sustainability of the global socio-economic system. The perception of the whole socio-economic system as a single metabolic socio-ecological system, makes us interpret the role of technological solutions differently. The knowledge we have gained over the last 50 years on the functioning of natural systems represent consolidated bases for interpreting and providing solutions on the sustainability of mankind. This perception, while providing uncomfortable solutions, should change the perception of applied ecology within the academy community. Therefore, applied ecology no longer as a study of human effects on the ecosphere, but as a discipline that teaches mankind how to structure its socio-economic metabolism compatibly with the constraints imposed by the ecosphere.

Keyword: Sustainability; MuSIASEM; Applied Ecology; Jevons' paradox; Uncomfortable Knowledge

Riassunto

L'insostenibilità della sostenibilità vuole sottolineare l'uso improprio e diffuso di un concetto complesso che non può essere banalizzato attraverso la proposta di soluzioni tecnologiche. Sebbene le soluzioni tecnologiche rappresentino strumenti "comodi" di rassicurazione sociale, il rischio è una deriva sociale generata dal fenomeno del "granfalloon". Dietro le soluzioni tecnologiche ci sono nuove proposte di mercato, che nulla hanno a che fare con la reale risoluzione della sostenibilità del sistema socio-economico globale. La percezione dell'intero sistema socio-economico come un unico sistema metabolico socio-ecologico, ci fa interpretare diversamente il ruolo delle soluzioni tecnologiche. Le conoscenze che abbiamo maturato negli ultimi 50 anni sul funzionamento dei sistemi naturali rappresentano basi consolidate per interpretare e fornire soluzioni sulla sostenibilità delle attività umane. Questa percezione, pur fornendo soluzioni scomode, dovrebbe cambiare la percezione dell'ecologia applicata all'interno della comunità accademica. L'ecologia applicata, quindi, non più come studio degli effetti dell'uomo sull'ecosfera, ma come disciplina che insegna all'umanità come strutturare il proprio metabolismo socio-economico compatibilmente con i vincoli imposti dall'ecosfera.

Parole chiave: Sostenibilità; MuSIASEM; Ecologia Applicata; Paradosso di Jevons; Conoscenza Scomoda

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Introduction

The concept of sustainability in the last decades has become part of the social lexicon: is it used in an appropriate way? This question is pertinent, since in many contexts the word, and the concept it carries with it, appears misused as a fashionable word. Such a concept and its application to the development of the social fabric can correspond to what Walter Bryce Gallie (1956) has defined as an "essentially contested concept" (ECC). According to Gallie, a concept is essentially contested if there is agreement on the means and objectives of a concept but disagreements on how to define it, on which units of analysis to use to capture the adaptive capacity, which are the conceptual cornerstones and which methodology of investigation is appropriate. This is what is actually being observed today on the tangled issues of sustainability about which, in my opinion, intense semantic fantasy activity is in full force. In fact, we all agree on what we want (a sustainable society) but not everyone agrees on how, because there is no univocal definition, there is no analytical system able to grasp the complexity and adaptive capacity of the system we observe, in the final analysis not everyone observes the same thing, since we are looking at a complex system. Can we assign the sustainability label to products, for example, bioplastics, biofuels, energy carrier, or to services, for example, tourism, transport sector? The answer to this question is not simple but, above all, it is not currently answered by the dominant narrative that makes strong reference to technology as a solution tool and to a reductionist science as an evaluation approach.

Trying to synthetize the dominant storyline developed in the recent decades, we can notice it is based around the link between innovation, efficiency and sustainability and it's conducted by a techno-scientistic thinking driven by the wind of the neoclassical economy which can be summarized by the following statement: "we have developed alternative and innovative technologies to modify production mechanisms, compatible with the limits and needs of the ecosphere, to build new forms of income and guarantee the social fabric to maintain the *status quo*". The *status quo* is represented by the unchanged need to ensure economic growth, decoupling it from the limits imposed by the ecosphere (Giampietro, 2019; Renner and Giampietro, 2020). In fact, the most widely accepted and therefore cited definition of sustainability is probably the one produced by the Brundtland report (World Commission for the Environment and Development, 1987). It states that: *sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs*. It is no coincidence that this definition is recognized and cited by the United Nations in the great global project represented by the "Sustainable Development Goals". The UN Department of Public Information cites the Bruntland definition and stresses that, to achieve the objectives, three elements must be harmonized: economic growth, social inclusion and environmental protection. These objectives, in tension with each other, recall the English idiomatic proverb saying: you can't have your cake and eat it too. What is being observed is a blind belief in human technological skills, satisfying gluttony saving the cake. Unanimous chorus was generated among various international bodies (International Monetary Fund, World Bank, United Nations, European Union, Organization for Economic Co-operation and Development, Food and Agriculture Organization) and national governments that amplify strategies as "green growth" and "blue growth" - whether smart, inclusive or responsible - through strategies of circular economy, bioeconomy and digitalization (Giampietro and Funtowicz, 2020). The storytellers of this vision are many, starting with scientists (do they have developed appropriate models of investigations?), passing through politicians and entrepreneurs (do they have been well informed?) to arrive at public figures of the show and culture (do they have the skills to do so?).

Elrich and Holden (1974) defined the impact of human activity on the environment with a simple equation, known as IPAT; it defines the impact as: $I = P \times A \times T$. The equation links the environmental impact (I) to the population (P), to the levels of consumption (affluence, A) and to the impact per unit of resource used, which depends on the use of technology (T). Changing processes toward sustainability, that are developing globally, are exclusively based by developing new technologies, since in the immediate future it is difficult to stem the reduction of the world population and since we continue to rely on

GDP (therefore high levels of consumption) as an indicator of the well-being of the social fabric. The stability of the *status quo* increasingly depends on rosy visions portraying painless solutions to sustainability problems thus avoiding uncomfortable discussions about our current life style and standard of living (Giampietro and Funtowicz, 2020; Funtowicz and Ravetz, 1994).

In the light of those who have developed a different view of the facts, based on the awareness of biophysical limits, these strategies appear to be based on shaky scientific foundations. The belief in the decoupling of economic growth from the use of natural resources through the unlimited power of the invisible hand of the market and human ingenuity - defying thermodynamic laws - should be considered a legend (Giampietro and Funtowicz, 2020). This blind belief in new technologies was defined by Jasanoff and Kim (2015) "the economy of technological promises". The same authors have defined socio-technical imaginaries as the production of collective visions of good and attainable futures through the advancement of science and technology. As discussed by Funtowicz and Ravetz (1994) this narrative about the sustainability of the economy, grounded over the technological promise, has led to a situation akin to the ancien régime syndrome: "a state of affairs in which the ruling elites become unable to cope with stressors and adopt instead a strategy of denial, refusing to process either internal or external signals, including those of danger".

Obviously, this background of facts affects social behavior and generate new governance conflicts, mainly the creation of inflated and unfulfilled expectations about sustainability, precisely the "*granfalloon*" (Giampietro and Funtowicz, 2020). Granfalloon is a term coined from Vonnegut's narrative fantasy, in his book "Cat's Cradle" (1963), within which many people loyal to an invented religion that takes the name of "Bokononism" are stirring. The foundation of this belief is that all existing religions - and therefore also Bokononism - are made up solely of lies. Those who believe in them can have a happy life thus achieving the purpose of Bokononism which, coincidentally, is happiness (the banner raised by the logic of the neoclassical economics). This term entered the lexicon of social psychology as the "paradigm of the minimum group" on which a powerful persuasion technique is based which, as always, addresses emotions and not reason; in other words it describes "a proud and meaningless association of human beings" who imagine (or are manipulated to believe) that they are involved in an important mission. The Granfalloon neatly characterizes this situation were inflated expectations are unfulfilled (Giampietro and Funtowicz, 2020). This social behavior is the reaction of a society that is unable to accept the awareness of the crisis, especially in an era that has made technology the main tool of development. The "global social experiment" emerged from the experience of the Covid, in spite of us, is a demonstration of how much today's society is unable to accept changes, at least in the short time and when the disturbance is unexpected.

On the discourse of sustainability, it seems rather bizarre to record public statements by ecologists of the academy who trust in technology to ensure economic growth, while safeguarding the ecosphere. If I think of the famous assertion of economist Kenneth Boulding - "*Anyone who believes that exponential growth can go on forever in a finite world is either a madman or an economist*" - raises a question about the position expressed by ecologists: have they been phagocytized by economists?

Why do I think these positions taken by some ecologists of the academy are bizarre? Because what they teach from university professorships, through established basic ecology programs, should lead them to think otherwise.

This paper has two main objectives: (i) it intends to direct readers to a correct interpretation of the complex world of sustainability, to avoid the improper use of the concept of sustainability (the unsustainability of sustainability), highlighting some of the critical issues that cannot make technology a saving strategy; (ii) in doing this, I will refer to the consolidated concepts of basic ecology that have been present for years in the study programs of university courses in order to trigger a reflection on the definition of applied ecology: wouldn't it be appropriate to enhance applied ecology as a discipline that allows you to translate the behavior of natural systems towards socio-economic ones, since both are complex adaptive systems that tend to move away from equilibrium like in the thermodynamic systems? The narratives developed in a conspicuous literature, for whose references I refer to Giampietro (2019), suggest a strong analogy between the processes of self-organization of ecological systems and social systems: both require the existence of favorable boundary conditions and the capacity to exploit them.

This paper is organized as follows. Session 1 is an attempt to synthetize the complexity of information to provide a definition of sustainability that is compatible with the need to define the relationship between socio-economic systems and the ecosphere. Session 2 deals with the concept of development from a socio-ecological perspective to demonstrate, only in broad terms, the structural difficulties that the global society of the future will have to face in becoming "sustainable". Session 3 addresses the concept of efficiency to demonstrate that relative efficiency does not affect absolute efficiency, in the case of system aiming for growth. Finally, session 4 draws the conclusions with the aim of providing points for reflection for the readers.

Sustainability rationale deals with the metabolism of socio-ecological system

We can all agree on a fundamental principle of sustainability: the concept of sustainability refers to the human socio-economic system and therefore the science of sustainability deal with this system as its "object of observation".

The etymology of sustainability is sufficiently explanatory (it derives from the Latin verb *sustĭnēre* - *sus* "under" and *tĭnēre* "to keep") to give a concise but effective definition of it: sustainability is the survival ability of the socio-economic system.

The socio-economic system is: (i) a complex adaptive system (Kampis, 1991; Gell-Mann, 1994; Holland, 1995, 2006); (ii) with its own metabolism (Giampietro and Mayumi, 2000a, b; Giampietro et al., 2012); (iii) in its structures and functions it is organized by holons at various hierarchical levels (holarchy) contributing to the so-called emergent properties (Koestler 1967; Giampietro et al., 2006) and therefore observable over different scales (Giampietro and Mayumi, 2018); (iv) it works thanks to cybernetic principles (autocatalytic loop) (Ashby, 1958; Odum, 1971; Giampietro and Mayumi, 2018) and autopoietic properties (systems capable of producing themselves) (Maturana and Varela, 1980; Maturana and Varela, 1992); (v) like all metabolic systems it is a self-organized and open system escaping from thermodynamic equilibrium gathering resources from their environment and dispose wastes into it (Schrödinger, 1967; Nicolis and Prigogine, 1977); (vi) for all these reasons it cannot be observed and treated with reductionistic and deterministic approaches (Ashby, 1958; Giampietro and Mayumi, 2018).

All these characteristics can certainly appear complex, the figure 1 helps to summarize and explain in order to define the socio-economic system. If we observe superficially the socio-economic system, as a "metabolic black box" (Fig. 1a), we can identify two main objectives of the system: (i) move away from thermodynamic equilibrium (purpose 1); (ii) increase its size (purpose 2). In order to achieve these two purposes, the system must be organized with structural elements with specific functions: the holons. Typical examples of holons are the different components of the social fabric (social sectors), each of which is organized in appropriate productive and consumption sectors making possible to stabilize a given metabolic pattern by means of energy and matter. Georgescu-Roegen, after the concept proposed by Lotka (1956), distinguished two distinct forms of metabolism of modern societies: (i) endosomatic metabolism, it refers to the food energy converted inside the human body to preserve and sustain the physiological activity of humans, that in turn are used to preserve and express structural and functional elements of the society, (ii) exosomatic metabolism, it refers to the energy converted outside the human body, but under human control, with the goal of amplifying the output of useful work associated with human activity (e.g., animal power, machineries, stuffs, buildings). The exosomatic metabolism became tremendously important in shaping the identity of modern societies after the industrial revolution (Cottrel, 1955, Hall et al., 1986). In fact, the accumulation of technical capital implied a dramatic increase in the productivity per hour of human activity. This allows the social fabric to use the flows of energy and matter to increase the number of individuals in a population (purpose 2 of figure 1a, equivalent to the reproductive fitness of natural populations) and to use the surplus to generate a parallel flow expressed by monetary added value of goods for economic growth (purpose 2 of figure 1a, represented by economic fitness expressed as GDP). To give an idea of the relative importance of the two types of metabolism of energy, in a developed society the metabolism of endosomatic energy (food) lies in the range of 10-12MJ/day per capita (approximately 2,400-3,000 kcal/day) whereas the metabolism of exosomatic energy (measured in primary energy sources) can be estimated at 500-900MJ/day per capita (or 200-320 GJ/year). Thus, the exo/endo energy ratio typical of developed societies falls within the range 50/1-75/1, while that of pre-industrial societies is

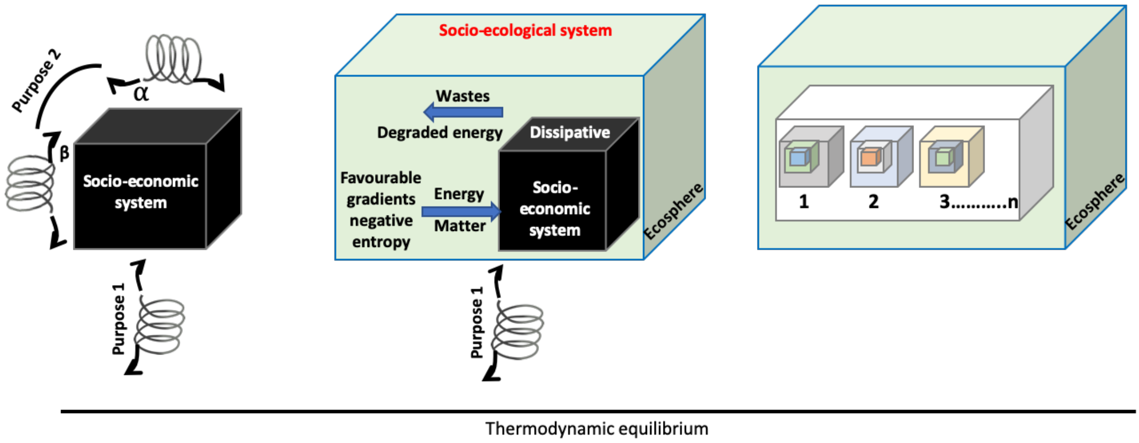

Figure 1: Metabolic perception of the socio-ecological system.

typically only about 5/1 including energy used for cooking, heating and illumination as well as animal power and local sources of mechanical power such as waterfalls or wind (Giampietro and Mayumi, 2009; Giampietro et al. 2012). A suggestive example is from the food systems. Due to the structure and spatial arrangement of the population in developed economy countries, where about 75% of the population lives in cities, large amount of energy is invested, besides food production in agriculture, in other activities such as food processing in the food industry, packaging, transportation, final distribution, home storage and preparation. In modern food systems, the post-harvest sector uses four times more energy than the agricultural sector (Heller and Keoleian, 2000).

The socio-economic system is an open system and as such it is unable to express its metabolic functions without interacting with the external environment, that is the ecosphere (Fig. 1b). Just like the socio-economic system, the ecosphere also aims to escape thermodynamic equilibrium. It succeeds in this task above all through the photosynthetic process of transforming solar energy into chemical energy, as regards the energy supply, and of matter gradients due to bio-geological events. Metabolic processes occur on a local and global scale for the different ecosystems and will be bound by the environmental conditions to ensure the transformation of solar energy and the recycling of the catabolites of their own metabolism, this translates into a steady state condition of the system. The socio-economic system is a dissipative system (Fig. 1b) whose conditions for the survival are determined by an expected pattern of interaction between the dissipative structure, generating a positive entropy flux needed to express its structures and functions and the environment, providing a flux of negative entropy compensating the continuous destruction of favorable gradients by the dissipative structure (Prigogine, 1980). This ineluctable thermodynamic constraint explains the impossibility of guaranteeing economic growth to a system that aspires to be circular and therefore decoupled from the ecosphere (Giampietro, 2019).

Georgescu-Roegen (1971), in his bioeconomic view of the socio-economic system, made a distinction between flows, stocks and funds for describing the process of interaction between the socio-economic system (technosphere) and the ecosphere. (i) Flows are quantities disappearing or appearing over the duration of analysis. They can be further divided into primary flows, requiring primary sources and primary sinks beyond human control and crossing the border between technosphere and ecosphere; and secondary flows that are produced and consumed inside the technosphere and transformed under human control. (ii) Stocks are quantities of accumulated flows that change their identity through the duration of the analysis because of outflows (stock depletion) and/or inflows (sink filling). Hence, in contrast to its use in economic jargon, in Georgescu-Roegen's analytical framework a stock is not a constituent component of the system, but an accumulated flow that changes its size in time. (iii) Funds are agents capable of both producing and consuming flows inside the metabolic pattern of the socio-economic system. Funds do preserve their original identity throughout the duration of the analysis (e.g., the human population, the work force, technological capital, land use). Fund elements define what the system is made of.

For all these reasons, it is no longer correct to speak of a socio-economic system but rather of socio-ecological system. A socio-ecological system can be defined as the complex of functional and structural components operating within a prescribed boundary that is controlled in an integrated way by the activities expressed by a given set of ecosystems (in the biosphere) and a given set of social actors and institutions (in the technosphere) (Giampietro,2018). Socio-ecological systems are open systems depend on their context for maintaining their current level of activity and size of production factor and must be adaptive and anticipatory in order to survive in time because of their option space being constrained by processes beyond control.

If we open the black box, we can appreciate its holarchy (Fig. 1c), that is the different structural and functional components (holons) organized in a multi-level space that guarantee the metabolic identity of the system (technosphere), compatibly with the constraints imposed by the ecosphere. These elements interact according to impredicative relationships and for this reason study approaches capable of considering relation analysis are necessary. The performance of the socio-economic system is tied to the "emergent property" determined by the interaction of lower-level functional components (e.g., economic sectors) made up of structural elements (i.e., expressing the physical processes) (Fig. 1c). The emergent property is represented by the ability of the economy to reproduce and adapt according to its internal values and aspirations, while interacting with its context (Giampietro et al., 2012).

In this framing, it should be quite evident that observing, describing and analyzing a complex system is a very difficult task, especially when different perceptions of the facts and the mobilization of huge monetary resources raises different interests, mainly in form of public subsides. An inclusive observation and, above all, not conditioned by interests must be able to move transversally through the different domains of analysis according to a multi-criteria perception (Fig. 2). The complex socio-ecological system is structured around three wide descriptive domains, environmental, social and economic, each of which can be described and evaluated by multiple dimensions of analysis. Ultimately, it is necessary to represent in the best way a multi-dimensional functional space which is none other than the socio-ecological niche of the metabolic system. We need to find the proper balance between avoiding the excessive simplification of information, which is not able to adequately represent the complex system, and generating an excessive number of information that can prevent a consistent and fast interpretation of the system. In the jargon of MuSIASEM (Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism), an accounting method used to analyze the metabolic pattern of social-ecological systems (Giampietro and Mayumi, 2000a; Giampietro and Mayumi, 2000b; Giampietro et al., 2009), the information space is enclosed inside three performance container: (i) *feasibility* (compatibility with external constraints determined by processes outside human control); (ii) *viability* (compatibility with internal constraints determined by processes under human control); (iii) *desirability* (compatibility with institutions and normative values) (Fig. 2). It is based on maintaining coherence of the quantitative representations generated using different metrics across different scales and dimensions (e.g. economic, social, demographic, ecological, technical).

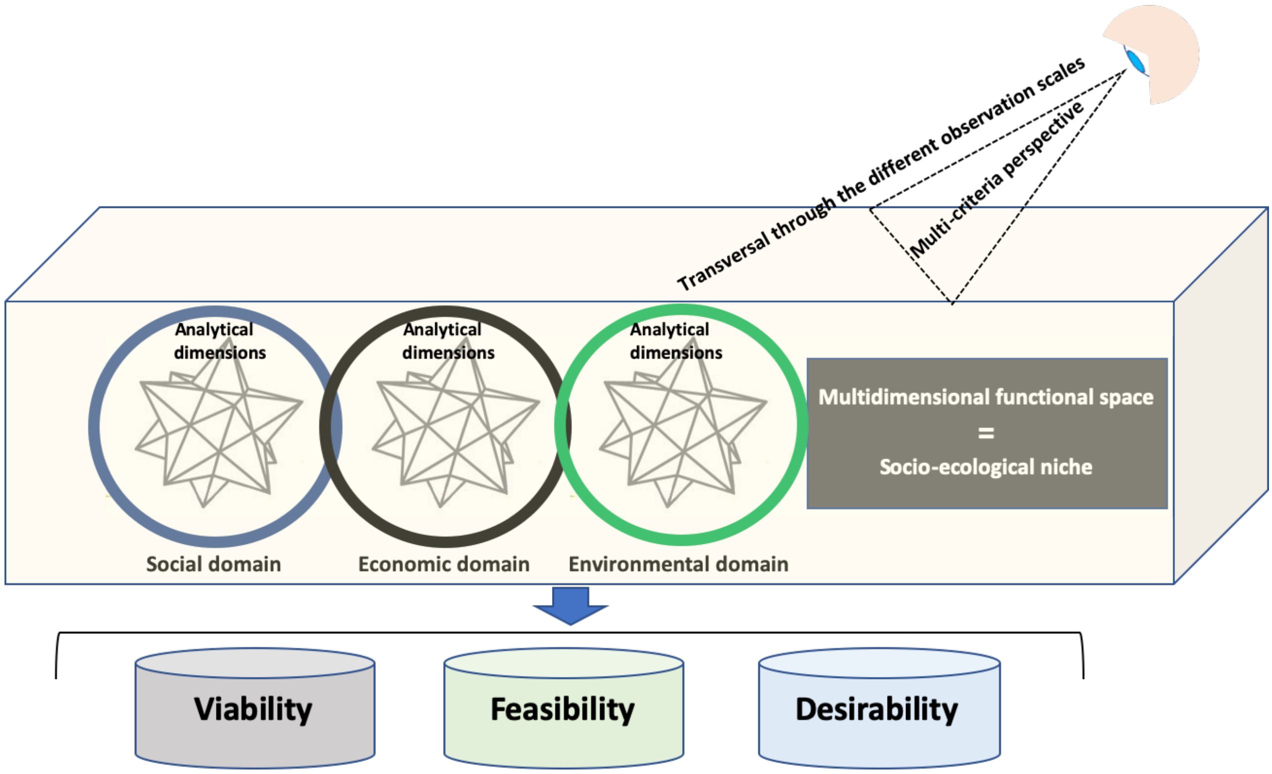

Figure 2: Multi-criteria perspective that allows to observe the multi-domain and multi-dimensional characteristics of the socio-ecological system. The system interpretation outputs are expressed according to the MuSIASEM jargon.

Development to ensure "the needs of the present"

The current structural and functional organization of the socio-ecological system was developed to ensure "the needs of the present" (Bruntland quote). Will a change in the socio-ecological development model still guarantee this societal need? There are many critical issues in the currently proposed "sustainability" models based on technological solutions. Let's try to understand why.

The concept of development is transversal, along the scale of organization of metabolic systems, from single cell up to socio-ecological system. Development is a progressive quantitative and qualitative change of the structural elements of a system which must guarantee specific functions. The temporal sequence of changes is organized over the short, medium and long term, according to the factors that act on the system to induce it to change and according to the system's ability to respond. It is known that in economics the concept of development refers to a society that passes from an economy consisting of primary activities (agriculture and exploitation of natural resources) to an economy focused on industrial production activities and in the tertiary sector with the aim of generating more value added. According to a metabolic perception, the constituent components of a society (i.e. its functional parts guaranteeing its metabolism) can be divided into: (i) the primary sectors (such as agriculture and energy and mining) that represent the catabolic part, taking advantage of favorable gradients provided by nature to supply the required inputs to the rest of society; and (ii) the "other sectors", representing the anabolic part, using secondary inputs supplied by the primary sectors to maintain and reproduce the society. The "other sectors" include: manufacturing and construction, service and government and the household (residential) sector. These constituent components depend on each other in terms of essential inputs. The household sector uses inputs from all the others to reproduce and supply hours of human activity (labor) to the rest; the primary sectors use human activity, primary sources and secondary inputs to provide secondary inputs of food, energy and raw materials to the others; the manufacturing and construction sector uses human activity and secondary inputs to supply technology and infrastructures to the entire society whereas the service and government sector uses human activity and secondary inputs to reproduce institutions and maintain people. According to the MuSIASEM jargon, a distinction between dissipative activities and hypercyclic activities is performed. The concept of hypercycle *vs* dissipative is taken from theoretical ecology of Ulanowicz, where it is used to describe the factors that stabilize complex metabolic networks. An hypercycle is a loop in which the output is larger than the input. Dissipative activities are those that consume biophysical flows and use exosomatic devices, without producing either of them. They are household sector (HH) and service and government (SG). This implies that in the same society we must find other activities that generate a net supply of flows and exosomatic funds, in alternative the flows and exosomatic funds consumed have to be imported (the activities generating a net supply of flows and funds are externalized to other societies). The demand generated by dissipative activities defines the required supply of flows and exosomatic funds. The hypercyclic compartment is composed by agriculture and fishering sector (AF), energy and mining sector (EM) and manufacturing and construction (MC). These compartments have to provide this supply or it has to be integrated by imports. Examples of hypercycle are the agricultural sector, which produces more vegetal and animal products than it consumes, and the energy sector, which produces more electricity and fuels than it consumes and manufacturing and construction producing more exosomatic funds that they consume. For this reason, the primary and secondary sectors can provide net flows of food, energy and exosomatic funds to the dissipative compartments of the society.

Figure 3 shows the societal structure of the Campania Region (ISTAT data for the year 2015) and therefore the respective functional roles of the individual sectors which, with a good approximation, is representative of a developed country. We can observe the limited contribution of the hypercyclic activities, less than 9% in a population of almost six million inhabitants, with an annual investment of working hours of just 1 Giga. Even more limited is the contribution of the catabolic sectors (AF and EM) that take advantage of favorable gradients provided by nature to supply the required inputs to the rest of society. The remaining 91.2% of the population is dissipative, with as much as 72.5% in the household sector. This "picture" of the developed society also helps us to better understand the economic impact caused by the sudden "perturbation of

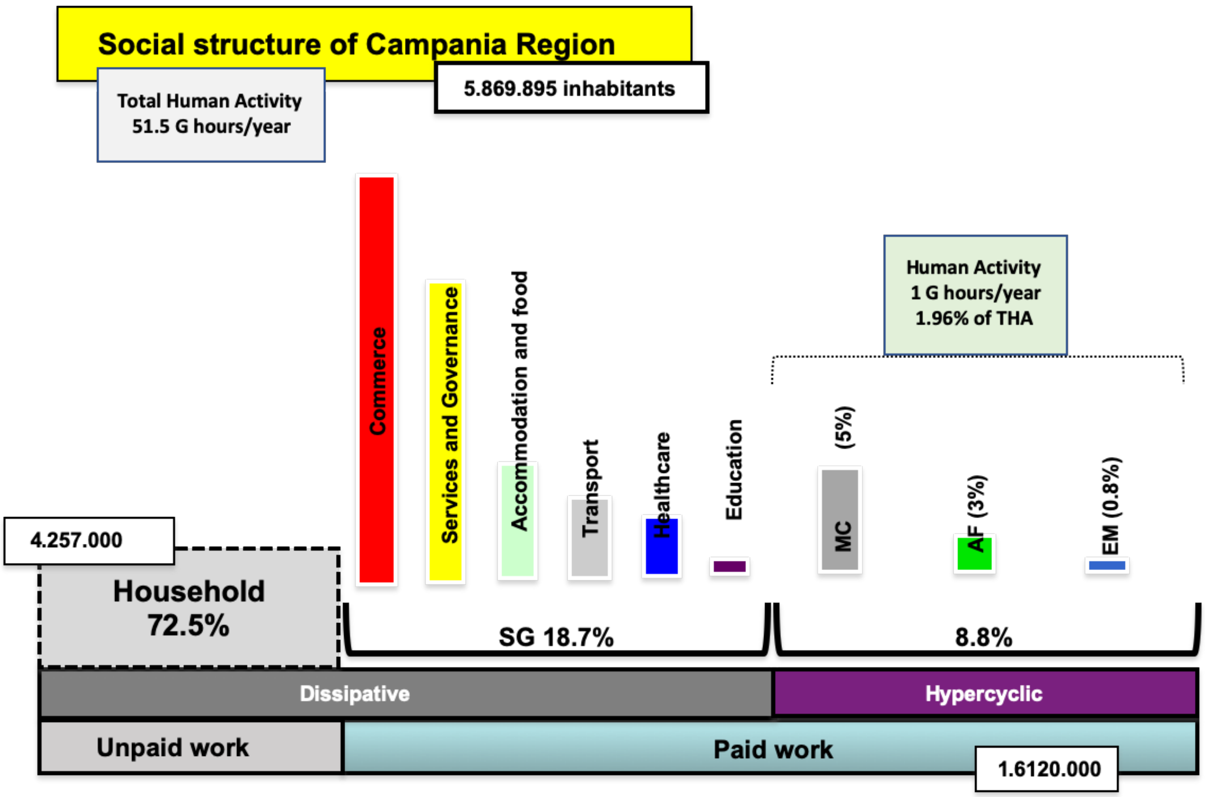

Figure 3: Structural and functional organization of the Campania Region as a representative example of a developed economy society (ISTAT, 2015).

Covid". The economic crisis was not triggered by the lack of production and the main factors that support it (i.e. the availability of energy) but rather by the lack of consumption.

Why has the social structure of the Region been able to take this form? The answer is because society has been able and still can have a high input of energy and matter from the fossil stock (stock flow economy). The current level of productivity of production factors (labor, capital, land) is obtained by altering the pace and density of the flows naturally occurring in the biosphere in managed ecosystems (human land-uses). In doing so, society can express structures and functions (associated with a given rate of positive entropy generation) that would otherwise not be possible (if relying on the negative flux generated by natural processes) (Smil, 2015). The level of power supply is the pivotal feature. Information about power levels, in fact, is fundamental to understand the viability of a societal metabolism and its interdependence with the social structure. The high metabolism of developed societies requires a high power level, which in turn requires a concentrated flow of energy as input. The power density of the energy source, that is to say the rate of energy flux per unit of area (W/m^2), is a key indicator (Smil, 1983, 2003, 2010, 2015). As described in the figure 4, the current developed economy societies (power density in end uses) have been structured on the high power density offered by fossil energy (power density in supply), this is a stock-flow economy mode. The energy supply of modern society predominantly consists of a linear exploitation of non-renewable stocks of fossil energy allowing a density and pace of flows that are orders of magnitude higher than those of circular renewable fund flows, such as biomass (Smil, 2003; Smil, 2015; Giampietro and Mayumi, 2009). The move to circular fund-flow mode, inevitably has to pay the price of low power density. For example, fossil fuels perform power density from 300 to 3000 times better than the biofuel. Fierro et al (2019) assessed a power density value of second generation bioethanol of 0.11 W/m^2. Smil (2015) report values ranging from 4 to 10 and from 0.5 to 1.5 for photovoltaic and wind energy, respectively. Giampietro and Mayumi (2009), argue that developed societies, in order to sustain their level of metabolism, require an energy throughput in the energy sector ranging from 10,000 to 20,000 MJ per hour of labor. Developed societies, thanks to a developed technosphere, gathers and concentrates material and energy forms required for its maintenance and reproduction, to achieve this result they heavily rely on non-renewable energy sources. Inside the technosphere both the densities and paces of flows per unit of societal funds (flow/fund ratios) are much larger than those of the natural flows per unit of ecological funds (flow/fund ratios) in the biosphere (Giampietro et al., 2012). The two graphs in figure 4 explain the progressive increase of urban populations on our planet: the massive use of fossil energy guarantees a high spatial density in the supply of energy inputs that enables a high spatial density in the supply and consumption of food, goods and services.

The combined effect of the changes that took place during the past two centuries in the agricultural and the energy sector of modern economies is well represented in figure 5. This figure clearly illustrates the essence of the industrial revolution that

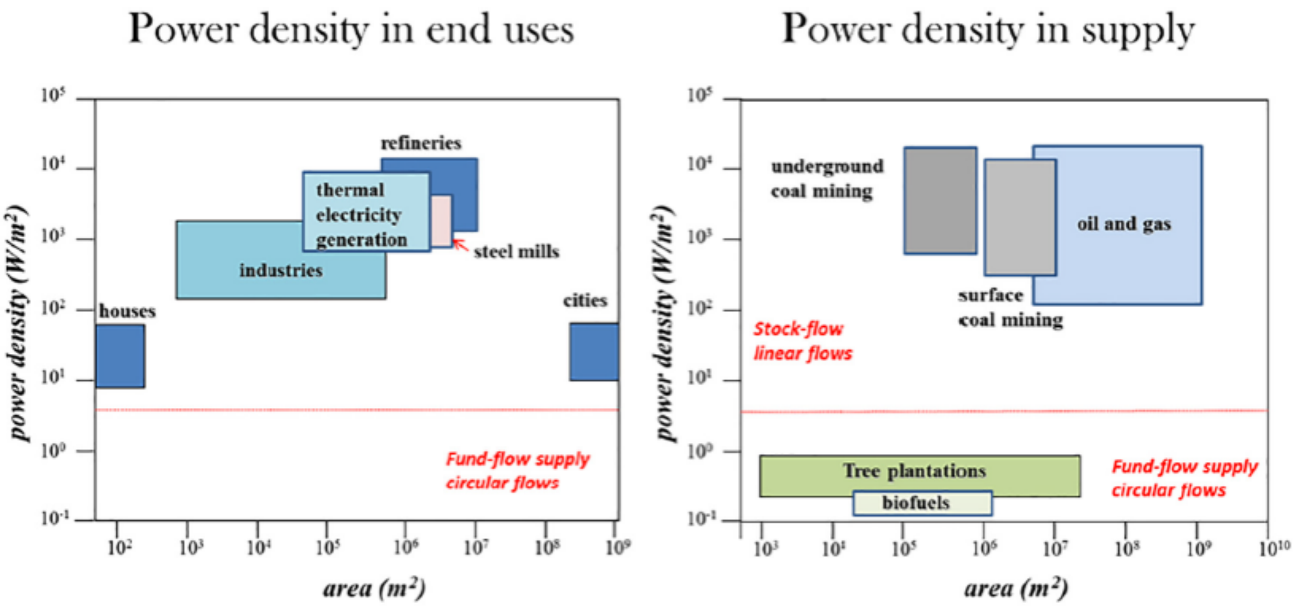

Figure 4: The power density, an indicator of how the current social fabric of developed economy countries depends on energy density (after Smil, 2015).

shaped contemporary society. The mode of energy and food production changed dramatically from being almost entirely based on circular fund-flows (inputs produced and wastes absorbed by ecological funds) to almost complete dependence on linear stock flows (inputs extracted from stocks and wastes overwhelming environmental sink capacity).

The current condition of the socio-economic systems of countries with developed economies is comparable with the condition of eutrophic systems. Eutrophication is a known dysfunction for many aquatic systems, it occurs when the system changes its pattern of receiving and using the main nutrients, passing from a fund-flow mode to a stock-flow mode, causing an explosion of the algal biomass and the consequent accumulation of this biomass in the detritus chain, with a collapse of the oxygen concentration and substantial consequences on fish populations. The observation time scale is important for understanding the normal situation of a system. Who observes a water body in the time scale of one year, may have the ability to recognize the condition of normality (system that works according to a fund-flow mode) compared to a temporary condition of abnormality represented by the system in a phase of eutrophication (system which works in a stock-flow mode). No ecologist would have the presumption to define the eutrophicated system as the condition of normal functioning of the system. The only exception may be in the event that the flow of nutrients becomes chronic, in this case the system will change its structural and functional condition to represent "normality". If in a similar way an observer were limited to observing the socio-ecological system in a short time scale, for example a decade, he would notice the society as described in figure 3, equivalent to the eutrophic society in stock-flow mode which could represent the normal condition. If, on the other hand, the observer would expand the time scale by jumping back two centuries (circular flow mode in Figure 5), he would observe a different social structure,

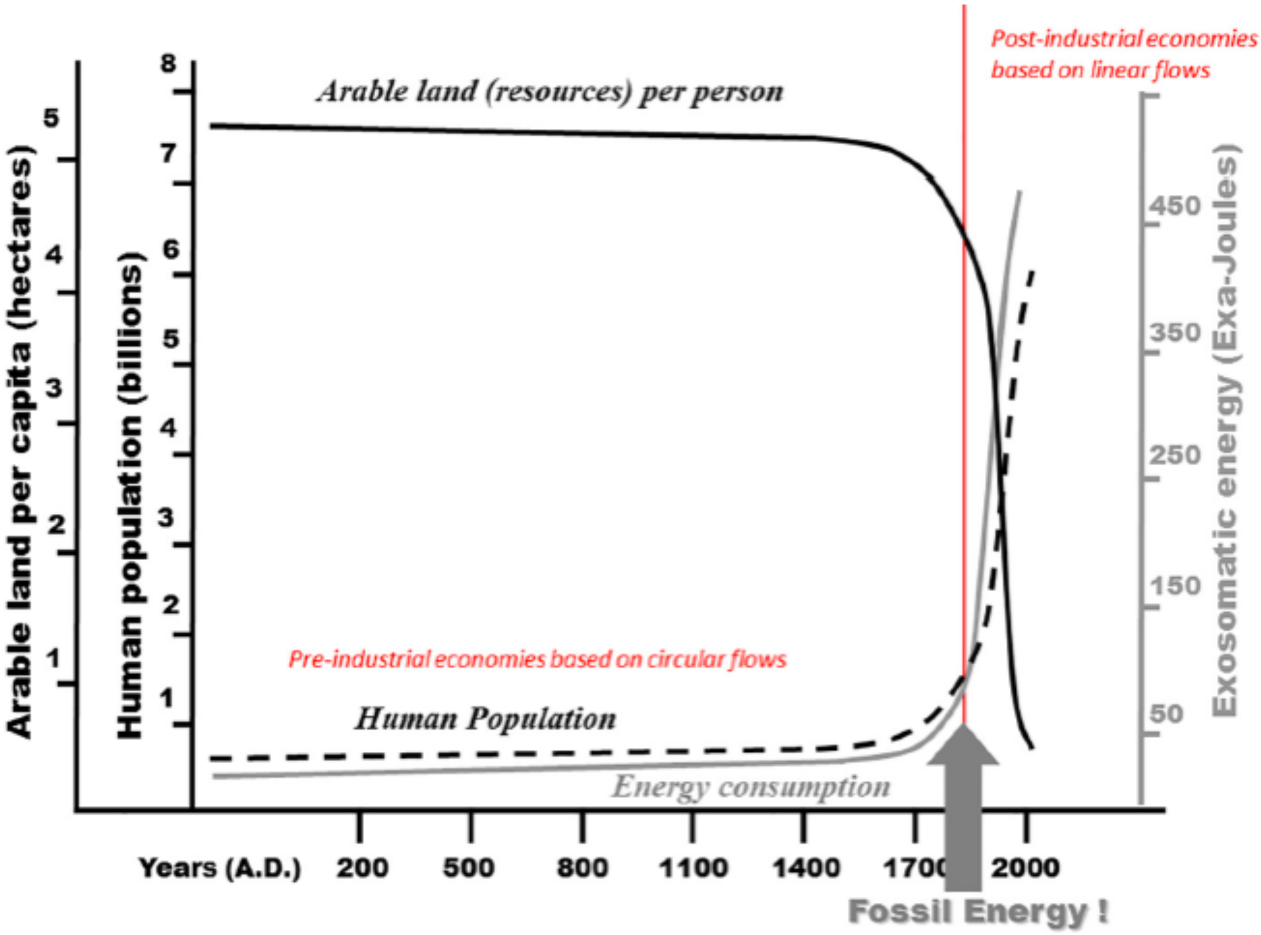

Figure 5: The industrial revolution changed radically the world economy, moving from exploitation of circular flows to dependence on linear stock flows (after Giampietro and Mayumi 2009).

that is to say the society structured on the basis of the constraints imposed by the ecosphere without having the auxiliary input of fossil energy. Which of the two represents the normal condition? It would therefore be difficult for anyone to affirm that a society that decides to become sustainable, thus moving from a stock-flow to a fund-flow mode, can continue to guarantee "the needs of the present".

In the end just listen to Jevons wisdom

Jevons paradox is an implacable sentence against human efforts to aspire technological innovation in ensuring the "sustainable" permanence of current socio-economic system inside the limits imposed by the ecosphere. For those interested in a more in-depth analysis of the issue, I refer to the work of Giampietro and Mayumi (2018). The Jevons Paradox states that, in the long term, an increase in efficiency in resource use will generate an increase in resource consumption rather than a decrease. Jevons, in his books, reported these words:

"Now, if the quantity of coal used in a blast-furnace, for instance, be diminished in comparison with the yield, the profits of the trade will increase, new capital will be attracted, the price of pig-iron will fall, but the demand for it increase; and eventually the

greater number of furnaces will more than make up for the diminished consumption of each. And if such is not always the result within a single branch, it must be remembered that the progress of any branch of manufacture excite a new activity in most other branches" (Jevons, 1865, p. 141).

A classic example, to translate Jevons's claim to modern times, is that of automobile sector. It is known that in recent decades the efficiency of cars has progressively increased such as to reduce the pipe emissions. This improvement has not translated into an overall reduction in emissions due to the tremendous increase in cars production.

I will give another simple example to make it clear how much the choice of "apparently sustainable" solution fail in its intent when applied to the current socio-economic system. If an individual decides to renounce the car for daily transport needs and to opt for the use of the bicycle, this choice will certainly have some advantages: (i) an "environmentally friendly" alternative since there will be no environmental impacts associated with the construction, use and disposal of the car; (ii) substantial economic savings. In a socio-economic system whose monetary value is the main element of performance (economic growth) the individual, who has made this choice, will have the need to allocate the money saved; they will be invested in the purchase of other consumer goods and as such they will always be associated with a dissipative system to produce them. If, absurdly, all the inhabitants of the planet were to renounce the car, this will cause the collapse of the automobile industry. In a system that aspires to economic growth, this will result in the reallocation of flows and funds to other productive sectors. During a phase of economic expansion (upward causation) the insurgence of the Jevons Paradox is practically inevitable. Whether it is because of an uneven distribution of wealth or a strong aspiration for a higher material standard of living, it is unlikely that an energy surplus generated by an increase in efficiency will not be consumed by a society to fix a problem or improve living conditions (Giampietro and Mayumi, 2018).

Briefly, we can state that complex adaptive systems work thanks to two principles: (i) the principle of minimum entropy production and (ii) the principle of maximum energy flux (Giampietro and Mayumi, 2018). They contemplate the functioning of complex adaptive systems, operating away from thermodynamic equilibrium, in an internal and external sphere of observation. By means of the minimum entropy production principle we can understand the efforts developed by each metabolic holon (inside the black box of figure 1c) to improve the efficiency (output/input efficiency). Therefore, we deal with lower hierarchical levels of the system operating under a strict set of constraints within stable boundary conditions. Under these conditions, system performance is well-defined and it is reasonable to assume a steady trend of learning new ways of reducing the required energy and matter input for sustaining a given function.

By means of maximum energy flux principle we can understand the phenomenon by observing the metabolic black box from the outside (outside the black box of figure 1c) and therefore its growth pattern (2 of figure 1a). In brief, if a certain unit of energy enters a system, if some internal metabolic systems use it efficiently, the saved energy will be reallocated to other metabolic elements to ensure the growth of the entire metabolic system. This happens in today's societies because expanding the ability to produce more in order to consume more, maximizing the energy flux, is a common attractor for socioeconomic systems. The principle of maximum energy flux in economics has been formalized in terms of the maximization of profit and welfare (Giampietro and Mayumi, 2018). A quick economic growth implies a continuous expansion of the activities of the metabolic pattern associated with a continuous enlargement of the economic process both in terms of the size of the metabolic system (population, technologies and infrastructures) and in terms of the pace of activity per unit of size (the pace and density of flows of resources consumed per capita). Therefore, we deal with the level of the whole complex adaptive system it is reasonable to expect that it will express as many functions as possible in order to enhance its chances of survival and well-being in its interaction with the context.

The functioning of natural ecosystems on the basis of the two principles set out above, is a well-known topic in the university curricula of basic ecology and appears with the concept of ecological efficiencies. This topic is part of systemic ecology, it explains that the capacity of energy flow along the food chain is conditioned by the metabolic characteristics of each trophic level along the chain, through different forms of transformation efficiencies. Environmental conditions are equally important in ensuring these forms of efficiency. In any case, the distribution of the amount of energy along the two energy and matter bifurcations of ecosystems (the trophic chain and the detritus chain) is, in any case, conditioned by the maximum power energy available to the system, i.e. direct and indirect solar energy and the ability of the different transformers to convert the energy.

Final reflections

The "unsustainability of sustainability" is about the simplified, improper and opportunistic use of this term. In the last two decades, also thanks to the mobilization of huge public funds, the discussion on sustainability has taken on a purely technical shape. The complexity of the facts has been reduced to a simple equation: technological innovation + new economic models = sustainability. According to the narrative, the algebraic binomial can generate new economic wealth by decoupling human being from the constraints imposed by nature. The main actors in this narrative are the old business lobbies that have recycled themselves (ancien régime). Thanks to the sounding board of the media, which they often own, they have spread the mission of the granfalloon.

What has been explained in the previous sessions should clarify that sustainability is about understanding a complex system, both to evaluate it in existence and in development. To avoid that it remains an "essentially contested concept" a systemic view is necessary, that cannot be based on scientific reductionism that allows solving single problems. The Bruntland definition is not robust enough to define sustainability. It prefigures a "virtuous" path of the globalized society but, in fact, does not define sustainability. It indicates a path to follow in time, but it does not tell us whether A in time t0 will remain A in time t1 or will become B in time t1. Even if the statement "*needs of the present*" leaves no doubt, in time t1 A will remain A. Continuing to guarantee the "*needs of the present*" means that it is unlikely that a socio-economic system, that is structured on a stock-flow economic model, continues to be the same when transformed into a fund-flow model. Defining sustainability in a solid and unanimous way is an epistemological necessity to structure the appropriate analytical models capable of providing robust information for the "science of governance". We must not only define the virtuous path about *what we want*; above all we must understand and indicate *how to do it* and *if it can be done* with reference to what we are observing. When we adjective the term "development", we refer to a process of forming a system. In our case the system is represented by the human socio-economic system. "Sustainable" quality refers to what? To who? What are the quality characteristics? This semantic problem arises because in fact, through the concept of sustainable development, the "substance" of sustainability is not defined: that is, how to appropriately define the aspects that characterize that system so that it is sustainable.

A metabolic definition allows to define the relationships between human capabilities to transform energy and matter (technosphere) and the relationships that associate these capabilities with the constraints imposed by the ecosphere. A metabolic perception therefore allows us to define the functional boundaries of the socio-ecological system (socio-ecological niche) in order to evaluate its "*ability to survive*", changing certain characteristics and conditions. When adopting the metabolic view of the whole socio-economic or, through a progressive breakdown, of the different production systems that compose it (multi-scale perception of the different structural and functional holons), inevitably we must understand how each of them interact with the external environment. In this view, the issue of sustainability boils down to the compatibility between: (i) the size and the metabolic pace of the fund elements operating in the technosphere and determining the flux of positive entropy, and (ii) the size and the metabolic pace of the fund elements operating in the biosphere and determining the flux of negative entropy. Put in another way, the identity of the fund elements entails a constraint on the pace and density of the flow throughput both in biosphere and technosphere.

A sustainable economy based on "renewable" flows coming from fund-flow relations that respect and maintain the identity of the funds. Biophysical representation based on the rationale of metabolic systems thus describes the "production factors" as fund elements, contrary to the economic representation in which they are considered stocks. In the view of Georgescu-Roegen, the sustainability of the economic process is not about stabilizing the flows of goods and services produced and consumed in the economy, but about reproducing the fund elements that are associated with the stabilization of the metabolized flows.

Therefore, the question is not just finding a technological solution that reduces environmental pressures (both in the withdrawal of resources and in the emission of metabolic waste), it is a question of understanding whether the new production system satisfies this new metabolic structure to stabilize new flows. Based on the MuSIASEM jargon, it is a question of understanding whether the new production system can survive compatibly with technical and economic constraints (viability), compatibly with environmental constraints (feasibility) and compatibly with the social structure of Figure 3 to ensure that there are no tragic changes for society (desirability). To ensure the current lifestyle, represented above all by the exosomatic metabolism, the socio-ecological system has taken on a particular conformation in its structural parts. A change in the economic modality, leaving the paradigm of economic growth unchanged, could compromise the possibility of guaranteeing the same material lifestyle but would also involve a structural change that could not be desirable for society.

The perception of sustainability not only requires to study how a new technology solves one or two problems, above all, it must understand the functioning of the whole metabolic system: we cannot assign the "sustainable label" to a product or service. Jevons' paradox is an inexorable sentence for all human efforts to produce new innovative technologies. We can also find infinite technological solutions to improve the "relative" sustainability of a single production process, what determines real sustainability is the behavior of the entire socio-economic system (absolute sustainability). Since at the present stage governments continue to trust GDP as a valid indicator for the objectives of a society, the need to rely on the maximum power principle must necessarily exist. It would therefore be difficult for a society that is structured on the availability of high gradients of energy and matter (stock flow mode) to maintain a high GDP by switching to a fund-flow mode with a slowdown in the flows of energy and matter. This change of functional modality will also involve the shift of working hours from the secondary sectors to the primary sectors, a solution that certainly does not satisfy the social desirability of producing high added values. In other words, sustainability is about understanding and anticipating the new identity of the society after changing. Since, the transition from a stock-flow to a fund-flow economy will radically change our social structure and expected functions.

Words are extremely important in understanding what a nation want do. In reference to the EU the words, which reflect the policies for the coming decades, clearly express a change in the management of resources to ensure economic growth. Therefore, the claims that with the green deal, circular economy, bio-based economy, in the next 30 years, the EU will be able to substitute fossil fuel, decarbonize the electricity sector, reduce the environmental pressures, make its agriculture competitive and capable of guaranteeing food security no longer depending on imports, show a remarkable lack of scientific and political understanding of these issues. It is becoming ostensibly clear that the current pattern of economic growth is incapable to solve growing concerns about inequity, environmental protection, dangerous dependence on disappearing resources and on the exploitation of less powerful social ecological systems. To avoid the risk of a collapse in the credibility of the EU system, it is the right time to move from the present class of "yes we can" narratives to the class of narratives "Houston we have a problem" (Giampietro and Funtowitcz, 2020). Proposing solutions for a sustainable socio-economic model today appears to be affected by many critical issues, thus evidence based policy may result in a dramatic simplification of the available perceptions, in flawed policy prescriptions and in the neglect of other relevant world views of legitimate stakeholders. In accepting the "yes we can" narrative, the flip side of evidence based policy prevails, namely policy based evidence. (Saltelli and Giampietro, 2017). A much more comfortable situation for those who want to aspire to funding by following the policy requests.

In a historical phase of large public economic investments many social actors, not least the class of scientists, insinuate their "yes we can" comfortable narrative, both in relation to the policies of the EU on the Green Deal and Blu Growth and in relation to Recovery Fund for post-Covid. It therefore makes us reflect the positions taken by many scholars, including ecologists, in full agreement with the "yes we can" narrative. Ecologists should have the cognitive tools to highlight the criticalities of these political strategies. For this reason, I highlight the need to evaluate the concept of applied ecology differently, no longer as a discipline that evaluates the effects of human pressure on the environment but as a discipline capable of transferring the knowledge of the functioning of natural systems to the functioning of socio-economic systems, which are nothing more than socio-ecological systems. I remember that this path was already paved over half a century ago by the speculative work of Georgescu-Roegen and by theoretical ecology.

On this playground of sustainability, made up of many interests, we are witnessing a dangerous cultural drift. A tangible risk of the "minimum group paradigm" is manifesting with a process of "cancel culture": the exclusion from debates and from funding opportunities for those who profess "politically incorrect" positions because they are not in line with the comfortable narrative of "yes we can". Steve Rayner (2012) describes this phenomenon: "To make sense of the complexity of the world so that they can act, individuals and institutions need to develop simplified, self-consistent versions of that world. The process of doing so means that much of what is known about the world needs to be excluded from those versions, and in particular that knowledge which is in tension or outright contradiction with those versions must be expunged. This is uncomfortable knowledge".

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