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## Circular economy and Post-growth movements: what can be the solution to the environmental issues? An analysis through the space sector

by

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# Circular economy and Post-growth movements: what can be the solution to the environmental issues? An analysis through the space sector

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## Abstract:

The current economic development model is based on the unlimited growth approach, where prosperity is produced through the consumption of energy and the exploitation of raw materials. It is evident that in a resource-limited ecosystem this development model presents numerous complications. In recent years, several alternative approaches have developed, such as Degrowth and Post-growth. These systems are designed and structured in such a way that they do not require continuous growth and at the same time provide justice and well-being even when productivity declines. They are based on the Ecological Economy, an economic system that includes, on the one hand, the circularity of materials to reduce the impact of human activities on the ecosystem, and, on the other, the creation of well-being through the implementation of activities of a social nature. To date, this category of approaches would seem to have the potential to thrive in the context of downsizing the economic system.

This transformation, which is oriented towards the creation of a sustainable economic system, seems to represent a challenge similar in some aspects to ones encountered in the "Apollo Mission", which in 1969 successfully achieved the goal of landing a man on the moon for the first time and returning him safely to earth. This new challenge, based on the concept of “Mission-oriented”, also appears today as "utopian and impossible". As in the Apollo Mission, the State, given its operational scale, has the potential to lead this transition successfully through the implementation of selected public investments.

The aim of this paper is to create a context in which the definition and design of alternative development models to continuous growth are considered feasible, testable and ultimately implementable.

**Keywords:** Economic growth, Post growth, Degrowth, Green Growth, Circular Economy, Prosperity, Space Economy, Mission oriented, State, Investments, International Space Station (ISS), Economic system, Sustainable development,

## Introduction

In 1966, the economist Kenneth Boulding in "The Economics of the Coming Spaceship Earth" was the first to grasp the urgency for industrialised countries to move from an open economy, defined as the "**Cowboy economy**", since this is seen as the symbol of the unlimited plains and associated with the behaviour of open societies where production and consumption have no limits, to a closed economy, also defined as the "**Spaceman economy**", capable of self reproduction and of maximising the value of the raw materials included in the economic system. In this case, planet earth is seen as a spaceship, characterised by a closed environment with limited resources and where the reduction of production and consumption is recognised as a real added value.

However, in recent decades it has been the Cowboy economy that has developed, relying on the exploitation of raw materials and causing an increase in greenhouse gas emissions. This

has led to changes within the planet's ecosystem, such as rising temperatures, melting glaciers and loss of biodiversity, all of which increase the probability of exceptional events occurring. According to environmental scientists, these events will be increasingly frequent in the future and will have important consequences both at an environmental level on the flora and fauna of the territory, and at a socio-economic level, damaging and in some cases destroying entire economic and social infrastructures.

To stop these ongoing changes, an imminent and drastic change in the economic development model is needed. In recent years, several **alternative** movements to unlimited growth have emerged, including Green growth, Circular Economy, Degrowth and Post-growth. All of these approaches have recognised the evidence provided by science on the anthropogenic impact on the ecosystem, and share the idea that change is needed immediately. However, the literature is divided on which of these alternatives should be implemented. Underlying this division are both economic interests and concerns about the effects on people's well-being that any downsizing of economic production could cause.

As can be observed in Figure 1, on the one hand there is the Green Growth, which envisages both a decoupling of economic growth from resource consumption and an increase in GDP and well-being. On the other hand, Degrowth foresees an increase in well-being through a reduction in GDP, since according to the supporters of this movement, the decoupling of economic growth and resource consumption is not feasible at the present time. Finally, the Post-Growth movement has an agnostic position as it has not yet taken a precise position.

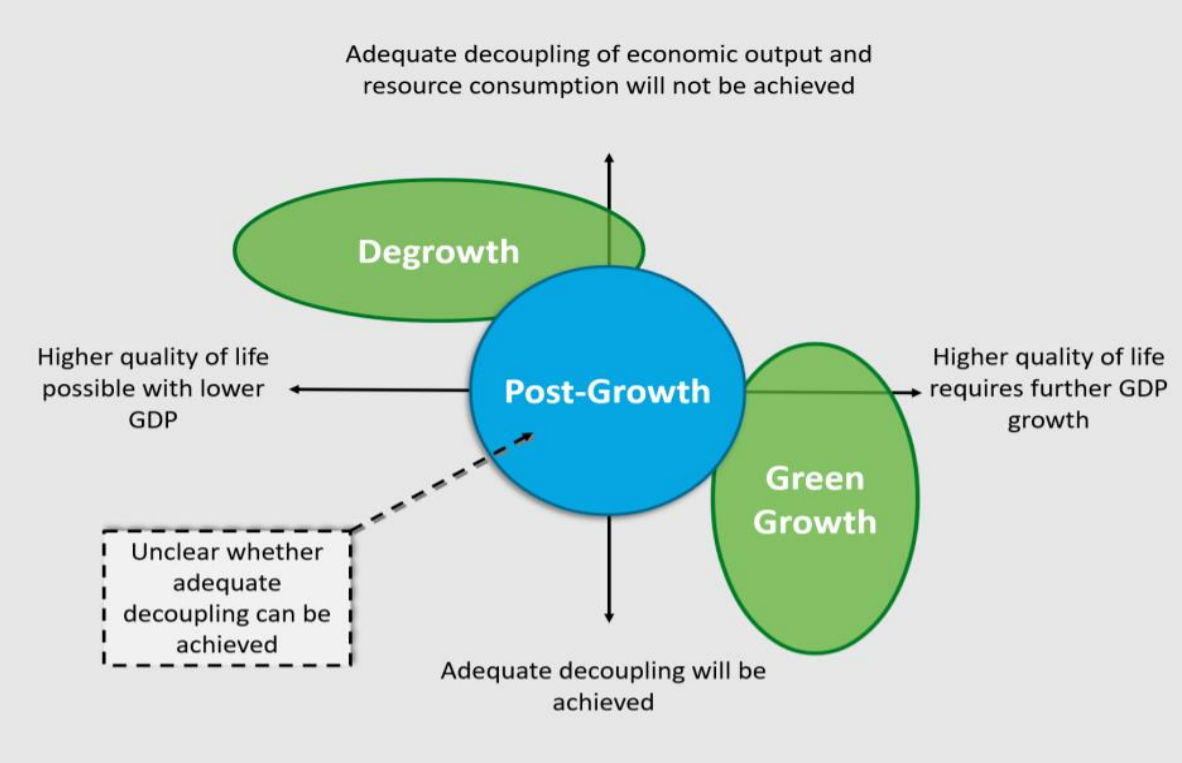


***Figure 1**: Overview of approaches (German Environment Agency, 2020)*

The aim of this paper is on one hand to answer the question of whether alternative approaches such as Green growth and Circular economy are valid solutions to the current environmental problem. On the other hand, it also analyses other movements such as Degrowth and Post-growth, which are based on the Ecological Economy, an economic system that includes both the adoption of circular development models and the creation of well-being through the performance of social activities.

The paper will attempt to create a context in which the definition and design of alternative development models to continuous growth are considered feasible, testable and eventually implementable on a large scale. This study is supported by interviews with researchers from the Wuppertal Institut such as Carina Koop and Jennifer Schinkel, and by the director of the centre for Post-growth research at the University of Vigo, Mario Pansera.

At the centre of this transition towards more sustainable development models there is the State. According to the concept of "**Mission-oriented**", the policy maker is not only required to support the market and correct its failures, but also to choose the direction and set the ambitious goals to be achieved in the long term. The State has to take a leading role in defining the

direction and the mission to be achieved within a certain period of time and work in partnership with the private sector to achieve it. It is not a question of choosing winners and losers, but of defining a mission in the interest of the community and carrying it out through alliances with willing businesses, institutions and associations.

The definition of an ambitious mission by the State, such as that of the "**Apollo Mission**" in the 1960s, where the USA aimed to be technologically more advanced than the USSR in the space field, is intended to create a climate of research and technological and social innovation, thanks to collaboration and the exchange of information between the various stakeholders. The Apollo mission, which had brought the first man to the moon, and which was considered "**impossible and utopic**" at the time, contributed to a general technological development and the creation of multiple spillovers in many economic sectors, such as IT, aeronautics, electronics, nutrition and materials. Today, the new mission, which is considered even more complex because it is also characterised by an indispensable transformation of the social, political and economic context, is the development of a new sustainable **economic system**.

As in the Apollo programme, investments in the new mission can once again be made in the space sector, which, thanks to the construction of facilities such as the **International Space Station (ISS)**, represents a point of inspiration for future sustainability. In the ISS, where astronauts live and are tasked with conducting scientific experiments, sustainability is achieved through the Circular model which, thanks to the concepts of prevention, reuse, repair and recycling of raw materials, allows astronauts to be autonomous from planet earth. The aim of this paper is also to analyse these closed environments, with an analysis of the current management of materials and resources. In fact, thanks to the contribution of the ESA (European Space Agency) astronaut **Luca Parmitano**, some consumption and production habits of resources inside the ISS will be explained. Finally, as was the case with the Apollo mission, the study will analyse the possible spillover into circularity resulting from these processes of innovation in the space sector, which can also be applied on earth.

## The current state

It has been about five decades since Kenneth Boulding, a British-born American economist, raised the issue in his study "The Economics of the Coming Spaceship Earth", related to a more sustainable development of our current economic growth model. The term "sustainability" first

appeared in German, coined by Von Carlowitz, in his work "Sylvicultura oeconomica" in 1713. Carlowitz was director of the Royal Mining Office in the Kingdom of Saxony when he perceived the problem of the wood shortage. In his writings, he argued that as much wood should be harvested as would grow back and used the term 'nachhaltend' to describe deforestation practices, which were later adopted in Germany. Nachhaltend was thus the seed of what became "Nachhaltige Entwicklung", in English “Sustainable Development” (Bompan & Brambilla, 2016). The definition of sustainable development was then taken up in October 1987 by the United Nations in the "Brundtland Report", as follows:

“*Sustainable development can be defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs*” (Visser & Brundtland, 2013).

## Report “Climate Change 2021 - The Physical Science Basis” by IPCC

In August 2021 was presented the report "Climate Change 2021 - The Physical Science Basis", the first of three parts of the Sixth Assessment Report, which will be completed by 2022. The report presented by the IPCC (Intergovernmental Panel on Climate Change), an intergovernmental body of the United Nations responsible for advancing knowledge on human induced climate change, counted around 234 authors (28% womens and 72% mens) from 66 countries and it reviewed over 14000 studies. The report sounds an alarm bell about the future of the planet, by providing a clear picture of the state of the earth's health and how **human activities** are affecting the climate (IPCC, 2021).

The most important message coming from the report is that climate change, which refers to long-term shifts in temperatures and weather patterns, is caused mainly by anthropogenic activities, and humans are now the primary drivers of that change on earth. On the one hand, anthropogenic activities have converted about five billion hectares, or 38% of the global surface area, into agricultural land. Of this, about one-third is used as cultivated land, while the remaining two-thirds are grasslands and pastures for grazing livestock (FAO, 2020). On the other hand, they have moved more sediments and rocks than all the natural processes on earth. The impacts of these activities are already affecting every region on the planet and every fraction of additional warming will have multiple consequences in different ways.

According to the report, global temperature has increased more in recent decades than in past centuries. In figure 2(a), the grey line represents a reconstruction of changes in global surface temperature, while the black line is representative of direct observations between 1850-2020. The black line shows that over the last 170 years, the temperature has been increasing with increasing values compared to the average of the last 2000 years. In figure 2(b), the black line represents the average of global surface temperature changes over the last 170 years, i.e. between 1850-2020. The brown line represents a simulation of the annual average global surface temperature including both human and natural factors. The green line represents global surface temperature changes including only natural factors (e.g. solar and volcanic activity). It emerges that the last four decades have been the hottest since 1800, with global surface temperatures increasing by between 1.2 and 1.3 degrees Celsius in 2020. According to scientists, an increase above 1.5 degrees Celsius would lead to irreversible consequences.

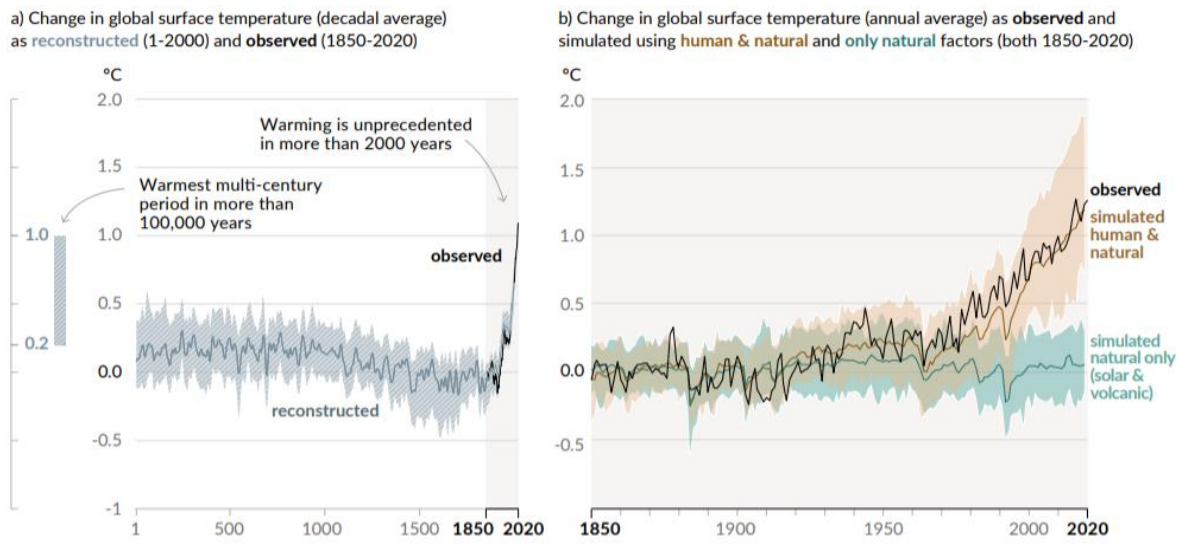


***Figure 2**: Changes in global surface temperature (IPCC, 2021)*

## Glimpse into the future

At the root of the current environmental problem lies the economic development model based on unlimited material consumption that has developed over the last few decades. Therefore, it is essential to reconsider this development model by defining new principles. Among the new

growth approaches there are two categories that deserve to be analysed in more detail: the first one, which includes Green growth and the Circular economy is still based on the concept of unlimited growth, while in the second, which includes the Degrowth and Post-growth movements, the concept underlying economic growth is redefined.

## Green growth

The main answer to the question of how continuous economic growth can exist within a finite ecological system is that of a "**decoupling**" of money growth from physical growth and its environmental impacts. The main features of decoupling are more efficient production processes, more sustainable production of goods and services. Here, the promise is that technological change and substitution will improve the ecological efficiency of the economy.

In recent years, the indicator for the absolute decoupling, situations where resources or emissions are reduced in absolute terms even though economic output continues to grow, seems not to have been achieved. In fact, although globally there have been reductions in carbon intensity, there has also been an increase in $CO_2$ emissions worldwide (figure 3), especially in Asia Pacific countries.

A deeper analysis of figure 3 shows that carbon dioxide emissions from fossil fuels have increased about threefold over the period 1965-2020. Today, they are about 60 % higher than in 1990. A major slowdown in this growth was seen in the years of the financial crisis; partly due to the fall in economic growth rates, but also to the efficiency achieved by companies in producing products and services. The countries of the richer regions such as Europe and the United States have had a more or less constant trend over the last 15 years.

However, this result is not entirely reliable. The issue is that carbon emissions are measured on a territorial basis and one of the characteristics of the modern economy is its global interconnection. Indeed, in recent decades more and more investments have been made in poorer countries, where environmental legislation is more permissive and production costs are lower. Thus, many of the products that are consumed in rich countries are manufactured in China or other emerging countries, allocating energy consumption for them production in different countries than where they are effectively consumed. We are in the presence of what George Monbiot calls a "**calculation error"** (Jackson, 2017).

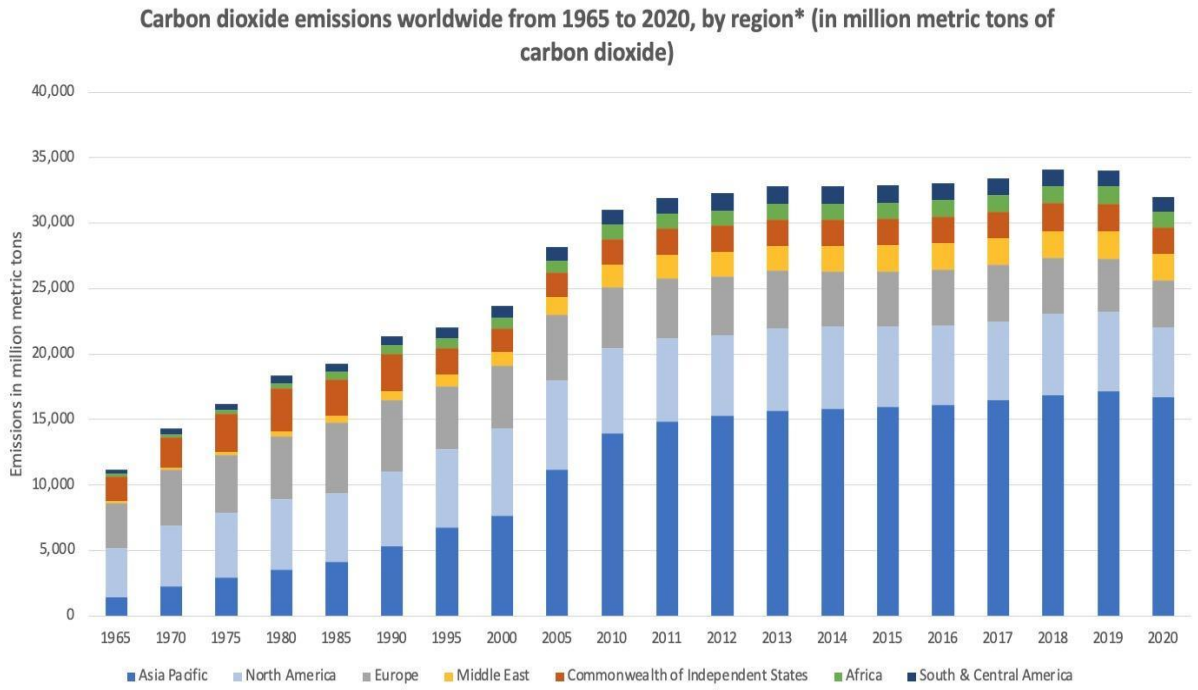


***Figure 3**: own illustration with data adapted from* (Statista, 2021)

In addition, another important comparison for an overall assessment of the effectiveness of absolute decoupling is the one between global raw material extraction and global GDP. As shown in Figure 4 and Figure 5, over the period from 1970 to 2010, the growth rates of all raw materials examined, such as zinc, copper, nickel and aluminium, increased. At the same time, the level of world GDP increased at exponential levels, slowing down the growth trend only since 2008. This comparison also confirms a lack of **absolute decoupling** (SCHANDL et al., 2016).

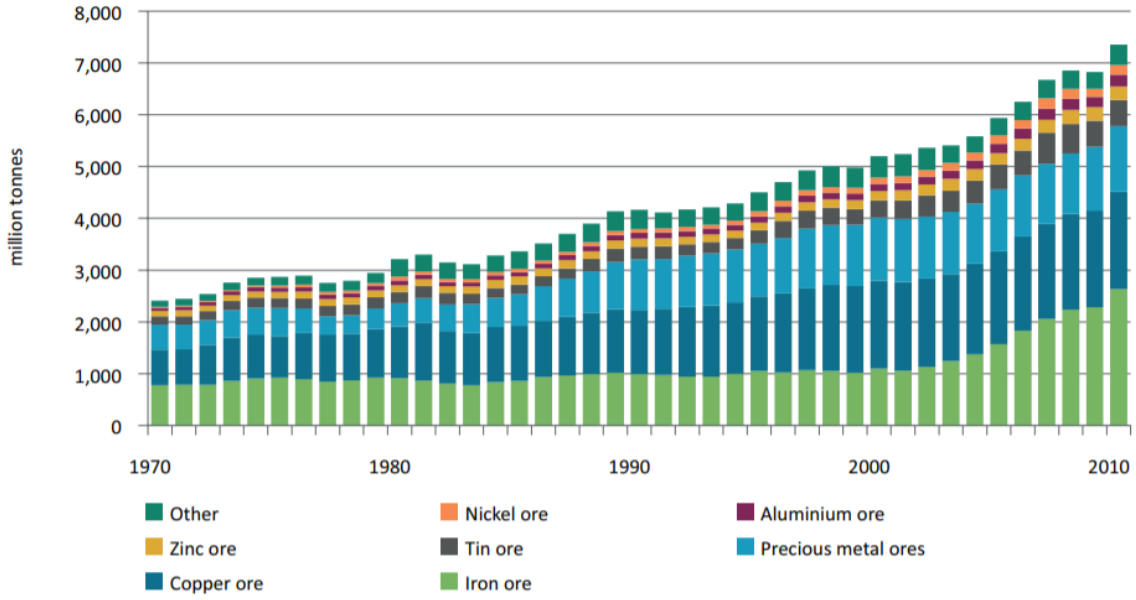


***Figure 4**: Global extraction (DE) of metal ores by material subcategories, 1970–2010, million tonnes, own illustration with data adapted from UNEP (SCHANDL et al., 2016)*

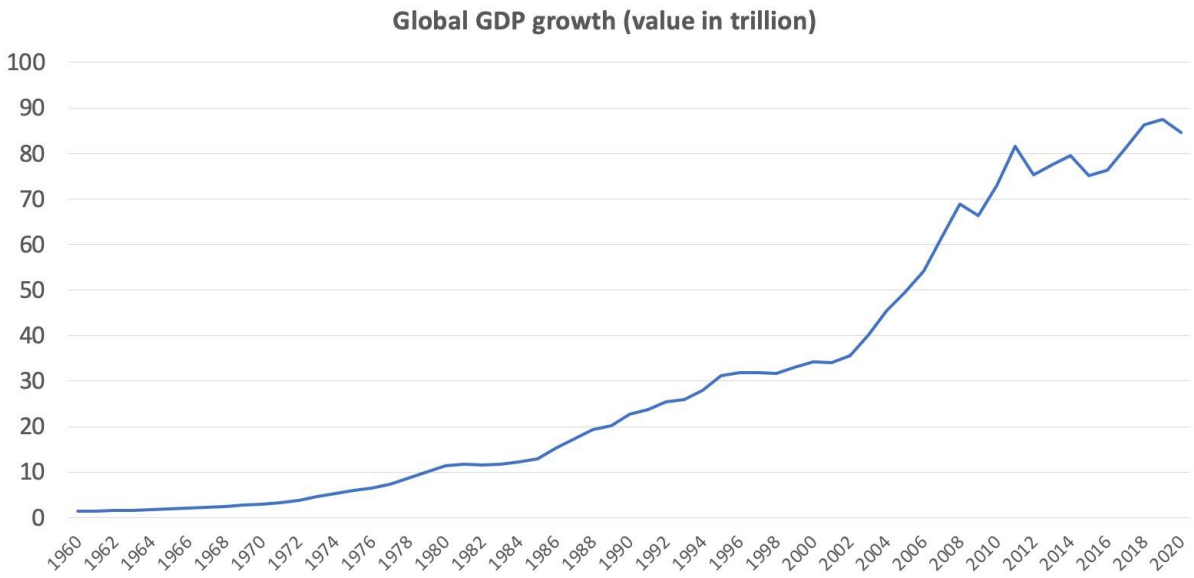


***Figure 5**: Global extraction (DE) of metal ores by material subcategories, 1970–2010, million tonnes, own illustration with data adapted from UNEP (SCHANDL et al., 2016)*

## Circular Economy

One of the most cited possible solutions is the adoption of the Circular model as a means of achieving Green growth. However, the current economy is only **8.6% circular,** leaving a huge "Circularity Gap" (91.4%) (Haigh et al., 2021). According to (Eurostat, 2020) at European level (EU-27) in 2019 the rate of circular material use, also called the "Circularity Rate", which measures as a percentage the share of material recycled and returned to the economy of total material use is about 12.5%. However, going into more detail on the issue of adopting the Circular model, there are some critical points to consider.

The first point, also supported in the interview by **Mario Pansera**, Director of the "Post-growth Innovation Lab" centre at the University of Vigo (UVIGO) (Annex 3), concerns the flow of materials. In practice, it is true that improving circularity could reduce the ecological impact of the material flow, but here it is important to understand what fraction of the total material flow has a truly circular potential. In 2005 it was found that about 44 per cent of the total material flow is composed of food and energy inputs, which are irreversibly degraded after use, and 27 per cent is net addition to stocks of buildings and infrastructure (Hickel & Kallis, 2020). It should be noted that the energy contained in fossil energy carriers, which are currently used to produce mainly energy, is released by combustion and in a highly irreversible manner. Thus, with the exception of plastics and a few other material applications where reuse and recycling practices are possible, for the group of fossil materials these are physically impossible. Furthermore, according to (Haas et al., 2015) the study calculates that if 50% of the fossil energy carriers used globally in 2005 had been replaced by solar, wind and geothermal generation, this would have reduced the volumes of materials processed by 10% and the amount of waste and emissions by 15%. The real question then is whether these reduction margins are sufficient to ensure an adequate amount of circular material for the potential new economic development model.

The second critical point is the adoption of new strategic and organisational models such as servitization. The main argument in support of this new strategy is that resource intensity will decrease as economies shift from the manufacture of material goods to services. However, an analysis of historical data here again shows that these do not currently support this argument. Indeed, according to World Bank data, as a proportion of global GDP, services grew from 63% in 1997 to 69% in 2015. During this same period, global material use has nevertheless seen

growth. This may be because services require resource-intensive inputs, or because income earned from the sale of services is used to purchase resource-intensive consumer goods. Another possible explanation is that the resource intensities of the primary and secondary sectors have increased to the point where they exceed any gains made by switching to services. Whatever the cause, to date there is no historical evidence that switching to services will, in itself, reduce the material output of the global economy (Hickel & Kallis, 2020).

The third point concerns the negative impact on companies' profit margins of certain strategies underlying the Circular model. On the one hand, closing cycles requires companies to bear downstream costs such as material recycling, while on the other, slowing down production cycles requires them to offer repair and maintenance services. Moreover, the same applies to dematerialisation and intensification of cycles, because making products more durable and replacing sales with alternatives such as renting, leasing or sharing between several consumers leads to a reduction in turnover. In this way, the business model of these companies goes against the economic principle underlying the current capitalist model, where companies minimise costs and maximise shareholder profits.

However, the current response to this problem is that this negative impact on the profitability and growth of firms can be mitigated by the business opportunities offered by these new circular business models. For example, the decline in revenue from the sale of tangible products can be absorbed by revenue from the adoption of a business-as-a-service model. Indeed, the additional costs incurred by companies to provide services such as repairs and maintenance can be covered by surcharges called "**premium prices**". It is precisely this economic increase that represents one of the limitations of the model, restricting this new type of consumption exclusively to higher-end customers, thus limiting the growth potential of this model to niche markets only.

In conclusion, the idea of merely replacing the current Linear model with a Circular one seems to be incompatible with a growing economy. Mainly because, on the one hand, most of the raw materials that enter the economic system find it difficult to be reused and recycled and therefore to re-enter the production cycles. On the other hand, because technological improvements and increased efficiency have physical ecological limits that the growth of the population and its lifestyles cannot withstand. Obviously, the concept of a Circular economy should by no means be abandoned. On the contrary, from an environmental point of view, it is crucial to pursue and

promote strategies of Circular business models, based on practices such as waste prevention and material reuse. In fact, as shown in the interviews with the two researchers from the Wuppertal Institut, Carina Koop and Jennifer Schinkel (see annexes 1 and 2), the Circular model should not be associated exclusively with recycling operations, but also with the prevention of waste creation.

## Degrowth

Among the most radical Post-growth approaches, there is one that is based on macroeconomic objectives that are reoriented towards both a fair scaling down of production and consumption and and at the same time to an improvement in well-being. This approach, which adopts the principles of the Circular economy, is denominated as "Degrowth". This terminology currently gives rise to much mistrust and confusion in ordinary society.

The key point to build support behind the concept of Degrowth is that it is in no way synonymous with economic recession, understood as that economic condition characterised by lower levels of productive activity than could be achieved by fully and efficiently using all available productive factors, and with the consequent increase in unemployment. Instead, it is a planned reduction in the use of energy and resources designed to bring the economy back into balance with the living world, so that it reduces inequality and improves human well-being.

Thus, according to Degrowth advocates, this new approach seeks to reduce ecologically destructive and socially less necessary production. Examples are the production of weapons, the excessive consumption of meat, the use of private transport vehicles and the production of goods and services through the strategy of planned obsolescence. On the other hand, the expansion of more socially relevant sectors such as health care, education, welfare and conviviality is encouraged. This new approach is about modifying consumption activities and eliminating them where they are not needed (Hickel, 2021).

At the economic level, the reduction of activity due to the lower use of matter and energy would imply on the one hand a profound reconsideration of the very meaning of doing business, which should be reconsidered around values such as cooperation, care, sharing, solidarity and a sense of community, instead of being based exclusively on profit. Thus, the achievement of social targets would also be at the core of business objectives. On the other hand, companies should

embrace the principles of durability, efficiency and prevention of material consumption that are at the heart of the Circular economy model. This reduction in economic output would also have a significant effect on the future development of GDP per capita. Indeed, this would decrease substantially due to the socioecological transformation. According to some members of the movement, this reduction should take place in a controlled manner, but above all without diminishing the quality of life and without giving rise to further social inequalities (Bauwens, 2021) (German Environment Agency, 2020).

Figure 6 shows three approaches that motivate Degrowth. There is the economic one, where it is stated that capitalism is responsible for global and intergenerational injustices. There is the cultural approach, which is based on the ideology of continuous growth, and finally the ecological approach, which accuses the current economic system of exceeding the physical limits of the planet through the exploitation of energy and raw materials (German Environment Agency, 2020).

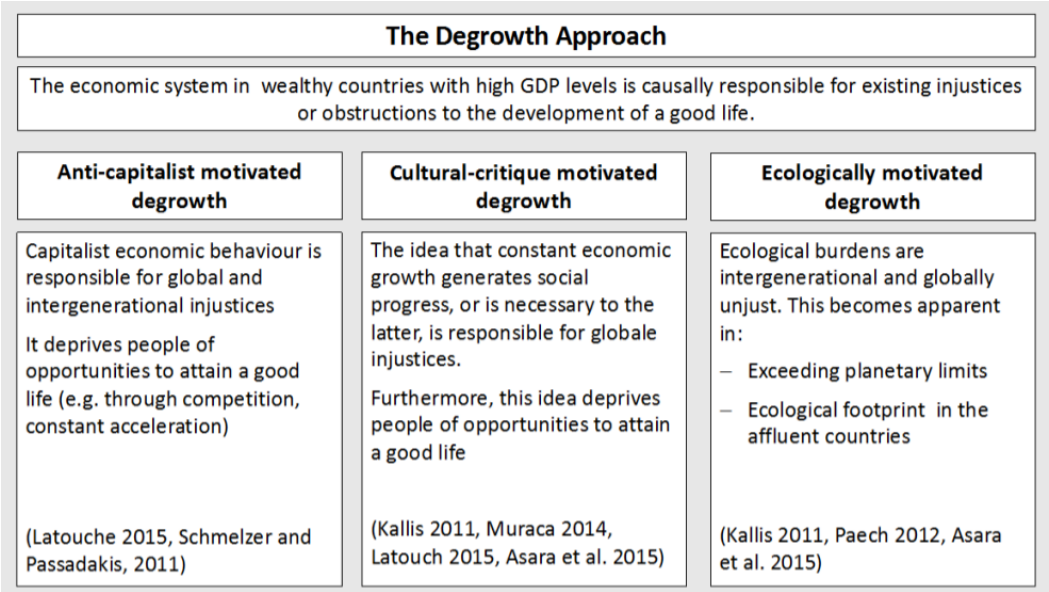


***Figure 6**: Comparison of Degrowth approaches (German Environment Agency, 2020)*

Among them emerges the ecologically motivated approach, which can be defined on the basis of two interesting relationships: the relationship between economic production and resource consumption (with the respective environmental pressures) and the relationship between economic production and well-being. The former plays a key role in justifying the Degrowth's strategy because it is based on the principles of global and intergenerational justice. However,

this strategy should ensure during its implementation that the principles of justice are respected, so that the effects of reduced economic production in rich countries do not cause even greater social inequality.

In the second relationship, supporters of the movement argue that social welfare can be increased while economic output decreases. This is because the indicator that measures economic activity, namely GDP, is not considered adequate for measuring social welfare. This is because, on the one hand, GDP includes services that do not increase social welfare, such as military spending or expenses for the treatment of illnesses. On the other hand, there are activities that contribute to social well-being but are not included in it. Examples are activities outside formal markets that influence well-being such as caring for relatives and basic daily activities. Thus, if GDP does not adequately represent some elements of social well-being, it is possible, in principle, that social well-being may increase even if it is decreasing (German Environment Agency, 2020).

There have been several criticisms of the relationship between GDP and well-being over the years. The main one is directly aimed at the thesis that well-being increases as economic output decreases. This is because there are currently no scenario calculations where the quantity and quality of well-being and consequently of the services offered are analysed in the presence of a reduction in GDP. Indeed, on the one hand, research on happiness and satisfaction which are based on the **hedonism** concept of well-being, where individual well-being is experienced in highly subjective ways and consists of experiencing as much happiness and as little pain as possible, provides no clear evidence that social life satisfaction or happiness remains constant or increases when economic output decreases. Moreover, time series for rich countries show that life satisfaction does not increase further beyond a certain level of GDP.

On the other hand, analysing the same relationship but changing the concept of well-being, i.e. selecting the one related to **values**, which consists on the realization of a list of certain values where their implementation can contribute to individual well-being, it emerges that social well-being could increase. This is because more people have the opportunity to satisfy basic human needs, guaranteeing the right to lead a decent life. Indeed, despite a reduction in GDP, some basic human capacities could be developed to a greater extent than before, for example access to nature or social solidarity. However, both a normative analysis of the degree to which the respective basic capacities need to be fulfilled for a human being to live a decent life and an

understanding of the kind of effects a reduction in GDP would have on basic human capacities are required (German Environment Agency, 2020).

One of the most important aspects of welfare is **employment**, since labour income is the main way in which most people support themselves and payroll taxes are one of the main sources by which nation States finance their public spending. The solution to these problems offered by Degrowth advocates is that the introduction of new policies with the aim of protecting workers will be of paramount importance. Some of these might be the shortening of the working week or working hours to allow more people to be employed, the introduction of a job guarantee with a decent wage, the creation of retraining programmes to move people from less socio-environmentally efficient sectors to more efficient ones, and finally the creation of jobs with low economic productivity but high social value, such as those related to health services, education and small local businesses.

Thus, the nature of employment could become more informal and less monetised, in addition to changing values related to work and social support. However, given that Degrowth is also explicitly focused on maintaining and improving the livelihoods of people adversely affected by change, some policies should include both State-guaranteed basic incomes and an employment system where it is the State that acts as an employer of last resort, especially in times of possible crisis. In this case, governments will have to cope with the increasing tax burden through a more drastic redistribution of income than is currently the case. This would entail a significant increase in taxes for those with higher incomes.

In conclusion, the link between welfare and access to wage labour in the Degrowth model may be weakened, because the new types of practices and activities based on sharing and volunteering cultivate aspects that are difficult to assign a monetary value to. Some examples are solidarity and the development of human interpersonal relations, which at the same time generate wealth shared by the different actors involved (Hickel, 2021) (Van Den Bergh & Kallis, 2012).

## Post-growth

The Post-growth movement has both common features and important differences from the three approaches mentioned above. The starting point for highlighting the principles and

dynamics underlying the Post-growth movement is through the definition elaborated by the "**Postgrowth Institute**":

"*Post growth is an umbrella term for this emerging perspective: for a way of seeing and being in the world that comes after the growth story. Just as there are many ways of living now in a growth-oriented society, a multitude of post-growth futures are possible and many ways of living post-growth already exist today. What these futures hold in common is a desire to separate good growth from bad, and to develop human potential and happiness within, and in relation to, a physically finite earth. A post growth economy puts life and everything needed to maintain it at the center of economic and social activity as opposed to the never-ending accumulation of money, and the pursuit of growth of all kinds without regard for its consequence*s." (Reichel, 2011).

As the definition shows, there are different ways of living in a context of infinite economic growth (such as Green growth) and others with respect to Post-growth contexts (such as Degrowth). The main aspect that characterises the Post-growth movements is to achieve quality growth through the creation of social welfare while respecting the limits of the ecosystem. In this new approach there are interesting differences that need to be addressed and analysed. Compared to the Degrowth and Green growth approaches, the Post-growth movement remains agnostic about the relationship between economic growth and resource consumption, because according to its proponents, to date it is not possible to know with certainty how GDP per capita would develop in rich countries if their economies were to respect ecosystem limits. It is possible that GDP per capita would increase, but it is also possible that it would decrease significantly. However, the possibility of economic output decreasing is considered a serious option.

Another important difference regarding the Green growth approach concerns the relationship between economic growth and social welfare. According to the Post-growth literature, economic growth as measured by GDP is not a complete or reliable indicator for measuring social progress, as social welfare in rich countries can increase even if GDP per capita is decreasing. Therefore, GDP per capita should not be given central importance, contrary to what happens during the current stages of designing policy measures. Finally, according to this movement, well-being needs a set of indicators that can give a broad representation of social progress (German Environment Agency, 2020).

Nowadays, one of the most interesting ideas in the Post-growth world is the concept of '**Prosperity without growth**', developed by the British economist Tim Jackson. According to the author at the moment there is still no viable, ecologically and socially sustainable scenario of continued growth in consumption and income for the estimated nine billion people in the mid-21st century. And the real issue is not whether the complete decarbonisation of our energy systems and the dematerialisation of our consumption patterns are possible: it is whether they can be implemented and diffused in our society. It is currently incompatible to assume a reduction in emissions and resource consumption without questioning the current structure of the economy based on continuous material growth.

According to him, the concept of prosperity of a country is different from the economic growth resulting from unlimited material consumption. Obviously, prosperity also has some material dimensions, such as the consumption of survival goods (water, food, clothing and housing), but it also takes into account important factors such as the level of education, health, the quality of social interactions and the ability of people to find a purpose in life.

These factors offer an extraordinary opportunity to radically change the concept of growth and invest in change by designing and implementing policies that aim to ensure enduring prosperity, understood as something that transcends material pleasures and concerns, but is based on quality of life, health and the relationships developed with others in the community. The new definition of prosperity includes the ability to fulfil oneself as a human being while respecting the ecological limits of our planet (Jackson, 2017).

Predictions about a reduction in the potential of the economy in a Post-growth world bring about important changes in the world of work. Here, the most interesting theory envisages the creation of a "**second labour market**" based on principles of sharing and participation. The aim is to create social welfare through fulfilling, sharing, participating and voluntary activities. In this new market there is also the production of numerous quality goods and services in order to satisfy some of the basic human needs. Thus, since some of the needs are already being met by these innovative types of activities, less income will be required to live in the mainstream economic system. The creation of this new market comes about through the reduction of working hours, which allows individuals to have more free time to engage in a wide range of subsistence activities and to create a new balance between self-sufficiency and dependence on others.

Currently, debates with a critical approach to unlimited growth offer mainly **three key suggestions** for reshaping employment. The first concerns changes directly to the structure of the employment sector. It envisages what is referred to as "**selective growth**", i.e. the simultaneous growth of sectors with high labour intensity but low consumption of resources and at the same time a reduction of those with low labour intensity and high consumption of resources. The result should be a shift from the sectors of the industrial society to those of the service society, with a significant reduction in resource consumption.

The second key suggestion concerns the approach of **reducing average working hours**. The basic theory is that since technological innovation increases labour productivity, employment can be kept constant by reducing working hours sufficiently. However, several studies show mixed results establishing that there is no clear correlation between the reduction of working hours and employment. Some interesting aspects that emerge from these studies are the numerous concerns on the part of both employees regarding possible reductions in real wages, and employers who are worried about poor coordination between employees resulting in a decrease in product quality.

Changing perspective, this decrease in working hours is a fundamental condition for access to the "**second labour market**". This free time could be converted into activities oriented towards individual and collective well-being. At the same time, factors such as democracy could also be strengthened, as people would have more time to inform themselves and become involved in democratic processes. Furthermore, this reduction in working hours should be accompanied by a change in consciousness and values, in order to prevent this free time from being devoted to materialistic attitudes. In conclusion, to date the complex effects of working time reduction show very heterogeneous results and therefore need to be further studied and investigated.

The last suggestion concerns the **dependence on labour income** and here the Post-Growth movement mainly provides two approaches: the first is based on the notion that a society needs fewer and fewer workers as labour productivity increases and at the same time economic output remains more or less constant. Therefore, one possibility is that in order to have a greater redistribution of national income an unconditional basic income (UBI) can be used, in which every citizen receives a basic income without providing any services in return.

The second approach, on the other hand, aims at creating the conditions under which citizens can satisfy some of their needs in the secondary market, thus reducing their dependence on monetary income. Here, the basic idea is that needs can be met collectively without any obligation to pay for them, as in these cases the use of a product is not always linked to a monetary transaction. Moreover, this approach creates the right conditions for reducing the amount of products and services needed, since their use is shared among several consumers (sharing economy) (German Environment Agency, 2020).

## Journey into space

In 1966, Kenneth Boulding was one of the first to grasp the urgency of changing the current development models of countries, because they were considered unsustainable in the long run. According to Boulding in his "**Spaceman Economy**" the earth is compared to a single spaceship where the availability of everything has a limit. These relate to the availability of raw materials, the capacity for waste management, and where it is necessary to create the right conditions for the continuous regeneration of materials, while respecting the constraints of the closed ecological system. Within this closed environment, humans must be able to reproduce and adapt through the exploitation and transformation of inputs such as air, energy, food, water and manage the subsequent outputs in a correct and sustainable way.

At some time, the US space race was born out of fear and competition with the USSR during the Cold War. The desire and need to beat the opposition galvanised one of the most innovative ventures in history. At the time, there was the possibility of a new military confrontation, and the USSR (Union of Soviet Socialist Republics) had a distinct advantage in the development of space technology. Indeed, in 1957 the USSR sent the first artificial satellite to orbit the earth and in April 1961 Jurij Gagarin became the first man to orbit the earth in the Vostok 1 capsule.

The USSR's advances in space technology increased American fears of technological and military defeat in the event of war. Thus, in the 1960s, the American government, through close cooperation between the public and private sectors, succeeded in carrying out the "**Apollo Mission**", which was considered impossible at the time, since humans had not yet developed technologies suitable for such an undertaking. The mission had the ambitious goal of sending the first man to the moon and bringing him safely back to earth within a short and precise time frame. It was President Kennedy, who despite the criticism he received for the high cost of the

mission, managed on the one hand, to create a strong sense of urgency derived from the strong competition with the USSR, and on the other hand, to set a highly ambitious and challenging goal. These two factors led to the **success of the mission** (Mazzucato, 2021).

The Apollo mission contributed to a general technological development and the creation of multiple spillovers in many economic sectors, such as IT, aeronautics, electronics, nutrition and materials. Nowadays, the space sector can once again play a leading role, as it represents on the one hand an excellent point of inspiration for the development of circular practices such as prevention, reuse and recycling of raw materials, and on the other hand, as explained by European Space Agency astronaut Luca Parmitano (annex 4), it is physically possible to live using a limited amount of resources.

## The role of the State in the Post-growth

Just as it did in the 1960s with the Apollo mission, the State nowadays does not have a plan oriented towards the new mission of sustainable and inclusive growth. However, despite often being seen as part of the problem rather than the solution, most of the concrete policy proposals put forward by growth-critical scholars are traditional 'top-down' and thus State-led measures. The top-down aspect of this transition would presuppose an "**Innovative State**", i.e. an interventionist one, with large public investments, State-owned banks, subsidies and other incentives for private investments, and more regulation through the implementation of new policies (Koch, 2020).

The lack of a blueprint to follow creates the conditions for the conceptualisation of a more resilient approach oriented towards a process of seeking new options for development and action. It is therefore clear that it is not a matter of pursuing a single specific path of change, but rather of developing "pragmatic" action-oriented strategies, corresponding to a "policy mix", which refer to appropriate and mutually compatible elements of different strategic approaches. Moreover, these strategies must also have the characteristics to be implemented immediately. This approach is redefined as "**Post-growth precaution**".

The integrative term "precautionary" is justified because it seeks to transform socio-economic institutions as far as possible so that they are able to function adequately in situations of declining GDP due to a downsizing of the economy. This transformation implies their

independence from growth and represents a real political challenge to create more resilient socio-economic institutions. It is precisely the expectation of making central institutions **independent** of economic growth that is the first policy recommendation of this new approach. This is because only a change in these institutions would make it politically possible to adopt measures aimed at reducing environmental pressures, with the consequent effect of significantly reducing resource consumption in rich countries.

The second recommendation considers the conceptualisation of social welfare as a political challenge. This could provide the basis for the creation of development strategies and paths that are both respectful of the planet's ecological limits and careful not to significantly reduce current levels of well-being. This is undoubtedly a challenge that presents many obstacles, first and foremost those related to the social-economic effects of changes in the employment sector.

However, these two recommendations are complementary because, on the one hand, greater independence of institutions from economic growth can ensure social welfare even in times of economic recession, but, on the other hand, this requires the guarantee of the provision by the State of specific basic goods.

In addition, according to the Precautionary Post-growth approach, public institutions play a major role in the transition. They have at their disposal **three key elements**, which are regarded as fundamental for the development of a new sustainable path. These are:

- ➢ the creation of an economic system compatible with planetary limits
- ➢ new research processes oriented towards the creation and implementation of socioeconomic development paths
- ➢ guaranteeing socio-economic institutions independence from economic growth (German Environment Agency, 2020).

The first action is to bring the economic framework conditions in line with the respective ecological objectives set. There are market-based economic instruments such as cap and trade systems or eco-taxes such as the carbon tax, which are indispensable to allow the internalisation of environmental damage resulting from production and consumption activities. Obviously, in order to be effective, these instruments must also be accompanied by a cultural change towards a lifestyle characterised by a lower consumption of material resources.

The second key element involves the exploration and design of new pathways for the development of society, given that to date the concept behind this approach has no solid premises regarding specific and desirable "final results". In order to design and implement these pathways, it is necessary to initiate a participatory process based on principles such as precaution and social resilience, as these are indispensable elements to support public actors and stakeholders in dealing with difficult and unpredictable situations.

One of the ways to enable these potential new sustainable development paths is through participatory social research processes, experimental spaces and new approaches to research and innovation policy. Precisely in the context of innovation policy, there is an active debate at European level regarding the concept of "Big Challenges", which at the same time introduces a certain directionality into innovation policy. Finally, the approach of exploring and designing new avenues of social development is linked to the fact that GDP growth should no longer be seen as the dominant social objective. Instead, the focus should shift to other indicators that take into account other relevant social aspects.

The third and final aspect involves the growth-independence of key areas and institutions of society in order to increase the resilience of social systems. This is because with greater independence from growth, the effectiveness and consequently the acceptance of policy measures oriented towards environmental protection would increase. However, to date this innovative type of differentiation has only been realised in small subsections of society and implemented through a series of small experiments with a low success rate. Consequently, further experiments are certainly called for (German Environment Agency, 2020).

With these three key elements on the agenda, the State has the opportunity to design **new missions** oriented towards fulfilling the principles of Sustainable development. The development strategy must therefore first be tested and then implemented by means of well defined strategies and policies capable of enabling society to adopt practical and convenient alternatives. These transition and development policies must be the result of collaboration between various responsible stakeholders, including policy-makers, institutions and business sector. The aim of the policy-maker is to create a vision in the market in order to foster the predictability of private investments.

# Conclusion

This paper has attempted to analyse and understand, through the analysis of the economic development model based on continuous growth, the complex dynamics underlying the current environmental problem. Business as usual has been shown in recent decades to guarantee prosperity to only part of the population based on ecological destruction and social injustice. What emerges from this work is that the future economy cannot be linked to the production of material goods as we understand it today, as this would compromise the ability to respect planetary boundaries. This is what emerges clearly from the IPPC report, which shows that **human activity** is primarily responsible for climate change on earth.

Society therefore has the data at its disposal to understand the environmental problem and act immediately towards planning a new sustainable economic system. The main response to this problem has been the adoption of the **Green Growth** strategy, based on the concept of decoupling economic growth from the exploitation of raw materials. However, as has been shown, given the short timeframe available, this approach has so far failed to meet the ambitious environmental objectives. Moreover, the choice of this option represents a real gamble on whether the technology will be able to innovate and achieve decoupling before the environmental system passes the tipping point.

In recent years, Green Growth has also been complemented by the concept of **Circular Economy**, theorising that the linear development model can simply be replaced by this new economic model. However, the analyses carried out in this thesis have shown that there are important limitations, first and foremost related to the flow of materials. In fact, in this case not all the materials that enter the production process can be reused, so it is necessary to introduce new raw materials to keep the system running. Again, given the limited resources of a finite ecosystem, the incompatibility with a growing economy is obvious. However, the concept of a Circular economy should by no means be discarded. On the contrary, from an environmental point of view, it is essential to pursue and promote strategies of circular business models, because they are more sustainable than linear ones.

This extraordinary opportunity to radically transform the concept of growth offers and demands from society a major collective effort needed for lasting prosperity. This concept of prosperity

refers to something that transcends material pleasures and concerns and is based on the quality of life, health and relationships within the community. These new required approaches are based on the **Ecological Economy**, an economic system that encompasses on the one hand the circularity of materials, through which the most value is extracted from each resource used in the production process to reduce the impact of human activities on the ecosystem, and on the other, the creation of prosperity through social activities.

In recent years, the two most relevant approaches have been **Degrowth** and Post-growth. The first one, despite being perceived negatively by the population, aims at achieving a planned reduction in the use of energy and resources, in order to bring the economy back into balance with the living world. According to the advocates of Degrowth, this new approach seeks to orient economic production towards environmental and social improvement. Of course, this downsizing of economic production would also have a significant effect on the future development of GDP per capita, which should follow a controlled reduction path, avoiding a decrease in quality of life and an increase in further social inequalities.

The main criticism of this movement is directed at the thesis that welfare increases as economic output decreases. This is because there are currently no calculations of scenarios where the quantity and quality of well-being and consequently that of services offered in the presence of a reduction in GDP are analysed. Indeed, on the one hand, the concept of welfare hedonism does not provide any clear evidence that social life satisfaction or happiness remains constant or increases when economic output decreases. On the other hand, the improvement of well-being seems to be possible only if it is understood as the possibility to satisfy the basic human needs of individuals. Again, further normative analysis is needed, both in terms of the degree to which the respective basic capacities must be met to ensure a decent life for a human being, and in terms of what effects a reduction in GDP would have on basic human capacities.

The **Post-growth** movement, on the other hand, is not yet well structured and does not have a fixed path to follow. Many of the aspects are being defined and further experimentation is needed. However, the basis of this approach is defined by the desire to separate good growth from bad (selective growth) and to develop human potential and happiness within a physically finite earth. Thus, although to date this model remains agnostic about the relationship between economic growth and resource consumption, a decline in the value of GDP as a result of reduced economic output is seen as a serious possibility.

Like Degrowth, the Post-growth approach considers the GDP indicator as incomplete and unreliable for measuring and assessing social progress. In fact, additional indicators are required that also take into account both socio-environmental and interpersonal aspects.

The basis of this movement is well represented by Tim Jackson's concept of "**Prosperity without growth**", in which the prosperity of a country is defined differently from the economic growth resulting from unlimited material consumption. The new definition includes the development of social well-being understood as the ability to realise oneself as a human being, both individually and within one's community, while respecting the ecological limits of the planet. From this aspect, it is important to increase the performance of activities oriented towards personal growth, volunteering and the sharing of goods and services. This change is achievable through the creation of a non-monetised 'second labour market', which aims to develop the social well-being of those who participate in it and to offer goods and services for the satisfaction of primary needs, thus making individuals less dependent on the main market.

Any economist of the past could not have imagined the current environmental and social situation that this unlimited growth has caused. And that is why humanity must not allow itself to think with the same mentality that was behind the creation of the problem. At present, this generation is the first to face such a great challenge, similar in some aspects to that of the Apollo Mission, which in 1969 successfully achieved its goal of landing a man on the moon for the first time and returning him safely to earth.

On the one hand, the similarities with the Apollo Mission are to be found in the fact that, to date, the new Mission, which envisages the creation of a sustainable economic system, appears to be "**utopian and impossible**" as at that time, since there is still no ready-made blueprint to follow. Despite this, the space sector would once again appear to play a leading role, thanks to the '**Spaceman Economy**', an economic system developed by the British economist Boulding, in which the Earth is compared to a spaceship and where throughput is perceived as something to be minimised rather than maximised. Indeed, in these contexts, added value is not only given by the quantity of goods and services produced, but also by their quality and sustainability.

The specific case of the ISS, as explained in the interview by **Luca Parmitano** (annex 4), certainly represents a first point of inspiration for the development of alternative movements

to unlimited growth. In this context of a closed environment with limited resources, the life of astronauts is allowed both thanks to the circularity of materials and elements such as oxygen and water, and thanks to personal fulfilment through the realisation of their own daily project.

On the other hand, there are interesting differences: unlike the Apollo Mission, where the problem was strictly related to the technological factor, nowadays there are many more aspects that influence the final result. These include political, technological, environmental, social and economic factors.

Underlying the framework that ensured the success of the Apollo Mission in 1969 was the concept of 'mission oriented'. This envisaged that the given State, both its potential and capacity to drive transformation on the scale needed and to reshape the way economic organisations are governed, would play the leading role. Underlying the concept of Mission are investments seen as the relationship between the present and the future. On the one hand, public investments have the potential to steer the market in the direction of safeguarding the principles of sustainable development. In fact, if they are made at the beginning of the innovation phase, they absorb the great uncertainties and long-term risks that private investors, being exclusively profit-oriented, are not willing to take on. On the other hand, there are the private ones, which, thanks to the support of the public ones, are able to develop and grow.

Finally, as a starting point, the State has three key elements, considered as fundamental points for the development of a new sustainable pathway: the first involves making the economic framework conditions in line with the respective ecological goals set. Here there are instruments such as the carbon tax, which help to internalise the environmental cost arising from a certain type of production and consumption activities; the second involves exploring and designing new pathways for the development of society, as to date the concept behind this approach has no solid premises regarding specific and desirable " final results ". In order to design and implement these pathways, it is necessary to initiate a participatory process and carry out new experiments; the last aspect involves the independence of key areas and institutions of society from growth, in order to increase the resilience of social systems. This is because greater independence of institutions from growth would make policies aimed at reducing environmental pressures both more effective and more politically accepted.

In conclusion, the end of the economic system based on unlimited growth brings with it numerous challenges and complex dynamics unlike anything human society has ever experienced. An immediate response oriented towards the creation of new development paths is absolutely necessary to find out what the future challenges will be. Certainly, the fact that Post-growth movements are designed and structured in such a way that they do not require continuous growth and at the same time provide justice and prosperity even when productivity declines, **suggests** that future prosperity is to be searched in this direction.

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# Annex 1

**Interview with Carina Koop**

**Date:** 24/11/2021
**Interviewer:** Turrini Stefano
**Interviewee:** Carina Koop
**Profession:** Researcher at the Wuppertal Institut; Division: Circular Economy; Research Unit: Material Loops

**1) What challenges will the circular economy face during its development?**

The first challenge is that often the Circular economy model is equated just with recycling, but there is a need for much more education here. Circular economy is understood to mean more, because there are processes that come before recycling in the waste pyramid i.e. reuse, prevention and remanufacturing. So, there is a lack of a unified definition of CE.

From the literature the other interesting challenge is the benefits to the society as a whole or the increase in people's well-being are missing from CE, so the new concept of the Circular Society is currently being discussed. There are opposing views in the literature on whether the Circular Economy should include social dimensions or not. The debate emphasizes that the concept is limited to circulating resources and extending the life of products, and essentially focuses on transforming the economic system. The benefits for society as a whole or the increase of people's well-being are aspects that are hardly dealt with in the CE.

It is argued that the discussion of CE to date represents a truncated view of the role of citizens and that engagement with new ideas such as the "**Circular Society**", is important if the Circular economy is to be further advanced by the EU as a key policy objective. The term "Circular Society" is used to delineate discourses that consider a holistic societal transformation in which not only resources but also wealth, knowledge, technology and power are managed in sustainable cycles.

**2)How developed is the principle of prevention? What are its challenges?**

Waste prevention is at the top of the waste pyramid. It is increasingly established e.g. there have been developed many waste prevention concepts. However, in people's minds, prevention

is still very much associated with the concept of **renounce**; here it is important to focus more on the opportunities offered by waste prevention and to communicate it less as something to abstain from.

Of course there are also some challenges that make waste prevention very difficult to grasp, one of them is the lack of measurability. It is difficult to prove what has been avoided, as it is of course easier to measure recycling quantities on a large scale.

## Annex 2

**Interview with Jennifer Schinkel**

**Date:** 24/11/2021
**Interviewer:** Turrini Stefano
**Interviewee:** Jennifer Schinkel
**Profession:** Researcher at the Wuppertal Institut; Division: Circular Economy; Research Unit: Material Loops

**1) What challenges will the Circular economy face during its development?**
My answer refers in particular to the Circular economy in the field of packaging. The focus here is often still on **recycling**. The prevention of waste, which has the highest priority according to the Waste Hierarchy of the EU and the German "Kreislaufwirtschaftsgesetz", has not yet been given the highest priority in practice. The volume of packaging waste in Germany is rising continuously and reached a new high in 2019. Reasons include changing consumption habits (e.g., increased out-of-home consumption, mail orders, etc) and smaller households, as well as the increasing functions that packaging fulfills. These changing conditions and challenges must be taken into account when adopting measures and creating policy frameworks to strengthen the Circular Economy in the packaging sector.

In the area of recycling of packaging, challenges still exist when packaging is designed in a way that makes it difficult or impossible to recycle (e.g. multilayer packaging, black dye packaging). Furthermore, it is a problem that sometimes packaging is changed to supposedly

more environmentally friendly packaging, which, however, can be worse from a resource point of view (this can be the case, for example, when using paper instead of plastic). Another challenge is that it is necessary to involve actors from the entire value chain to ensure circularity.

**2) Are the EPR systems developed worldwide and in particular in Europe efficient? Do they take into account the principles that are at the top of the waste hierarchy issued by the European Commission?**

In the project "STyMIE. Screening the Efficiency of Packaging Waste Management in Europe", it was found that the data situation for assessing the efficiency of EPR systems remains poor. There is evidence that, in some cases, collection and disposal costs for producers are still not aligned in a way that incentivizes the consideration of environmental aspects. However, in some cases, approaches to promote material efficiency or waste prevention are being set or planned. These include, for example, choice and weight of packaging, recyclability or share of recycled materials.

At the EU level, it was also decided within the framework of Extended Producer Responsibility, that manufacturers of single-use plastic products will in future cover the costs for collection and clean-up of their products in public areas, as well as costs of awareness raising measures (Article 8 Single-Use Plastics Directive).

## Annex 3

**Interview with Mario Pansera**

Date: 10/02/2022
Interviewer: Turrini Stefano
Interviewee: Mario Pansera Profession: Director of the "Post-growth Innovation Lab" centre at the University of Vigo (UVIGO)

**1) What is your background and what are you working on at the moment?**

My initial background was as an engineer. Later, I decided to investigate the sociology of technology and innovation theory. Then I did a PhD in England where I focused on analyzing

what is the narrative behind technological development, i.e. what is the basic idea that directly drives innovation.

I'm currently managing as a coordinator the H2020 project called "JUST2CE" and I am director of the "Post-growth Innovation Lab" at the University of Vigo (UVIGO). Here we mainly deal with topics related to science and innovation in a post-growth world.

**2) In your opinion, what is the real problem behind the environmental issue?**

To date, we know that the economy is a subsystem of the biosphere and the planet and that it depends on all the mechanisms that sustain life such as energy and raw materials. We also know that the idea of an economy that extracts resources, produces pollution and waste is not sustainable over time, and this model must be replaced with one that does not have maximizing economic activity as its ultimate goal.

The issue is not scientific knowledge, but the fact that the economy is not managed on this science's knowledge. To date the rules of economy, for example those concerning supply and demand or the fact that human beings decide rationally to maximize their own utility, are postulates that serve to maintain a status quo, and are not used to make predictions about how economic systems will sustainably function in the future. Moreover, these theories are so entrenched that they influence political decisions.

This is a problem, on the one hand, material scientific evidence argues that the economic system can no longer grow indefinitely, and on the other, political and cultural hegemony claims that problems related to social and environmental issues are solvable through technology, i.e. through the phenomenon of decoupling. However, analysis of current data shows that decoupling is not currently feasible.

This situation creates the conditions in which people whose task it is to create economic policies always focus on the same concepts. The first starting point was sustainable development, then Green growth, then eco-innovation and now the Circular economy. Personally, I am convinced that today we have the technology to reduce, for example, greenhouse gas emissions. So the question is purely political. In fact, focusing on technology and the circular model has the effect of distorting attention from the real problem.

**3) Why do you think the linear model cannot simply be replaced by the circular model?**

First of all we need to understand what is meant by the term Circular economy. This is because an analysis of the European Union's Circular Economy Action Plan and various documents of the Ellen MacArthur Foundation shows that this is represented as a more advanced way of recycling materials.

To answer the question, on the one hand the linear economy is a system designed to create waste which is no longer sustainable today. On the other hand, the Circular economy, despite promoting principles such as waste reduction and prevention, seems to be implemented to date with the aim of giving value to waste. Thus, instead of trying to develop a serious reflection on why the system is designed to produce waste, the current priority of the circular model remains that of profit maximization and capitalist accumulation.

More specifically, there is also a problem of the physical impossibility of the Circular economy. This is because the economy is an open system, which needs energy and raw materials to function. Being a system with a metabolism similar to that of human beings, it is dissipative, i.e. not all the materials included in the production process can be reused. This is the main criticism of the Circular economy model from the world of ecological economics.

Thus, the problem is that this circular model is not compatible with an infinitely growing system. This is because the production system will always need the inclusion of new material. I agree that, through prevention and recycling, it is possible to delay the problem, but I don't think this is enough to eliminate it. For example: imagine a boat going in the direction of a cliff: it is true that you can slow down its speed but in the end, if you want to avoid a collision, you have to change direction.

**4) What is the status quo of Post-growth movements?**

Since economic growth is no longer yielding benefits compared to previous decades, we need to rethink a model that is capable of decreasing economic activity while maintaining or potentially increasing well-being. I personally see no difference between the Post-growth or Degrowth models.

The only difference is that the Degrowth model today is very much feared by the population. Essentially, when referring to the Post-growth concept, there is less emphasis on decreasing

economic activity and more focus on replacing the growth target with other ones. Some examples of these are ensuring a quality level of public education, access to efficient health care, and meeting food needs for all. However, this will entail the need to reduce some types of economic activity, although it is not yet clear how this will be achieved.

**5) In my thesis, I analyze the Apollo mission and the fact that it was a success thanks to the State's leadership role. Do you think it is preferable to adopt a similar approach, i.e. top-down?**

Certainly the role of economic planning is vital. However, to date it is seen as the result of State "control" and therefore perceived as inefficient. I agree that some solutions can be found through top-down planning mechanisms. The key point is to understand what is meant by the term "top-down" and especially who is the body that ultimately decides. I think there is much to think about whether it should be a technocratic core of the European Union or a group composed of informed citizens in a participatory form who take the decisions.

With regard to Mariana Mazzucato's book, I agree that the State is the main driver of innovation through investment. In my opinion, however, it is also important to analyse the political and controversial aspects behind the choice of which type of technology to use.

**6) What do you think about the role of education systems? How much can they contribute to the new change of mentality?**

Certainly one of the components of the change of mentality must be to break the neo-liberal cultural hegemony in the universities. This is because the concepts that are taught are considered by students as an objective reality. So I think that the education system is a fundamental first step, especially from a political and future perspective.

**7) You have participated in a project in Bolivia, where the aim was to provide solar panels for the production of electricity for indigenous people? Can you describe it?**

I participated in an international development cooperation project where the objective was to install solar panels for electricity production in schools and hospitals. Here, the dilemma I faced was: does the solar panel solve the problem of the population that does not have access to basic services in Bolivia or is it functional for European industry that needs to look for new markets to sell new products? In my opinion, most of these projects are more functional for the industry than to solve the problem of a single native community.

As Wolfgang Sachs, one of the founders of the Wuppertal Institut, has said, the idea that richer countries bridge the gap in the development of poorer countries by sharing technologies is an extremely racist idea that has not worked so far.

**8) If rich countries decide to reduce economic growth to enable poor countries to develop their economies, do you think it would be fair to share existing technologies?**
This is a very interesting question. The Post-growth and Degrowth movement absolutely does not think that underdeveloped countries should remain in their current conditions. When we talk about Degrowth, we mean that of the industrialized world, referring to societies that consume too much compared to what they should consume to be healthy. Certainly, in order to achieve certain levels of well-being, poor countries need economic growth as we understand it today.

However, if this economic growth were to be achieved with technologies that have been designed on the basis of Western values and worldviews, I think the issue would need to be explored further. For example, I think that some shares such as the solar panel are of fundamental importance. On the other hand, for example Google's machine without a conductor, which in the first prototypes was not able to recognise black skinned people because the programmers had trained the algorithm exclusively with photos of white people, makes us reflect on how technology is not neutral but develops from the ideas and mentality of its creators.

In conclusion, while it is essential to export the technology, it also requires an element of reflection on both its characteristics and principles.

## Annex 4

**Interview with Luca Parmitano**

Date: 04/02/2022
Interviewer: Turrini Stefano
Interviewee: Luca Parmitano Profession: Astronaut at the European Space Agency (ESA)

**1) During the space missions, the resources to which astronauts have access are limited, how important is their reuse? Can you give some practical examples?**

To date, unfortunately, the ability to reuse resources in the space sector is very low for basic materials. However, as far as instruments and experiments are concerned, the usual practice is to reintegrate the materials used, trying to avoid any kind of waste. For example, a particular search in a particular field is planned, it will be repeated over time, then this will be reproduced in a modular way, so that part of the material used in the on-board experiment is taken back and reused in subsequent experiments.

**2) How do recycling operations work on the International Space Station (ISS)?**

At the moment, the only real recycling is in the atmosphere, using gasses such as oxygen. Inside the ISS we have a system of "Scrubbing" of carbon dioxide, which removes carbon dioxide 74 and produces oxygen, which is then returned to the atmosphere for reuse. This procedure saves resources by reducing the amount of gas refueling from Earth to the ISS. A similar procedure also takes place in transport shuttles, although in this case it is not a question of actually recycling the components of the atmosphere, because the carbon dioxide is captured by special filters, thus creating the conditions for extending life in the capsule.

To date, the best recycling system, in the sense of the circuit in the ISS, is certainly the one of water. About 92-95% of the water is recycled through the collection of urine and humidity (sweat and respiration). There are two systems available: the main one consists of in a series of filters that mechanically remove all impurities from the water, with a final check to ensure that it is perfectly neutral. Water without any impurities is demineralized and distilled. However, due to the impossibility of reaching certain temperatures, the distillation process does not take place thermally but mechanically through filters. At the end of the process, mineral salts are added. Thus, the final result is a very pure and drinkable water.

Recently, a further "brine filter", also linked to urine, has been added in order to increase the recycling rate of the water. The reason for this is that once the urine has been processed to remove the water, there remains a granular part in which water is still present. The new system then heats up what is left over from the first filtration system and extracts the last remaining amount of water.

As far as solid waste is concerned, a closed recycling system has not been developed yet, nor has any machinery been brought on board to try out recycling on an experimental basis. Only 3D printers and a biofabricator, capable of reproducing biological tissues, are present at an experimental level. As for the possibility of incinerating waste inside the ISS, this is an extremely sensitive issue for safety reasons.

**3) In the space sector, how important are factors such as eco-design when designing modules and machinery?**

The terminology used to describe these operations in the ISS is Orbital Replacement Unit (ORU). There are two systems of eco-design: the first is for facilities that have a life expectancy and involves replacing broken or malfunctioning components. In this case, instead of changing the whole system, only the defective part is replaced, as the entire system has a specific life expectancy.

An even more intelligent aspect is modularity. This has been taken into account for both existing and future habitats. In this modularity concept, standardized support systems are designed, which can be readapted and reused for many types of experiments, to which electricity, data and a variable atmosphere are supplied, giving the possibility of introducing oxygen, nitrogen and other types of gasses.

**4)In your opinion, again with a view to circularity, what could be some of the technologies or best practices from the space sector that could be applied on earth?**

The first obvious step would be to build houses with solar heating and solar panels to produce electricity. This should take place in countries such as Italy or throughout the southern hemisphere (below 45 degrees).

In the specific case of the ISS, it is completely powered by solar panels. In the non-insulated part, lithium accumulators (technology that won the Nobel Prize three years ago) have been installed. So the first technologies that absolutely need to be implemented are solar resource recovery and energy distribution.

Subsequently, not only water recovery and recycling systems but also water revitalization systems are needed. Even today, most of the wastewater is discharged in an uncontrolled way instead of being managed through plants which, with appropriate filtering operations, would

allow its recovery. Whatever the investment in water recovery is, the future return will certainly exceed the initial investment.

In summary, water recovery and the use of renewable energy (particularly solar energy) are the first two aspects to be implemented on earth. Moreover, these have become increasingly convenient given the continuously decreasing costs and the high level of technology currently available.

Lastly, a judicious use of available resources is also essential. On board the ISS, the astronauts learn that it is possible to live with extremely limited resources - it is just a matter of habit. For example: on Earth, people are used to excessive consumption in daily hygiene and extensive use of available resources. Even if they are small gestures, when considered over a lifetime and multiplied by a large number of people, they have a big impact.

**5) I read that you carried out experiments on biological fuels during your time on the ISS. What is this about?**

It's an experiment from 2013 called "Green Air", so it's almost 10 years ago now. Basically, it was about combustion in orbit: it involved burning biofuels by varying the amount of fuel and comburent to see what stoichiometric ratio would make the exhaust less toxic, so the search was on for a technology that could release as little harmful exhaust into the atmosphere as possible. This was the basis of the Italian Space Agency's 2013 experiment.

**6) In my thesis I argue that well-being is not always related to the consumption of material goods. Other aspects such as self-fulfillment and one's relationship with others also play an important role. During your long stay on the ISS, what did you learn from being forced to consume less? How did you feel?**

I believe that well-being is never related to unrestrained consumption of resources, otherwise the rich would always be happy: but as can be ascertained, this is not the case. In my opinion, part of personal well-being is related to self-satisfaction and self-realization, whatever the direction taken for this personal fulfillment. You don't have to be an astronaut, you can be a researcher, an engineer, a cook: whichever way you manage to realize your daily project, that is the first step towards well-being. The second step is relational, i.e. how one relates to others.

So, once again, I repeat that well-being and happiness are almost never linked to the waste or abuse of resources: on the contrary, it is essential that these are used in a shared way