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Sustainable and Sustainable Development from a socio-economic Perspective

Discussion Paper 01/2021

RRIL - Responsible Research and Innovation Learning

RRIL working team

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Abstract

The outcome of the Erasmus+ project Responsible Research and Innovation Learning are learning modules to anchor the concept of Responsible Research and Innovation (RRI). This required to develop a coherent concept of what sustainability and sustainable development is and which is the linkage to RRI.

This discussion paper is not a result of an empirical research, but a revision of selected works consulted as policy documents, technical reports, articles and books on sustainability, sustainable development, social sustainability, economic sustainability and environmental and ecological economics. The purpose of this paper was not to provide new evidences, but to clarify basic concepts for the development of a learning programme.

Despite the critics, we advocate for the three-pillar model of sustainable development. We take for grounded the validity of ecological sustainability as the main goal to mitigate the Anthropocene Crisis. We focus on the pillars of social and economic sustainability, underpinning that the social pillar, despite the recent efforts, is the less developed. In the area of economic sustainability, there is an important debate which concerns not only sustainability but also basic assumption of conventional economic approaches. In the background stands the question if the focus lies on economy as an integrated part of the system earth or as a system by its own. In the first case, the question is how economic activities contribute to maintain the earth as an ecosystem in which humanity can live. In the second case, the question is how to maintain economy as a value generation system considering the scarcity of natural resources in the frame of sustainable development.

In both fields, social and economic sustainability, we observe a distinction between weak and strong sustainability, as two extremes of the societal implications of sustainability policies. The weak social sustainability approach support strategies without substantial change in society as a social system and the lowest political intervention as possible. The strong social sustainability approach assumed that ‘real’ sustainability strategies to contribute to solve the Anthropocene crisis will imply a fundamental transformation of society.

Our starting point was that sustainability must be the reference point of RRI due to the Anthropocene crisis. In the conclusion, we argue that RRI should be an integrated part of sustainability as goals reinforcing the social pillar, but also as means to promote a high participation of society in the transformation to a sustainable world, to achieve a high degree of fairness of the transformation and to provide a sustainable ethical framework for science-based social and technological innovations.

Introduction

Working on learning modules for responsible research and innovation (RRI)[1], we took the decision to anchor the RRI in sustainability talking about Responsible & Sustainable Innovation (ReSI). This decision implied to affront the question what sustainability and sustainable development means. For this reason, we decided to work out a conceptual paper on both topics, which we present here as discussion paper. It is not a result of an empirical research, but a revision of selected works consulted. The propose of this paper was not so much to provide new evidences, but to clarify basic concepts for the development of a learning programme.

Today's society is characterised by the *Anthropocene crisis*[2]. The mitigation of this crisis requires, besides political measures, new forms of behaviour and mind-sets. The European Green Deal strategy[3] promotes actions towards the fair transition to a sustainable Society and Economy. This strategy, which strengthen the topic of sustainability already presented in the previous strategies, is the result of the pressure of diverse social movements in combination with the evidence of the climate change and lost of biodiversity provided by science. In the Green Deal strategy, the EU recognises the central role of citizens in the fair transition through the promotion of social innovation towards sustainable mind-sets and behaviour. Implicitly it fosters the expansion of sustainable behaviour developed by social movements in the field of ecological agriculture, ecological products, protection of the biodiversity and combat of the climate change among others. However, for the goals of the Strategy to by fulfilled, the change of the behaviour of the individual citizens is not enough. Instead, the actions of political and business leaders and decision makers are necessary.

For the development of our concept, we try to give answers to two questions:

1) What means sustainability?

2) What means sustainable development?

For this reason, we will first present briefly our understanding of sustainability, followed by a revision of the concept of sustainable development. As the last concept underpins the interrelation between ecology, economy and the society, we come back to the term of sustainability in the discussion on how economic and social sustainability is conceived in the academic debate. As the discussion about economic sustainability is more extended compared to the one of social sustainability and as the project RRIL focused on Economy and Energy, the concept of economic sustainability stands in the centre of this concept paper. At the end of the paper, we will link both

[1] A short introduction to RRI can be found in Krüger et al. (2020) and a longer introduction in Spanish in Krüger (2018).
[2] Introduced by Crutzen & Stoermer (2000) and Crutzen (2002) at the beginning of the 2000s; the *Anthropocene* is a term used originally by physical scientists to describe a new geological epoch where humankind is dramatically altering the functioning of Earth systems and breaching planetary boundaries. The *anthropos* (Greek word for 'humans') are transforming Earth system processes (see Steffen et al. 2011).
[3] The different aspects of the European Green Deal Strategy are outlined in several documents as 'A Clean Planet for all' (EC 2018); 'The European Green Deal' (EC 2019); 'A new Circular Economy Action Plan' (EC 2020a); 'EU Biodiversity Strategy for 2030' (EC 2020b); and 'Stepping up Europe's 2030 climate ambition' (EC 2020c).

concepts with Responsible Research and Innovation, especially with the dimension of public engagement, gender equality and ethics.

Sustainability

Voinov & Smith (1994) observed already in 1994 the absence of common definition of sustainability, despite of the large academic and public debate. This is confirmed by Grigoroudis et al. (2012) and Johnson et al. (2018: 6), who consider the term "*is now so ubiquitous across social, environmental and economic domains as to seemingly no longer require definition for operationalization*". Ben Eli (2018) observes that it is used as a buzzword, whose application in many areas blurs its meaning. Voinov & Smith (1994) suggest to use operational and reduced definitions as:

1. the system does not cause harm to other systems, both in space and time;
2. the system maintains living standards at a level that does not cause physical discomfort or social discontent to the human component;
3. within the system life-support ecological components are maintained at levels of current conditions, or better.

Table 1: Planetary boundaries	
Climate change	(i) Atmospheric carbon dioxide concentration (parts per million by volume) (ii) Change in radiative forcing (watts per metre squared)
Rate of biodiversity loss	Extinction rate (number of species per million species per year)
Nitrogen cycle (part of a boundary with the phosphorus cycle)	Amount of N2 removed from the atmosphere for human use (millions of tonnes per year)
Phosphorus cycle (part of a boundary with the nitrogen cycle)	Quantity of P flowing into the oceans (millions of tonnes per year)
Stratospheric ozone depletion	Concentration of ozone (Dobson unit)
Ocean acidification	Global mean saturation state of aragonite in surface sea water
Global freshwater use	Consumption of freshwater by humans (km3 per year)
Change in land use	Percentage of global land cover converted to cropland
Atmospheric aerosol loading	Overall particulate concentration in the atmosphere, on a regional basis
Chemical pollution	For example, amount emitted to, or concentration of persistent organic pollutants, plastics, endocrine disrupters, heavy metals and nuclear waste in, the global environment, or the effects on ecosystem and functioning of Earth system thereof.
Source: Rockström et al (2009a)	

From a system perspective, Ben Eli suggests to define sustainability as "*the integrity and health of its biosphere, and the future wellbeing of humanity*" (2018: 1339), which he later refined as

followed: "*A dynamic equilibrium .in the process of interaction between a population and the carrying capacity of its environment such that the population develops to express its full potential without producing irreversible adverse effects on the carrying capacity of the environment upon which it depends*." (*ibidem* 1340)

Although some still denies the ecological crisis, from a scientific perspective there is no doubt about the *Anthropocene crisis.* The scientific debate about ecological sustainability indicates that the question is no longer how to avoid degradation of the natural environment, but how to avoid abrupt environmental changes with serious consequences for the humanity. We take here as example the work of Rockström et al. of the year 2009, in which they propose planetary boundaries or thresholds defining "*the safe operating space for humanity with respect to the Earth system and are associated with the planet's biophysical subsystems or processes*" (Rockström et al 2009a: 472). They call the attention to the fact, that the reaction of the different ecological subsystem could be abrupt and that the subsystems are interrelated, so that "*if one boundary is transgressed, then other boundaries are also under serious risk*" (*ididem* 474). They defined boundaries for nine dimension (Table 1). They observed that regard climate change, biodiversity loos and interference with the nitrogen cycles, the thresholds has been transgressed still in 2009.

In the following parts, we will discuss more in detail the conceptions of economic and social sustainability.

Sustainable Development

Academic discussion about sustainable development is complex and broad. A main reference is the so-called Brundtland Report of the year 1987 (WCED, 1987). It defines sustainable development as: "*Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities.*"

From academic side, this definition has received critics as ambiguous or vague (Bartlett 2006: 10; Connely 2007), which is the case of almost all terms used in the intersection of academy and policy. For this ambiguousness it could become a catch-word used in different environments (Grossman 2012). The term has also received critical comments as it interprets sustainability framed in a mainstreaming economic approach advocating for economic growth in all countries as a requisite for ecological, economic and social sustainability:[4] Martinez-Alier (2015) argues that the historically the term sustainability is not rooted in the respect of the ecological environment, but "*how monetary profits could be made from nature by obtaining optimum sustainable yields from tree plantations.*" This business orientation is still present in the actual

[4] It is important to underpin that the critics is oriented to the consideration that growth in **all** countries as necessary. Many of the critics considered that growth in the less favoured countries is necessary for a fair transition, but not in the rich countries.

use of the term. Jacobs (1999: 24) argues similar stating that, "*the vagueness of the definition … allows business and 'development' interests (and their government supporters) to claim that they are in favour of sustainable development when actually they are the perpetrators of unsustainability*".

This rejection is often linked to the thought that the care of the ecological environment is incompatible with economic growth. Dematerialisation and decarbonisation could not be achieved with growth policies.

Also the use of the term development has been criticized considering the 'development' implicitly promotes the idea a certain kind of socio-economic change taking as reference the so called 'Western World'. For this reason, degrowth approaches use the term flowerishing. Banerjee, B. (2003: 144) support this critics arguing "*that sustainable development, rather than representing a major theoretical breakthrough, is very much subsumed under the dominant economic paradigm. As with development, the meanings, practices, and policies of sustainable development continue to be informed by colonial thought, resulting in disempowerment of a majority of the world's populations, especially rural populations in the third world.*"

In spite of the critics, we maintain the reference to sustainable development for the development of out learning module on Responsible & Sustainable Development, as it is one guiding vision for global, national, regional and local policies in reference to the Sustainable Development Goals.

For our proposal, it is more relevant that the policies of sustainable development, e.g., the so called Millennium Development Goals (MDGs), had limited effectivity in the 1990's and 2000s. "*By early 2010s, it had become evident not only that the MDGs were not going to be sufficient even if they were successful by their own standards but that seeing environmental degradation as a separate concern that can be dealt once the development question is resolved would no longer be tenable*" (Arsel 2020: 10). For this reason, a next step was taken with the elaboration of the 2030 Agenda for Sustainable Development and the respective Sustainable Development Goals (SDGs). Without going into the debate about the adequacy of the 2030 Agenda to achieve full sustainability, a resume would highlight the following elements:

- Living without harming the environment, that means living within limits.
- Understanding the interconnections among economy, society, and environment.
- Equitable distribution of resources and opportunities.

The Agenda is based on a three pillar model of sustainability with the interconnected domains: ecology, economy and society. It assumes that:

- humanity can have neither an economic nor social well-being without the ecological environment.
- these domains are interwoven.
- its requires actions, which work in all three domains under the overarching perspective to maintain alive the ecosystem Earth (see Dawe & Ryan 2003: 1459).[5]

[5] Some works and initiatives consider or add others domains, e.g., the institutional (Spangenberg et al. 2002; Turcu 2013), cultural (Soini & Birkeland 2014), technical (Hill & Bowen 1997), religious-spiritual (Burford et al 2013) and

Taking as reference point the prevention or mitigation of the environmental degradation and the avoidance of transgression of more planetary boundaries, we propose the following operational definitions:

- Environmental sustainability is the ability to maintain rates of renewable resource harvest, pollution creation, and non-renewable resource depletion indefinitely without degradation of the environment and avoiding the transgression of planetary boundary and the break-down of ecological subsystems.
- Economic sustainability is the ability to support a defined level of economic re-production indefinitely without environmental degradation avoiding the transgression of planetary boundary and the break-down of ecological subsystems.
- Social sustainability is the ability of a social system, such as a country, to function at a defined level of social well being indefinitely without environmental degradation and avoiding the transgression of planetary boundary and the break-down of ecological subsystems.
- To which we could add an operational definition of the interrelation between economic sustainability and social impact in the sense that sustainable economic policy must be oriented to an equal distribution of the social benefits and loss overall related to environmental risks.

Social sustainability

The social sustainability is the least defined and developed domain of the three pillar model of sustainability. It is a common understanding, that there is no universally accepted definition of the term.[6] There is a large set of topics handled under this label, such as basic needs satisfaction, well-being, social justice, social cohesion, social capital, participation, employment, income, and safety, but also good governance.

Here is not the place to go into details of the wide range of definitions and conceptual orientation. We present briefly some examples from the recent discussion aimed at defining social sustainability and advancing its conceptualisation (Table 2). We only want to underpin, that a shared opinion is that the statement of the provided in the Brundtland Report: 'Development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987, p. 40) is a reference point of social sustainability.

Now we focus on the works of Opielka (2016 and 2017) and Valance et al. (2011), who elaborate a categorisation of the different strands and come back later to the recent proposal of Eizenberg & Jabareen (2017).

global domain (Raskin et al. 1998). Without going into the discussion of the the relevance of these other domains, our article centred on the interrelation between social, economic and ecological sustainability as the fundament of the fair transition to a sustainable Europe.

[6] For instance, Lui et al. (2017) observed a lack of theorization and of an integrative conceptual framework, so that the concept of social sustainability is still ambiguous and vague.

Table 2: Selected definition and concepts of Social Sustainability		
Authors	Key Dimensions	Definition
Harris (2000)	Social Equity	Social equity, the fulfilment of basic health and educational needs, and participatory democracy are crucial elements of development, and are interrelated with environmental sustainability
Jabareen (2008)	Equity	The concept of equity represents the social aspects of SD. … The concept of equity itself encompasses various concepts such as environmental, social and economic justice, social equity, equal rights for development, quality of life, equal economic distribution, freedom, democracy, public participation and empowerment. (183)
Cuthill (2009)	Social Capital Social Infrastructure Social Justice + Equity Engaged Governance	The discussion focuses primarily on 'social' in development and is based on the following premises. 1. Environmental problems are first and foremost social problems. You manage the people who impact on the natural environment, you do not per se manage nature itself. 2. Economics is meant to serve people, rather than a view that people serve economic interests. This is especially relevant in relation to equitable distribution of resources. These two factors are reflected in the social sustainability framework, which describes an interdependent and self-reinforcing relationship between four key components: (1) social capital, (2) social infrastructure, (3) social justice and equity and (4) engaged governance
Woodcraft (2015)	Social and cultural life Voice and influence	Social sustainability is a "p*rocess for creating sustainable, successful places that promote well-being by understanding what people need from places in which they live and work*" (133)
Renn (2017)	Equity Social-cultural identity Mutual trust Basic needs	Social and cultural sustainability is "*the preservation of human identity within the framework of communities and society. In the future, too, people must have the opportunity to build sustainable relationships on the basis of mutual trust, to see themselves as part of a meaningful culture and to find orientation within the framework of social systems of order, as well as to find*

Table 2: Selected definition and concepts of Social Sustainability		
		institutional possibilities for the peaceful resolution of conflicts. The functions of social systems include motivation through fair distribution schemes, solidarity with other people, cultural identity building and sense-making as well as ensuring norms and laws to regulate behaviour. Above all, it is about the institutional safeguarding of basic needs that are constitutive for human development" (own translation).
Missimer (2017)	Diversity Learning Self-organisation Trust (social capital)	Sustainability is about the elimination of basic mechanisms of systematic degradation of essential aspects of both the ecological and the social system. Such basic mechanisms can then act as exclusion criteria for re-design, thereby serving as boundary conditions within which the system can continue to function and evolve, outside of which it cannot. In that sense, the definition of sustainability is not about a flourishing of human life or all needs being met, but about the basic conditions that are necessary for the ecological and social systems to not systematically degrade.
Eizenberg & Jabareen (2017)	Equity Safety Sustainable Urban Forms Eco-Prosumption	We propose that social sustainability comprises socially oriented practices intended to address major social issues to cope with the risks of climate change and environmental hazards. In other words, social sustainability strives to confront risk while addressing social concerns. Although we agree that without socially oriented practices, efforts to achieve sustainability will be undermined, and too many gaps exist in practice and theory. (6)

In the debate about social sustainability Opielka, distinguishes four strands:

a) A narrow interpretation, as part of the three pillars model of sustainability referring to distribution of income, loos and risk, but also to the reduction of conflict potential. Examples are the discussion about the distribution of the cost of the transition to a sustainable society, e.g., around the ending of coal mining and the compensation of its social costs. Under this perspective, social sustainability has an instrumental function in relation to both other dimensions: ecology and economy.

b) An internal interpretation, which refers to the social dimension itself "*to the preservation and reproduction of the core community systems of a society", also* intergenerational justice e.g. through the pension systems, but also of good governance. It is connected to the concept of sustainability through the debate about commons (air, water, biodiversity etc. which are under risk by the selfishness of the people and short-term thinking. On one hand it treats under an inter- and intragenerational perspective, what in German is called '*die soziale Frage'* or in Spanish the 'Question social'. On the other side, it concerns to the classical sociological question how social order can be maintained over time, which does not exclude dynamic changes in society but is more oriented to conversational aspects also through public interventions. In a certain way, this position is close to the policies of the ordo-liberalism or the social-democratic approach

c) A sceptical interpretation in the sense of intergenerational justice similar to the internal interpretation, but rejection of public investment in the promotion of sustainability by taking on new debt. It advocates for solution within the conventional framework putting emphasis on possible technical solution to resolve to achieve the ecological sustainable goals. In difference to the previous interpretation strand, it advocates for a reduce role of the state and is close to the neo-liberal approach.

d) At least a broad interpretation, which refers to society as a whole and conceives social sustainability as a societal transformation process. This is expressed in the movement of post-growth and degrowth. It conceives the Anthropocene crisis a systemic problem of the society arguing that the solution lies in fundamental changes of society. "*To be hoped that the sustainability movement, like the labor movement before it, will succeed in demanding and promoting new institutions that systematically develop the social equalizing impulse of the welfare state into a kind of "eco-welfare regime*" (Opielka 2017: 11)

On the other hand, the work of Vallance et al. (2011) classified the different approaches in three categories:

a) Development social sustainability: This strand claims for the development of a 'brown agenda' beside the 'green agenda'. Following Allen & You (2002); the 'green agenda' focused on the protection of the ecological environment and the impact of human activity on it at the regional and global scale. The 'brown agenda' asked for the human well-being, social justice, and the problems derived from the green agenda at the local level especially in urban environments in developing countries. This strand addressed basic needs, the creation of social capital, justice, equity among others. It considers essential to address the brown agenda to face the green agenda as it could not be expected that poor people worried about cold, hunger, unsafety and

not having work will take care about the ecological topics (see Bhatti & Dixon 2003) have concluded that it is a little unrealistic to expect. The 'brown agenda' includes a wide range of issues form basic tangible conditions as potable water, access to energy, healthy food, medication, housing – to less tangible conditions as education, remunerated work, equity and justice.

b) Bridge sustainability promotes actively ecological behaviour or ethics. It considers changes in behaviour as an essential to achieve ecological sustainability. It tries to identify "*the social conditions necessary to support ecological sustainability*" (Chiu 2003:26). Vallance et al. distinguish between "non-transformative" and transformative approaches. "*This distinction is important because transformative approaches radically 're-imagine' people's relationships with the environment, other humans and non-humans, whilst non-transformative methods are conventional, fairly limited in scope, and aspire only to small, incremental changes*" (Vallance et al 2011: 344).

c) Maintenance sustainability referring to the preservation of socio-cultural settings in front of the social-economic and ecological changes. This strand refers to traditions, historical constructed practices and preferences as well as place, which people want to maintain. "*Maintenance social sustainability is, therefore, concerned with the ways in which social and cultural preferences and characteristics, and the environment, are maintained over time. This maintenance occurs through habit, movement and protest.*" (Vallance et al. 2011: 345). It concerns the resistance of people to accept measures thought to protect the ecological environment without taking into account the daily routines of the people.

Implicitly in both classification is a distinction between strong and weak approaches as two extremes of the societal implication to promote the social sustainability in policies. The weak extreme means to apply sustainable strategies without any change in society as a social system and with less state intervention as possible. On the strong pole, we found the social transformation approach, which advocates for a fundamental changes of society as it is assumed that the capitalist society can not resolve the Anthropocene crisis. Its inherent orientation to constant growth (Binswanger 2001 and 2019) invalidate all efforts reduce the negative impact of human activities, especially economic activities, on the ecological environment.

On the other side, all attempts to develop concept of social sustainability rejects that social sustainability has only an instrumental function in relation to both other dimensions: ecology and economy, which seems to be the mainstream interpretation of the three pillar model of sustainability. On the contrary, the proposals defence that the social pillar has the same relevance as ecological and economic sustainability arguing that without resolving the social question the ecological goals can not be achieved.

The Table 2 gives an impression of the broadness and richness of the interpretation of social sustainability. We choose the recent proposal of Eizenberg & Jabareen (2017) to expose in more detail one of these concepts as it fits well with the orientation of our project to urban innovation projects and the fields of economics and energy. The authors claim for the elaboration of a coherent concept of social sustainability based on the concept of social risk sustaining that without

"*socially oriented practices, efforts to achieve sustainability will be undermined, and too many gaps exist in practice and theory*" (*ibidem* 7).

Referring the risk society approach of Beck (1986), Eizenberg & Jabareen state that the environmental risks are also uneven distributed, as the COVID-19 pandemics has recently demonstrated. Eizenberg & Jabareen (2017) advocate for an equitative protection against environmental risks and sustainable forms of urban life, as well as for equity and safety strategies, which are also ways to engage the citizens to the sustainable efforts, especially in the eco-prosumption[7]. This last dimension links the concept of social sustainability directly to economic sustainability and indicates the need of fundamental changes in global society giving more voices to the citizens in the mitigation of the ecological risks.

In a nutshell, their concept contains four dimensions:

- Equity: assuming that with less equality and justice the engagement with sustainability will decrease (*ibidem* 6).
- Safety: means the right to be protected and secured in cases of environmental and climate change vulnerability (*ibidem* 8).
- Urban forms addressed the way of life in the physical urban spaces within the broad sustainable framework (*ibidem* 9).
- Eco-prosumption refers to practices focused on the mitigation of environmental risks. It "*refers to modes of consuming, producing and gaining values in socially and environmentally responsible ways*" (*ibidem* 9).

Economic sustainability

Within economics, there is a long discussion how to handle the ecological issue. This can be resumed in the difference if economy is an added-value system based on energy and matter input coming from outside the system, or if the economy must be conceived as a system integrated with the environment earth forming a quasi closed system under the risk of achieving the maximum level of energy and matter entropy, which impedes any further action. The first assumption is framed in conventional economic approach considering economic growth measured in GDP as requisite to resolve the environmental problems. This stream confides in the capacity of the economic system to find technological innovation to reduce the energy entropy level (e.g., through solar and fusion energy, and entropy by recycling to achieve zero new material input in the system to resolve and zero pollution). The other streams, as the reproductive or care, steady state or degrowth economics, distrust the capacity of the actual global economic system to achieve levels of sustainability avoiding or mitigating the environmental degradation. They question basic assumptions of conventional economics advocating, for instance, for abandoning the quasi exclusive orientation to quantitative growth models.

[7] Prosumption is the combination of production and consumption. The term was introduced by Alvin Toffler in his book The Third Wave (1980). A prosumer is an individual, who combined both consumption and production in one economic action. An example is a household producing photovoltaic energy for its own consumption and selling the part of the produced but not consumed solar energy.

From a non-economic viewpoint, this dispute seems quite rare, as economics assume that the resources (for instance, labour force, land and raw material) are limited, while the demand is considered infinite (see https://www.bankofengland.co.uk/knowledgebank/what-is-the-economy). This is linked to the assumption that economics is the science how to manage scare resources

This stands in intrinsically contradiction to the consideration that the goal of business is the creation of value. Under this perspective, scarcity is a question how to pay the best prices for the resources. Scarcity is accepted as the starting point of economy, but tramped through the price mechanism and through the idea that technology development will always provide a substitute for finished resources or that the production or service activity will be substituted by another. Therefore, economics does not have to worry about whether the resources used can or should be restored or regenerated. There are always some new resources that can replace old outgoing resources or the corresponding product or service is simply no longer produced. Since the atmosphere (and oceans) did not have a price, it could be used for free to create value and was not included in cost accounting.[8] As value or capital is a human-made, is can be generated infinitely, so that economy can and must grow infinitely (see Binswanger 2019). Under the value perspective, economy is a perpetual motion machine.

This perspective was already questioned in the 1960, for instance, by Kapp (2000 [1963]) and Boulding (1966)[9] and further in the growing area of ecological economics, which, however, is still minority in economic science. This strand takes serious the assumption of scarcity of time, energy and matter asking how this topic must be integrated in economic theory and actions. In the following, we present a short resume of the origins of the ecological economics referring to Kapp, Boulding, Georgescu-Roegen and Daly.

One of the pioneer of ecological economics was K.W. Kapp with his theory of social costs. Söderbaum (2008: 5) calls Kapp 'the first modern ecological economist'. Kapp's point of departure are the social costs of economic activities, on which he published in 1950 a book, which later was republished in 1963 and in 1978 under a slightly modified name. Kapp (2000[1963]: 13) defined then as "*all direct and indirect losses sustained by third persons or the general public as a result of unrestrained economic activities. These social losses may take the form of damages to human health; they may find their expression in the destruction or deterioration of property values and the premature depletion of natural wealth; they may also be evidenced in an impairment of less tangible values*."

The conventional economic since Coase (1960) conceived this as a market failure from an inadequate concept of rights and productions factors. "*The right of doing something which has a harmful effect*" (Coase 1960: 44) must be conceived as a production factor and included in the calculation as a cost. Following Coase, the problems created by external effects could be resolved efficiently by market actors (e.g., environmental problems) through negotiations under the

[8] The treaty if CO_2 emission is a step towards the pricing of atmosphere.

[9] Boulding coined the term of 'spaceship economy' as a metaphor for the earth as a closed system, in which economy acts.

condition of clearly defined property rights independently how the rights are distributed among the actors, complete information, limited numbers of actors and little or no transaction costs.

On the contrary, Kapp argued the social costs, as the environmental disruption cannot be explained by externalities and market failure, should be included in the cost-benefit calculation. He sustained that it is in the logic of the profit oriented market economy, economic actors tend to exclude as much as possible negative effects of the own decisions (e.g., air and water pollution) from the cost-benefit balance and discharged it (Kapp 1970a: 18). Under this perspective, decisions, which could cause environmental disruption, could be interpreted as economically rational within a given socio-economic and legal framework, meanwhile they are from a societal perspective totally irrational as they ignore the ecological and social consequences (*Ibidem*: 19)

Moreover, conventional economics based on market mechanism are not capable to understood the "*interdependencies and complex causal chains, which have long ceased to occupy a peripheral place in modern industrial societies and are bound to assume increasing significance as residual industrial waste products and debris are permitted to be discarded freely into the environment*" (Kapp 1970b: 840). In the background stood the problem, that conventional economy conceived economic processes as a closed and autonomous system. In the line with Boulding (1966) and Georgescu-Roegen (1971), he advocated to conceive the economy as an open system interrelated with the environment and society. To know the complex interrelation of economic decisions, the environment and society, it is necessary a cooperative multi-disciplinary research at national and international level. Only knowing the causal chains allows to estimate the consequences of decision allowing to take informed decision to act or not (see Kapp 1970a: 26).

In the year 1966, Boulding (1966) published an article, in which a coined the term '*Spaceship earth',* for which the economy must take care. He pointed to a paradigm shift in economic theory from an open system to a closed system concept. Traditional economic theory sees the economic cycle, similar to living organisms, as an open system that receives input from outside of the economy in form of raw materials, energy and information and secrete waste to the non-economic system. Regard to material, he admitted that it could be possible to imagine a closed system in which "*all outputs from consumption would constantly be recycled to become inputs for production"* (*ibidem* 5). But this is not the case for energy, where there is no escape from the second law of thermodynamics. The treaty of information is more complicate to trace as it only partially based on the transformation of energy and matter and it is essentially human-made. Boulding observed also that knowledge can degrade or lost, especially in the intergenerational transmission, but he did not apply directly the concept of entropy to information.

He coined for the open system economy the term of 'cowboy economic' associated with unlimited resources, but also "*reckless, exploitative, romantic, and violent behaviour*" (*ibidem* 7). For the close system earth economy, he used the term 'spaceman economy' associated with limited resources and where the human beings must find their place in "*cyclical ecological systems*" (*ibidem* 8). The main difference between both system lies in the fact that the open system approach advocates for consumption as main economic driver, meanwhile the 'spaceship economy' looks on the stock maintenance. This has implication for the consideration of technological innovation:

"*any technological change which results in the maintenance of a given total stock with a lessened throughput (that is, less production and consumption) is clearly a gain*" (*ibidem* 8). Or in other words: any technological change which results in the reduction of a given total stock is a loose. The author also calls the attention to the fact that the spaceman economy stands in contradiction to the assumption of the '*homo oeconomicus*', oriented to maximisation of its own benefits without taking in consideration neither the contemporaries nor future generation. This type of selfish individuals has no reason to act 'spaceman economic'.

We have still mentioned Georgescu-Roegen before. In his work 'The Entropy Law and the Economic Process' (1971), he applied, as Boulding, the thermo-dynamic laws on economic processes, especially the 2nd law concerning the entropy, which became in the following a key word in the economic debate on ecology. Without going in the discussion of 'entropy', it is sufficient to know that:

a) in a closed system the level of internal energy is constant over time;
b) there is a key difference between available and unavailable energy. Only the available energy is useable for work in the physical sense or for actions in a more general sense. Its use implies to convert available energy into unavailable energy.
c) The level on entropy indicates the level of unavailable energy. The higher the entropy, the higher the rate of unavailable energy in the close system. It increment is an irreversible process. As the internal energy level is constant, it means that the level of available energy diminished. At the maximum level of entropy, all actions cease as no more energy are available.

Georgescu-Roegen criticized the conventional economics, including Marxist economics, as anchored in the mechanistic paradigm conceiving economic processes as "*isolated, self contained and ahistorical – a circular flow between production and consumption with no outlets and no inlets*" (*Ibidem*: 2) without including "*the nature's perennial contribution*" (*Ibidem*: 2). He advocates for the application of the Entropy law and takes as point of departure the difference between the available and unavailable energy considering that earth is a quasi close system, in spite that it received constantly available solar energy from outside the system. The problem consist in that the humanity has still not achieved a satisfactory efficiency level of use of solar energy and that it uses matter without restoring it in an efficient manner.

The novelty of this approach was that he expands the law of entropy also to matter considering that also matter exist in two states: available and unavailable. And following the entropy law he considers that in the course of time, the level of unavailable matter tends to increase. Under the matter perspective, the earth is considered regard matter a closed system as it practically does not receive matter from the universe.

The human use of energy and matter without restoring the natural environment implies a constant and accelerate growth of the entropy of the earth and degradation of the ecological environment. From this viewpoint, the crucial question is if this process can be stopped or inverted, how to convert the earth into an open system with a high level of efficient energy use of solar energy and achieving that the use of new material of the economic process tends to be zero and the used material could be restored in the environment avoiding its degradation.

Georgescu-Roegen admits the theoretical possibility to recover all material but under the condition of infinite available energy and infinite time. But this means, that recycling can be never complete. Economy needs always some input from the environment and produce always output (waste and pollution) to the environment (Georgescu-Roegen 1975: 357). "*The conclusion is immediate: just as steady work cannot be continued indefinitely without being continuously fed with unavailable energy, such work also needs a continuous supply of available matter. The point is that both available energy and available matter are irrevocably degraded into unavailable states.",* so that "*the perpetual motion of the third kind is impossible" (*Georgescu-Roegen *1986: 7)*. In this sense, the entropy applied to energy and matter reinforced the theory of scarcity of resources even more as low entropy energy and matter are constantly converted to high entropy energy and matter, the scarcity of both increase constantly in the virtual closed systems as the earth it is.

Looking for technological solution for this dilemma means to look for a new technology which includes procedures "*that converts the environmental energy and matter into energy and matter at our disposal for other activities*" (*Ibidem*: 15). Georgescu-Roegen calls this Promethean technology. Technologies for the broad use of solar energy could be such a solution, but in the 1980's he did not appreciate that solar technologies have such promethean element. He advocates for solar energy[10], as the only available source of energy, which does not contribute to the increase the entropy level of the quasi closed system earth and do not produce pollution. Meanwhile the Promethean effects of such future technologies has still not achieved he advocated for avoiding all waste of energy and if necessary for the strict control of energy use. He also argued for a gradual reduction of the global population to adequate level for organic agriculture. This must be accompanied by the change to frugal behaviour, the production of more durable products, the strict prohibition of instruments of war, by programmes to aid underdeveloped nations "*to arrive as quickly as possible at a good (not luxurious) life*" (Georgescu-Roegen 1975: 378) and a disacceleration of modern life.

Another important pioneer is Daly (1971 and 1973), who grounds the stream of steady state economy. Similar to Boulding he criticized the conventional economic approach to the stock maintenance: "*Economics forgot about physical dimensions long ago and centred their attention on value. But the fact that wealth is measured in value units does not annihilate its physical dimension. … the constraints of physical constancy on value growth will be severe and must be respected*." (Daly 1980:7)

The 'steady state economy' aims to keep throughput of the economic system constant at a level that does not burden the ecological environment. In other words, the quantitative growth of the economic system should be prevented as it is assumed that any quantitative growth consumes energy and material harming the ecological environment. This approach, as we will explain below, thus represents a fundamental critique of conventional economic paradigms as e.g. the consideration if economy as a closed system and the quasi exclusive orientation to quantitative measurement. But it does not fundamentally question the capitalist economy, rather it seeks to set limits to it.

[10] He also mentioned the nuclear fusion as another alternative.

Steady-state economics uses the fundamental distinction between two basic forms of capital: natural capital and human-made capital. From an economic perspective, it is assumed that both forms of capital are mutually dependent: human-made capital often remains worthless without natural capital, such as a sawmill without wood from the forests. From an ecological perspective, the aim is not to maintain the stock of natural capital, what does not mean that structure of the natural capital stock becomes qualitatively unchanged.

This point is the fundamental difference to conventional economics, which also assumed the existence of natural capital. The conventional ecological approach considers the existence of the different types of capitals valued in money, which allows a conversion of one capital type to another. Under this perspective the different capital types forms one stock, in which the decrease of one type of capital can be compensate by the increase of another type (see UKEssays 2018) Under this perspective, Solow defined (economic) sustainability as the preservation of "*productive capacity for the indefinite future. That is compatible with the use of non-renewable resources only if society as a whole replaces used up resources with something else*." (Solow 1993 163) An example could be the substitution of fossil sources by renewable source for the creation of electricity. He argued that intergenerational sustainability, assuming that always non-renewable resources will be introduced in the production process, could be achieved if each generation will add enough new human-made capital to maintain the productive capacity. "*In other words, it should replace the used-up resources with other assets of equal value, or equal shadow value*." (*Ibidem*: 170).

On the contrary, the steady state economic approach denied the transformation of natural capital into human made capital. Paraphrasing the citation of Solow: The use of non-renewable resources is not compatible with the maintenance of the productive capacity for the indefinite future as the society as a whole could not replace all used up ecological resources. It advocates for the maintenance of the natural capital stock above a critical level.

Daly distinguishes between quantitative growth measured for instance by Gross Domestic Product and qualitative growth or development. "*Growth is quantitative increase in the physical scale of throughput*" (Daly 1996: 31). Qualitative development is the change of the use of the throughput at a given level or a lower level through technological innovations or an "*deeper understanding of its purpose*" (*Ibidem* 31). In other words, a steady state economy aims not to grow quantitatively consuming more energy and material, but is dynamically changing the use of energy and material and the produced goods and services. A second criterion is that the level of throughput must be ecologically sustainable completed by a third criterion, which is assuring sufficient per capita resources for a good life.

These are only four examples of the pioneers in ecological economics, to which J. Martinez Alier (1987), R.U. Ayres, Kneese (1971), von Ciriacy-Wantrop (1952) and Robert Constanza (1992) among others, can be added. These approaches are framed in the historical emergency of ecology as a political and scientific priority in the 1960 (see Krüger, 2019). They put the fundament for alternative approaches questioning micro-foundations of conventional economics as:

a) the *homo oeconomicis* as the reference model of an economic actor
b) the need for constant quantitative economic growth through which the generation of value or productivity becomes the main reference for economic policies to detriment of efficient societal management of the scare resources available at earth.

Also from the gender economic, the micro-foundations of conventional economics received substantial critics. For instance, Biesecker & Hofmeister (2010) claimed for the inclusion of care or reproductive work in the analysis arguing that any economic analysis, which considered re-productive work, for instance, home work, as extrinsic "*will necessarily prove unable to preserve and regenerate the ecological and social foundations on which it rests*" (*ibidem* 1703). They criticized also the concept of natural capital, as proposed by Schumacher (1973) and further used by environmental economics (see following section Convention economic policies to reinforce sustainability) and ecological economics as Daly and Constanza, as it "*overlooks the fact that society and its economy are already physically entwined with nature. Human production and consumption inevitably transform nature*" (*ibidem* 1706)

The proposed alternative is the use of the term (re)productivity for the interwoven activities of the ecological and the social-economic sphere. From such economic viewpoint, that ecological environment[11] is productive and its products are consumed by the human activities. In this process, human activities transform the ecological environment. It engenders socially the ecological environment. That means, the ecological environment is at the same time the starting and the endpoint of economic activities. This aspect is generally neglect by conventional economic approaches. It implies, that economic activities should not be conceived only as productive work: producing products and services, but also as re-productive (positive and negative impact on the ecological environment). Conventional economic and business analysis disregarded this aspect with the fatal consequences of the reduction of the ecological productivity (the transformation of the ecological environment to an uninhabitable environment for human beings).

Convention economic policies to reinforce sustainability: Green Economy and Green Growth

After this review of the different concepts of economic sustainability, we present two example for the actual conventional economic approaches to handle the Anthropocene crisis, developed by transnational organisation: Green Economy and Green Growth.

Green Economy

Green Economy is not a coherent economy approach or theory. Essentially it is a political approach to steer global economy to sustainability, leaded by two international actors: a) United

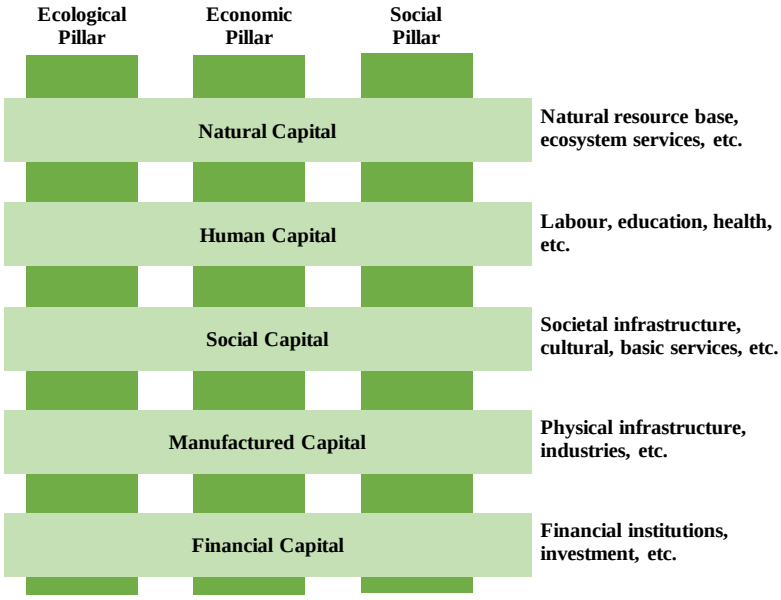
[11] Biesecker & Hofmeister (2010) use the term nature. We prefer the term ecological environment as the term nature suggest a clear cut between humanity and nature. On the contrary, the term ecological environment insists on the influence of human activities on 'nature', on the necessary transformation of the ecological environment.

Nations Environment Programme (UNEP) using the term Green economy[12] and b) the OECD, using 'Green growth'.

Following the UN, the term 'Green Economy' was used first by by a group of leading environmental economists in a work entitled 'Blueprint for a Green Economy' (Pearce, Markandya & Barbier, 1989). The term gains relevance in 2008, when the UN take up the idea to launch " Green Economy Initiative" and the idea of an "Global Green New Deal" (GGND) as an answer to the multiple crisis, which affected the world in that moment. The GGND established three goals: "(i) economic recovery; (ii) poverty reduction; and (iii) reduced carbon emissions and ecosystem degradation"[13].

Figure 1

Capital Types used by the Green Economy approach



Source: Adapted from UN (2011: 41)

The Green economy approach was defined in 2010 by the UNEP "*as one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities*" (UNEP 2010). It is "*low carbon, resource efficient and socially inclusive. In a green economy, growth in employment and income are driven by public and private investment into such economic activities, infrastructure and assets that allow reduced carbon emissions and pollution, enhanced energy and resource efficiency, and prevention of the loss of biodiversity and ecosystem services.*" (UNEP 2011: 16) In so far, UNEP sustained that the way towards a green energy should not focus only the ecological and economic problems (degradation and scarcity of resources) but also on actual and intergenerational social equity.

[12] https://sustainabledevelopment.un.org/index.php?menu=1446
[13] https://sustainabledevelopment.un.org/index.php?page=view&type=400&nr=670&menu=1515

It proposes to combine economic growth, increasing environmental quality and social inclusion and a mix of public and private investment. It takes up the idea of natural capital proposed first by Schumacher and further developed by Daly and Constanza (see section about Steady-State-Economy). Natural Capital[14] is different from the other capital forms as human capital, social capital, manufactured capital or financial capital as it is hardly replaceable and could collapse without prior warning (see Figure 1).

One of the mechanism to resolve the market failures is to assign value to all ecosystem services and the payment for the use of such services. Ecosystem services are in general common goods and services, which are invisible in the economic and business calculation as they have no value assigned. This implies that they could not be detected by market mechanism. For this reason, "*the market prices do not reflect unsustainable use and overexploitation*" (*Ibidem* 18). This is also a reason, why national economic policies failed in managing natural capital, as it is not visible in the national accounts as the example of the calculation of the Gross Domestic Product shows. Form an economic perspective, the ecological environment should be concerted to natural capital, assigning values and prices, so that it could become a source of benefits but also loss. The aim is to translate the ecological issues in the language of business and economics so that they could appreciate environmental and be more aware of the hidden costs and long-term consequences of their actions. In so far, this strategy opts for the integration of the ecological environment into the economic system through pricing.

Among the measures proposed to paw the way for a green economy, UNEP propose to implement systems of appropriate and effective information as essential for private and public decision taking. UNEP sustains that "*the use of market-based instruments, the creation of markets, and where appropriate, regulatory measures, have a role to play in internalising this information*" (*Ibidem*: 19). In so far, the Green Economic approach advocates for a mix of market and state regulation to steer global economy towards green economy. To achieve a green economy, it advocates for the substitutability of less sustainable by more sustainable technologies and products, as for instance fossil by renewable energy source.

Green Growth

A similar approach is promoted by the OECD under the label of 'Green growth', which has the goal to decouple the economic growth form the irreversible use of natural capital. As the UNEP strategy, the central term is 'natural capital`. Also the OECD advocates for valorisation of natural assets converting them into natural capital, of the internalisation of until now considered externalities. The green growth strategy "*explicitly recognises the dual role played by natural capital in both contributing to production of marketable goods and directly providing valuable ecosystem services to individuals and society at large*" (OECD 2011: 19). The expression 'dual

[14] "*In a green economy, natural capital – comprising the biosphere as a whole, including biodiversity and ecosystems – is an enabler of economic growth and human well-being. Rather than being seen as a passive receptor of wastes and pollution generated by economic activity or as one of many substitutable factors of production, the environment in a green economy is seen as a determining factor of economic production, innovation, value creation, stability and long-term prosperity*." (UN 2011) Working towards a Balanced and Inclusive Green Economy: A United Nations System-wide Perspective. Geneve.

role' refers to the fact that natural capital is a production factor, but natural assets also influence the individual and social welfare. The challenge is to evaluate economically their use, indirect use and non-use. The approach defines direct use as the acquisition of natural assets, meanwhile indirect use refers to the regeneration of the ecosystem services used. Both form the 'use value', which includes "*the actual or planned use of the good or service in question (that is, as a source of water for irrigation purposes) or possible use (that is, a spawning ground for development of fisheries in the future*)". More interesting is how the non-use value is defined referring to the value which "*people attach to a good or service even though he or she does not have (or foresee) any actual, planned or possible, use for the good or service for him or herself.*" (*Ibidem*:27). It is added the '*optional value*", which refers to the alternative use, which could be given do a natural asset, which is lost once the decision of the commercial use of a natural asset is take n. These four values types can be aggregated to the 'total economic value', which as such is not fully accounted by the market nor by the macro-economic indicators as the Gross Domestic Product. On the other side of the balance must also stated the benefits or lost produced by the use, indirect use or non-use of the natural resources, for instance regard their impact on health, life expectation and well-being.

In so far, the OECD approach of Green Growth follows as the Green economy model conventional economic assumption, but appointed to the improvement of the market and marco-economic information to take into account in decision about business or economic policies. It doubts about the efficiency of the markets to make steps forward to sustainability and proposed pricing the natural resources and the impact of their economic use on the ecological environment. It proposes also to remove subsidies for the use of natural capital producing degradation of the ecological environment, as well as regulation to promote sustainable economic behaviour. At the political level, the OECD add a) fostering innovation to promote green technology and practices in substitution of unstainable technologies and products, b) the creation of programmes to invest in sustainable infrastructures and c) to increase the governance capacity to steer the transition. (OECD 2011: 35). Through innovation, the limits of the resource use can be postponed contributing to the decoupling of the economic growth from the use of natural capital (OECD 2011: 10).

Both concepts are very similar with slightly different focus, but sharing two basic assumptions:

a) in the line of the ordo-liberalism, they mistrust the capacity of market and complement it with state or transnational steering mechanisms as regulation, norms, incentives, but also public investment in ecological sustainable infrastructures and promotion of innovations.
b) The need to make economically visible the until now invisible costs and benefits produced by natural assets assigning them monetary value converting natural assets into natural capital. This implies changes in the international, national and business accounts for which the Gross Domestic Product is a good example. This is in the line of the conception of economy as a self-referential systems (Luhmann 1989), which only can communicate external topics – as ecological and social problems - using their own codes based on monetisation and prices.

Within this lines of thinking, two concepts are of high relevance: the circular economy and the bio-economy. Both can be taken as blueprints for the success or failure of the strategy of Green Economy and Green growth.

Conventional economic models to mitigate the climate change

In this section, we present two current conventional sustainable economic models, which are the main reference in the actual economic strategy towards a sustainable society. The circular economy and the bio-economy model form, for instance, part of the EU Green deal strategy.

Circular economy

The concept of the circular economy can be traced back to "industrial ecology" in the definition of Frosch & Gallopoulos (1989: 144): "*The industrial ecosystem would function as an analogue of biological ecosystems. (Plants synthesize nutri-ents that feed herbivores, which in turn feed a chain of carnivores whose wastes and bodies eventually feed fur-ther generations of plants.) An ideal industrial ecosystem may never be attained in practice, but both manufacturers and consumers must change their habits to approach it more close-ly if the industrialized world is to maintain its standard of living-and the developing nations are to raise theirs to a similar level-without adversely affecting the environment.*"

In a certain way, they took up the suggestion of Boulding (1966) of the theoretical possibility to create a closed system in turn of the material used in the economic system, so that the material economic system will not take any material from and create any waste to the environment. The reduced quantity of material input can be restored in the nature. The energy used in the circular economy will come, in the idealised version of the model, to 100% from renewable energies (Murray et al., 2015; Ellen MacArthur Foundation, 2013).

Kohorne et al (2018: 41) define the circular model as: "*The environmental objective of CE is to reduce the production-consumption system virgin material and energy inputs and waste and emissions outputs (physical throughput) by application of material cycles and renewables-based energy cascades. The economic objective of CE is to reduce the economic production-consumption system's raw material and energy costs, waste management and emissions control costs, risks from (environmental) legislation/taxation and public image as well as to innovate new product designs and market opportunities for businesses. The social objective is the sharing economy, increased employment, participative democratic decision-making and more efficient use of the existing physical material capacity through a cooperative and community user (user groups using the value, service and function) as opposed to a consumer (individuals consuming physical products) culture.*"

Generally, it is accepted, that the application of this model is one step forward to achieve the sustainable goals established by the European Union, but there are doubts, that through this model alone ecological sustainability could be really achieve. The critics are centred in:

a) The objective of zero new input and zero output can not be achieved. The actual economic model based on constant growth and consumption impedes the achievement of the goal of zero new input. On the contrary, in spite of the increased effectivity of the resource use, the actual growth model conduced to an increase use of material, but also of energy. Paech (2011) argued that the assumption of disruptive innovation implies that older production capacities become obsolete and will be substituted by new ones. This implies necessarily an increase of the use of non-renewable resources.

b) Besides the material flow, it is obvious that the circular economy needs a constant energy input. It is not realistic to sustain that this energy will come 100% from renewable energy. Actually the main part of energy comes from non-renewable energies, which according to the 2nd thermodynamic law, can not be reused and it must emit emission and pollution contributing to the climate change. The actual economic model conduced to a constant increase of energy, which could not be satisfied by the renewable energy. For instance, the digitalisation of society has increase considerably the energy consume. Zehner (2012: 172) talks about the boomerang effect, that the increment of renewable energy is accompanied by an increment of fossil energy.[15]

Bio-economy

Complementary to the circular economy strategy is the bio-economy. Meanwhile the circular economy model focused on the processes internal to the economy system (recycling and reuse of material) the bio-economy focus on the material and energy input advocating for the use of inputs derived from renewable biological resources, with research and innovation enabling the transformational process (Bugge et al., 2016; and Pfau et al., 2014). In this context forestry and the agriculture and forest industry can play a fundamental role in providing bio-based substitutes for non-renewables. Its contribution to the transition to a sustainable economy lies, on the one hand, in its contribution to the de-carbonisation of the energy use (bio-energy) and, on the other hand, on the development of applications in a wide range of industrial sectors including the chemical industry. The German Bioeconomic Council defined bio-economy as "*the production and utilization of biological resources (including knowledge) to provide products, processes and services in all sectors of trade and industry within the framework of a sustainable economy*"[16] The EU defined it as "*using renewable biological resources from land and sea, like crops, forests, fish, animals and micro-organisms to produce food, materials and energy*"[17]. As the OECD expressed, the bio-economy could be a strategy to decouple economic growth form ecological impacts (see OECD 2004).

Based on an exhaustive literature analysis, Bugge et al. (2016) identified three guiding visions of bio-economy, which are not exclusive: a) Biotechnology, b) Bio-resources and Bio-ecology. The first two visions (framed in the paradigms of conventional economics) are research driven looking

[15] Others are talking about the rebound effect referring to the increase of economic efficiency accompanied by the material expansion. An example is the increase of energy efficiency which is accompanied by an growing energy consume (see for instance Berkhout et al. 2000; Binswanger 2001; or Maxwell 2011)

[16] https://biooekonomierat.de/en/bioeconomy/index.html (accessed September 2021).

[17] https://ec.europa.eu/info/research-and-innovation/research-area/bioeconomy_en (accessed September 2021).

for new application of the bio resources, meanwhile the third vision, without excluding research and development is focused more on the careful use of the environment being so in the conventional vision linked to the circular economy, but also to the ecological economy: agriculture and food production and care economy putting the focus on biodiversity, conversation of the eco-system and avoiding soil degradation.

Birch (2019: 70) resumed the different strand of bio-economy in the following definition: "…*a concept that refers to the sustainable use of biological, renewable materials in the development of bio-based products, services and energy that substitute for existing fossil fuel-based products, services and energy, as part of a broader societal transition to a low-carbon future*."

Pfau et al. (2014) also based on a literature study, observed four perspectives on bio-economy which goes from the consideration that bio-economy by definition contributes to ecological sustainable to the position that bio-economy will not contribute to solve the problems of ecological sustainability. In the middle is, first, the moderate position, which consider that it could contribute to ecological sustainability under certain conditions (e.g., in the agriculture through sustainable cultivation and harvesting practices). Tentative critical positions estimate possible positive impacts, but sees serious problems, remarkably in the form of the land use and the high demand of water, to achieve this positive impact on sustainability for the inherent logic of the competitive market economy.

These statements to the circular and the bio-economy indicates that there are reasonable arguments to put in doubt that the Green Deal strategy will achieve the objective of zero new material input in the economic process and contribute to maintain the entropy level of the 'spaceship earth' and to reduce the pollution level contributing to mitigate the ongoing climate change.

The Doughnut Model of Sustainable Economic Development

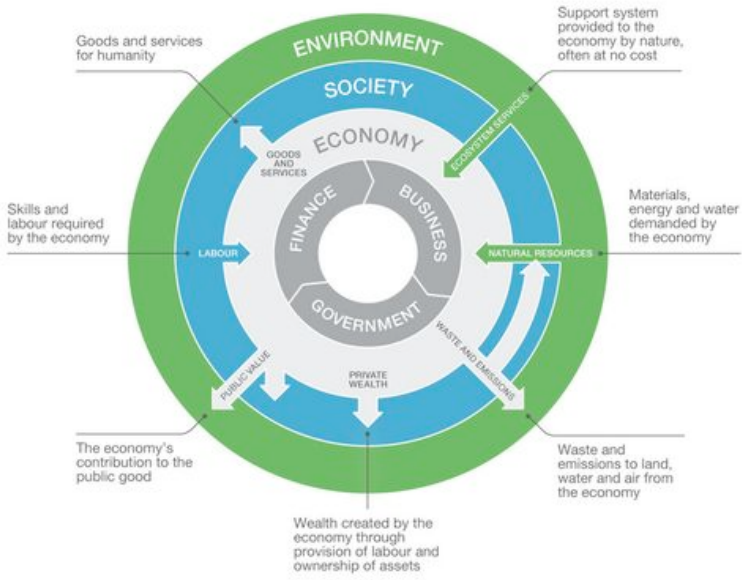
We will not go more into this dispute about the concepts of economic and social sustainability.

However, what is important is to visualize the complex interrelation between ecology, economy and the social, which out the ground also to visualise the impact of economic policies, e.g. the Green Deal, on both ecological and social environments.

For this objective, we could refer to several models as the stationary economy (Daly 1971 and 2013), care or reproductive economy (Biesecker & Hofmeister 2010), doughnut economy (Raworth, 2017), diverse models of sustainable economy, as an example the model of the Cambridge Institute for Sustainability Leadership (Figure 2).

Figure 2

Rewiring the Economical Model



Source: Cambridge Institute for Sustainability Leadership

https://www.cisl.cam.ac.uk/about/rewiring-the-economy/rewiring-the-economy-model

For our project, we chose the model of the doughnut economy enriched with elements of the (re)productive or care economy (see Figure 3). It has the advantage that it visualised well the interrelations between reproductive and consumptive actions (use of energy and matter resources), the social distribution of gains and lost and the impact on the society in several dimension on one side (the inner circle) and the impact on planet boundaries or the ecological environment (external circle).

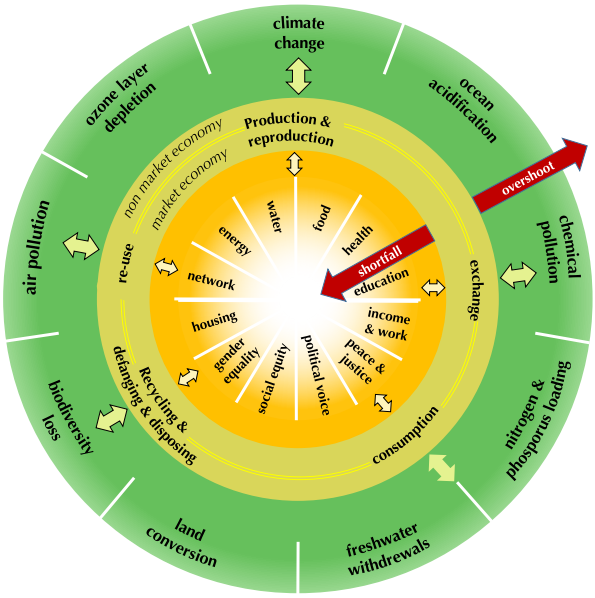
Raworth addressed, on the one hand, the interrelationship between economy and environment and on the other hand the well-being of the citizens. The Doughnut model was presented in 2012 as an Oxfam working paper, in which Raworth took up a proposal of Rockström et al (2009b) to define planetary boundaries "*for key Earth System processes associated with dangerous thresholds, the crossing of which could push the planet out of the desired Holocene state*." (Rockström *et al.* 2009b). Raworth took up the 9 dangerous thresholds and add 12 indicators of social threshold putting in risk the social well being of human beings based on established minimum well-being standards.

Although Raworth include here concept elements of the care economy, we integrated the topic of (re)productive economy in Figure 3 insisting in the fact that conventional economy neglect the non-monetised economic activities, which are in its majority carried out by women. This enriched model allows to talk about the different areas of economic sustainable strategies as

decarbonisation, dematerialisation including recycling and restoring of the environment and its insertion in the daily life of the citizens.

Figure 3

Enriched Doughnut economic model



Source: adaptation of Raworth (2017)

In other words, it helps to show the impact of individual behaviour on environment and society and citizens' co-responsibility for the achievement of the sustainable goals. We take this model as a reference to identify sustainability competence as it allows us, without going into the details of the economic disputes (e.g., growth or de-growth), to visualize the impact of economic activities (productive, reproductive and consumptive) or political and economic strategies as the society the circular economy and bio-economy models, which are the pillars of the European Green Deal strategies.

Concluding remarks and linkage to RRI

In this discussion paper, we present our perception of the state of the art of the conceptual debate about sustainability and sustainable development, with a strong focus on the economic viewpoint. We expose recent proposals to reinforce the topic of social sustainability and classifications of these attempts. However, the different authors acknowledged that this topic is the less developed of the classical three-pillar approach to sustainability. We exposed two efforts to summaries and categories the different approaches on social sustainability. Both classifications assumed a distinction between weak and strong sustainability, as two extremes of the societal implications of sustainability policies. The weak social sustainability approach support strategies without substantial change in society as a social system and the lowest political intervention as possible.

The strong social sustainability approach assumed that 'real' sustainability strategies to contribute to solve the Anthropocene crisis will imply a fundamental transformation of society.

Within economics, we observe different strands to treat sustainability:

a) The open system approach, which conceive as an open system receiving constant energy and matter input from outside. This open system approach is combined with a self-reference system perspective considering that the economy is a value creating system, which communicate through values expressed in prices (capital approach). It is assumed that any type of capital can be converted principally in another type of capital. Under this perspective, sustainability is seen as the preservation of the production capacity over time, which depends on the capacity of the economic system to replace any resource by other resources. This could be achieved through substitution and technological innovation.
b) The combination of the open system (economy) with the closed system (earth), which takes the entropy as a main argument to advocate for sustainable economic policies. In spite of using also a capital approach, the difference to the previous strand is that natural capital is conceived as not totally substitutable by other capitals. For this reason, the level of the natural capital stock must be maintained above a critical level.
c) The conception of economy as productive and reproductive subsystem of the earth, whose function is the contribution to the maintenance of the earth, so that humanity can live on it. The main difference to the previous approach is that economy is not seen as a value creation system expressed in quantitative terms. It proposes to take into consideration that as well as the production and consumption, also reproduction and destruction must be considered in any economic analysis. It put in doubts main micro-foundation of conventional economics as quantitative growth and the selfish *homo oeconomicus*.
d) The last conception fits best with the perspective, that the goal is not to reduce the harm of economic activities on the ecological (and social) environment, but to avoid that the planet boundaries are transgressed with catastrophic consequences for humanity. This position is expressed in the Doughnut model of Raworth. Despite of the critical position to fundamental conventional economic assumption, the model can be used to visualize the impact of any economic policies on both the ecological and the social environment.

In Table 3, we classify both social and economic sustainable approaches based on a distinction proposed by Steuerer (2010), which we adapted here. The author defined three categories: weak, intermediate and strong sustainability taking as reference point the assumed relation between ecology and growth and considers that the dispute between these three positions is "*the continuation (and further development) of the growth controversy of the 1970s*." We adapted this scheme including the dimension of social sustainability.

RRIL give not preference to any of these approach as all of them have a normative basis, but it takes as point of departure that the climate change as well as other ecological problems are proved by scientific evidence and requires urgently coherent strategies to mitigate the inevitable climate change and its negative impact on human life at local, regional, national and global level.

Table 3:
Classification of Social and Economic Sustainability regard Sustainable Development

Distinction criteria	**Sustainable development**		
	Weak sustainability	**Intermediate sustainability**	**Strong sustainability**
Substitutability of natural capital	Fully substitutable	Partially substitutable	Not substitutable
Relationship between humans and nature	Anthropocentric	Eco-anthropocentric	Ecocentric
Compatibility of quantitative growth and the environment	Compatibility of objectives of growth and environmental policies	Growth and the environment are compatible through environmental policy	Incompatibility of objectives of growth and environmental policies
Fundamental position	Unreservedly pro-growth	Environmentally friendly or ecologically sustainable growth	Impossibility of ecologically sustainable growth
Strategy	Efficiency through market and growth	Efficiency and ecological consistency through policy and market	Sufficiency/Frugality; consistency and efficiency
Representatives (social sustainability)	Sceptical interpretation of social sustainability	Internal interpretation of social sustainability	Broad interpretation of social sustainability
Programmatic orientation	Functional approach to avoid conflicts	Approach with a distribution function of risks (social development & non-transformative bridging)	Social transformative approach (transformative bridging approach)
Representatives (economic sustainability)	Conventional neoclassical economists (Growth optimists)	Conventional ordo-liberalism or social-democratic economics (growth optimiser)	Ecological & feminist economists (Growth Critics)
Programmatic examples	Green Technology, Green Economy, Green Growth	Green Technology, Green New Deal, Social-Ecological Market Economy	Post-growth economy, or society, degrowth Ecosocialism

In the introduction, we explained that we elaborate this paper in response to a weakness of RRI missing a clear reference point for responsible innovation. We propose to anchor RRI in sustainability and sustainable development in spite of the critics on both. At the end of the paper, we want to have a look of the contribution of RRI to sustainability and sustainable development focusing on three of its dimensions: public engagement, gender and ethics. We consider them as means to achieve sustainability, but also as ends located in the area of social sustainability.

For this discussion, we propose to adapt the three categories proposed by Vallance et al. (2011):

a) Development sustainability: linking the ecological agenda to the socio-economic agenda (the so-called brown agenda).

b) Bridge sustainability asking how ecological sustainability can be anchored in the behaviour of the people.
c) Maintenance sustainability which asks for the resistance of people to accept measures thought to protect ecological environment.

Going back to the basic problem: why many of science-based innovations do not achieve implementations in society and to which RRI give answers. The core question in both areas is how to achieve that the developed innovations will be accepted by the society and give answer to urgent societal challenges. Under the premise of ecological, social and economic sustainability, the final idea of the original proposal of RRI shift from marketable proposal contributing to resolving big societal challenges to societal acceptable solution to mitigate the global climate change and its negative impact on society at local, regional, national and global level. This change in the fundamental assumptions of the original RRI concept, which is based on a distinction between the research and the innovation system, so that the main problem addressed by RRI is how to structure efficiently the knowledge transfer from the research to the innovation system. The means to achieve these goals are the public engagement, gender equality (or social vulnerability) and ethics. But taking sustainability has the reference goal of all research and innovation activities, implies that these three elements are not only means, but goals.

In the exposition of the debate on social sustainability, we have argued that social equity is a core transversal element of the proposed concepts. It is also a goal within the scheme of the Sustainable Development Goals, as this is considered a basic factor of social inequality. This aspect is included in the RRI approach under the header of gender equality. However, in the gender debate surged intersectional approaches combining gender with other discrimination factors as social class, ethnicity or race, age, religion among others (see the brown agenda). Without denying the relevance of gender as factor of inequality, it is only the starting point to achieve a broader inclusion of the fairness of any responsible and sustainable innovation process as goal and means.

Gender is also a good example for the relevance of public participation in innovation processes. From a gender perspective, the insertion of this topics transversally in science-based innovation processes implies a constant confrontation of the methods, procedures and (provisional) results of the innovation process with the citizens. As Haraway (1988: 581) expressed "*feminist objectivity means quite simply situated knowledge"* underpinning that knowledge is framed in specific historical, social and political contexts. Under these conditions, the achieved knowledge must permanently be questioned and contrasted by the knowledge of other actors. This is even more an imperative in science-based innovation processes with a direct impact on the life of the citizens. So far, public engagement is oriented to insert the knowledge of laypersons in the science-based innovation processes, in the best case from the beginning on, oriented to empower citizens and hear their voice (and vote).

However public engagement is from the sustainable perspective not only a mean but also a goal. In many concepts of social sustainability, the topic of public engagement is included under different headers as participatory democracy (Harris 2000), public participation and empowerment (Jabareen 2008), engaged governance (Cuthill (2009) or sustainable relationships based on mutual trust (Renn 2017).

Probably, the ethic topic is the most complex one within both RRI and Sustainability. RRI made general references to human rights, European values and standards of good research. But in the actual situation of the Anthropocene crisis, this seems not enough. The need of ethical commitment becomes more evident by the transformation of the research system and its closer commitment to societal and business interest. As Krüger (2018) showed the closer connection between research and industry is a strategy of the European Union, which can be traced back to the 1960 tacking the USA and Japan as reference models. This implied that business interest became stronger also in public research institutions as universities and research centres, which has its expression in the increase of their funding through competitive mechanisms. Another examples are the strategy to create business oriented spin-offs from the universities or research centres. This trend is linked to the increasing relevance of science-based knowledge, for which the term knowledge-based society stands for. However, this requires even a more ethical commitment within research and innovation. Integrating science as an element in economic processes submit science more and more to the logic of business processes, which in the capitalist society is characterised by its low ethical commitment (Skidelsky & Skidelsky 2012).

The expression of a Fair Transition to a Sustainable Europe (and World) expressed well this general need of an ethic compromise. Within the weak and the intermediate concepts of sustainability, this means to anchor capitalist behaviour to sustainable ethics putting limits to the infinite process of value creation. Using the strong approach, it would mean to transform fundamentally society towards a more frugal behaviour. In both cases, the goal is to insert ethics of sustainability into society, but also into the science-based innovation processes.

This means, that public engagement, gender or intersectional equality and ethics must be conceived holistically to develop sustainability taking seriously the three-pillar model of ecological, economic and social sustainability; to bridge sustainability in the sense to anchor it as a basic principle of behaviour, and to maintain sustainability taking into account the needs and socio-cultural identity of the people to advance in the mitigation of the Anthropocene crisis and its negative impact on society. All three elements must be holistically integrated in the reflection and anticipation of the goals and societal impacts of science-based innovation through processes of inclusive deliberation with interested and affected stakeholders

Learning on responsible research and innovation and its interrelation to ecological, economic and social sustainability is critical for achieving environmental and ethical awareness, values and attitudes, skills and behaviour consistent with sustainability and effective public participation in decision-making. It is basic to promote competences for responsible and sustainable innovation not only among academics and future academics, but also agents of change in non-academic organisations. It also is a blueprint for a future conceptual development of sustainable citizenship competences framework.

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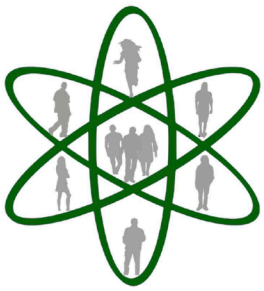

Responsible Research & Innovation (RRI) is a concept developed by the EuropeanCommission for the governance of research and innovation processes with a view on the(ethical) acceptability, sustainability and societal desirability of the innovation processand its marketable products. It aims to shape, maintain, develop, coordinate an alignexisting and novel research and innovation-related processes, actors andresponsibilities with a view to ensuring desirable and acceptable research outcomes.

RRIL – Responsible Research and Innovation Learning has developed and tested alearning programme on RRI anchoring it in Sustainability and Sustainable DevelopmentGoals talking about Responsible & Sustainable Innovation. For the development of thelearning programme, RRIL focus on three core dimension of RRI: public engagement,gender equality and ethics based on interactive real-problem approaches

The learning programme is composed by fours course: (a) Introduction to Responsible &Sustainable Innovation (ReSI); (b) Public engagement; (c) Gender equality; and (d)Ethics.The learning programmne is accesible in English and Spanish at:
https://lor.instructure.com/resources/3d459de396ba4ad59e5f6b87a306d5e6 (EN)
https://lor.instructure.com/resources/37a7c39cd06543b1819fe610b19c3ef7 (ES)

At the beginning of the project. RRIL prepared a internal conceptual working paper on sustainability and sustainabile development, which was in the course of the project constantly updated and is published here as a discussion paper.