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## New BIOTECHNOLOGY

journal homepage: [www.elsevier.com/locate/nbt](http://www.elsevier.com/locate/nbt)Biodiplomacy, the new frontier for bioeconomy<sup>☆</sup>Alfredo Aguilar<sup>a,\*</sup>, Christian Patemann<sup>b</sup><sup>a</sup> Chairman Task Force Bioeconomy, European Federation of Biotechnology, Head of Unit Biotechnologies, ret., European Commission, Brussels, Belgium<sup>b</sup> Director, ret., European Commission, Member of the 1<sup>st</sup> German Bioeconomy Council, Germany

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## ABSTRACT

Most of the initiatives to adapt, reduce and mitigate the effects of global challenges of our planet are currently dominated by the consequences of climate change. These are unintentionally overshadowing others such as food security, increase of human population, preservation of natural ecosystems, water scarcity and reliability of energy supply, amongst others. This fact tends to obscure the reality that most, if not all the global challenges, are closely interdependent and need a holistic approach to deal with them in a coherent and effective way. Likewise, society at large must be made fully aware that there will not be an enduring solution unless there is a change in the level of consumption of goods and energy in affluent countries. There is an increasing perception, understanding and concern in academic circles as well as in other sectors of society that the unsustainable production and consumption of natural resources need to be tackled by novel approaches. These combined efforts should ensure that they will be enacted in policy initiatives and in the actions that pave the way to building a global biodiplomacy. This new biodiplomacy should have the courage to develop and act in the interests of the human population overall, and not be undone by the legitimate but narrower interests of any single national priority. This article concludes by highlighting some of the key elements needed to give a biodiplomacy a chance to address, effectively, responsibly and synergistically, the current global challenges that affect mankind.

## Introduction

*"The world needs more diplomacy". Stuart Beare, Lt.-Gen. (Ret'd)*

Mankind is currently confronted with several global threats related to climate change and the biosphere which are coincident in time, interdependent and synergistic in their effects. There is a consensus that the world's greatest threats or challenges are beyond the ability of any one nation to confront them alone, needing to join international efforts to address them effectively. This article focuses on the global challenges of the biosphere, namely: climate change, food security, increasing population, growth preservation, ecosystems, including the oceans, and energy demand and supply. The rationale for focusing on these challenges is that they are closely intertwined, making necessary a holistic approach towards their causes, impacts and the ways to confront, mitigate or adapt to them. The issues addressed in this article correspond to what in Maslow's hierarchy of needs is considered people's most

basic needs: physiological and security ones. They are independent of ethnicity, gender, age or social condition [1]. In one way or another mankind and the whole biosphere is bound to be affected by these global challenges.

One global challenge which is not fully acknowledged by society and policymakers is the myth of unlimited economic growth linked to a steady increase in production of goods, particularly renewable ones. This mirage is encouraged by many politicians and economists. However, in the last decades, not only scientists but also an increasing number of economists argue that the stock of natural resources is limited within the planetary boundaries and some are irreplaceable. In consequence, sustainable development must, therefore, take a different approach to value them. There is no discussion in the scientific community and in societal sectors such as ecologists, environmentalists and others, on the fact that natural resources are finite on Earth. Notwithstanding, on the scale of individuals seemingly unlimited,

*Abbreviations:* UN, United nations; IPCC, Intergovernmental Panel on climate Change; GHS, greenhouse gases; FAO, Food and Agriculture Organization; EU, European Union; WHO, World Health Organization; KBBE, knowledge-based bioeconomy in Europe; SDG, sustainable development goal; GBS, Global Bioeconomy Summits; NGO, non-governmental Organization; GDP, gross domestic product

<sup>☆</sup> The views expressed in this publication are the sole responsibility of the authors and do not necessarily reflect the views of any organization or institution mentioned in it.

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particularly in the past, when the planet was far less populated than it is today. Moreover, the Earth being a closed thermodynamic system, nothing comes or leaves the Earth except for the electromagnetic radiation coming from the Sun and beyond. Agriculture and food production, to name just two examples, can certainly increase their production, but within the chemical and physical boundaries imposed by the availability of soil, water, nutrients, fertilizers, temperature and light, among many others.

Most current economic theories about economic growth that govern Western societies were developed at the time of an “empty planet” [2], compared with today’s “full planet”. The human population is not only rapidly growing, and will continue to do so, at least in the coming decades, but also its requirements for food, goods and energy is steadily growing and largely exceed its real needs. It also depletes a huge amount of valuable non-renewable resources such as phosphorus for agriculture and food production of which a large percentage goes to waste [3]. This trend is encouraged by obsolete political and economic systems that must keep moving to prevent their collapse. Now, before becoming too late, is the time to develop and implement novel ways of organising and managing the sustainable societies of the future and develop socio-economic paradigms with social values compatible with the times and the global challenges with which we are currently confronted. Humanity is also responsible for the increase of CO<sub>2</sub> and other greenhouse gases (GHGs), in the atmosphere. Road and other modes of transportation are important contributors to CO<sub>2</sub> emissions, 16.5 % and 6.5 %, respectively [4]. However, according to [5] “the global food system, from fertilizer manufacture to food storage and packaging, is responsible for up to one-third of all human-caused greenhouse-gas emissions”, a figure similar to those of manufacturing industry. Therefore, one important approach, in addition of optimizing and modernizing industry and agriculture, would be, firstly, to reduce food overconsumption and waste. The figures for the latter range between 30–50 %, both in industrialized as well as developing countries [6].

### Beyond global warming

It is in only in the last 20 years that the term “global challenges” for the planet has spread from the academic communities to the media, political debates and into society at large. Global warming has been highlighted over the other challenges. Its impact on the biosphere and on mankind constitutes a major concern for large sectors of society, particularly for young generations. Current initiatives on climate change overshadow and minimize some of the other global challenges related to the biosphere: food safety and quality, increase of human population, sustainability of biological resources, availability of energy sources, preservation of the environment, including the oceans, etc. It has been said before that all global challenges are mutually interdependent and intertwined [7]. In fact, any one global challenge affects all the others, often in an unpredictable way, increasing the likelihood of a combined synergistic effect with potentially dramatic consequences for mankind and the world as we know it. Therefore, the need for an integrative and coherent approach that addresses global issues with a battery of convergent initiatives is badly needed. Current UN initiatives on climate change or the EU activities on bioeconomy, circular economy, sustainable food systems, blue growth, etc., would have a much wider impact if operated under the ‘umbrella’ of a global biodiplomacy [8]. The authors applaud and support all initiatives currently in place, but are of the opinion that:

- a) there is a need for a holistic approach which acknowledges that natural resources, and particularly biological resources, are finite,
- b) there is a physical limit to the capacity of the biosphere to produce and renew the world biomass and,
- c) the current economic paradigm of unlimited economic growth based on steadily increasing production is biologically unsustainable.

Without a broad awareness and a wide social consensus on the above points, most current initiatives will have limited impact in their fight against global challenges and may elicit frustration in large sectors of society. This article invites dealing with all the global challenges related to the biosphere holistically, by promoting a global biodiplomacy that would maximize the impact of current initiatives and promote coordinated and synergistic actions at the global level. It would need to be inspired and act in the interest of human population over the legitimate but narrow sectoral interests or national priorities.

The UN has taken the lead for the last forty years in creating awareness and promoting initiatives at the global level on climate changes [9]. The main instrument that has addressed this is the IPCC, the UN Intergovernmental Panel on Climate Change. In its 2018 report, the IPCC reiterates the impacts of global warming and signals that even limited increase to 1.5 °C would require rapid, far-reaching and unprecedented changes in all aspects of society [10].

Most of the current discussions on global challenges are monopolized by the effects of climate warming, but as pointed out by a recent publication co-signed by over 11,000 scientists [7], climate change is indeed primarily temperature, but also its connection with other aspects of the environment and society, such as energy supply, gas emissions (GHG and other pollutants), preserving the environment and biodiversity, food and feed security and the transition towards a sustainable bioeconomy. It is critical to realize that the global challenges would still exist even in absence of climate change.

The 2018 IPCC report is extremely thorough in its sources and on the analysis of the consequences of global warming at different temperature intervals. The forecasts are scientifically sound and precise for several parameters dealing with natural ecosystems. However, despite the scientific evidence basis of the report, it missed a deeper insight into the impact of global warming on agricultural productivity and a description of the current ecological fingerprint of food production and its sustainability. The World Bank, using Food and Agriculture Organisation (FAO) data states that world arable land, expressed as the number of hectares per person, diminished from 0.37 in 1960 to 0.19 in 2016, a decrease of about 50 %. Far more worrying is the fact that most of that decrease has taken place in African countries, which are already overpopulated and with stressed agricultural production [11].

Up to now, the effects and the impacts of global challenges have been approached from different angles by UN agencies, the EU, other regions and countries, developing numerous initiatives, strategies and policies. In addition, issues such as sustainability, circular economy, bioeconomy and responsible consumption currently form part of ample societal debates, urging politicians to develop and implement measurable and effective initiatives to address global challenges. Again, a joint, integrated approach to dealing with them is badly needed. Biodiplomacy is proposed to play a role in the global management of natural resources connecting UN agencies, concerned regions and countries to ensure a coherent and an efficient approach.

### Securing food security

Although any government would claim to rank food security and safety amongst their top priorities, the issue of food security is not often translated into governmental agendas. This is, at least in industrialized countries, because it is taken for granted. In just a few generations food has evolved from a precious and scarce good to becoming abundant, cheap, largely processed and industrialized. Food has become another commodity in the post-industrial’ digital society’. The unquestionable success of the ‘Green Revolution’ has changed the life of hundreds of millions of persons, allowing a higher intake of calories and proteins, reducing famine and malnutrition, and consequently diseases. A successful example is Indonesia, where improvement of agricultural technology has led to a significant increase in food production and, concomitantly, to a parallel reduction of poverty, increase of life expectancy and slowing down population growth. Unfortunately, in

several African regions, where the Green Revolution almost passed unnoticed, food shortage, malnutrition and poverty related diseases continue to ravage the population for many other reasons. The human population was roughly 3 billion by 1960 and has increased to 7.7 billion in 2019 [12]. However, there are some drawbacks to the Green Revolution. In industrialized countries, agricultural productivity has been so successful that it has led to large stocks of surplus agricultural products, creating dysfunctions in production and commercialization. Abundant, cheap and high caloric food products have led to overweight, obesity and metabolic diseases in a significant number of persons. Currently, worldwide obesity has nearly tripled since 1975. The World Health Organization (WHO), has reported that in 2016, more than 1.9 billion adults were overweight, of whom, over 650 million were obese [13]. Most come from industrialized countries, although in transition economies the growth of overweight and obesity related disease such as cardiovascular diseases and diabetes is an alarming trend [13]. Whilst this is happening, 790 million people suffer malnutrition, mostly in Africa. Unfortunately, the benefits of the Green Revolution have passed almost unnoticed in Africa, where it is most needed. A radical new global approach is required needed, particularly because environmental costs of food production are very high, with agriculture being a key driver of water scarcity.

#### *Impact of global warming on food and global security*

There is considerable scientific evidence that climate change is affecting the temperature from the poles to the equator. It can easily be inferred that the impact would be the most devastating for humans would be in those areas where, simultaneously, there is a high density of population and where agriculture is already under critical stress conditions such as drought, very high temperatures, soil desertification, salinity, etc. In those regions, any minor alteration of the already critical agricultural conditions could easily make vast zones of the planet uninhabitable.

Africa will be the continent most affected by global warming. Hundreds of millions of people may find themselves like their ancestors in the sadly famous famines of the past. Some critics argue that, globally, the impact of climate change would be statistically, negligible [14]. These views tend, however, to ignore the huge differences in economic development, climate, agricultural development, etc., among the populations of different areas of the planet. The scientific community has reached a consensus on the dramatic and global impact of global warming. However, it may well be that, locally, the effects would be more mitigated, whereas its impact on specific regions could be devastating.

Climate is not a deterministic phenomenon, but rather a chaotic event as Lorenz found [15] and the UN report has also recognized. In several African regions the access, albeit limited, over the last decades to drinking water, sanitation, vaccines and some medicines has allowed a huge increase of population over the last fifty years. This growth trend of African population is projected to double by 2050 [16]. A quantum leap in global warming would lead to additional stress and environmental changes that could easily collapse agricultural production. The consequences are easy to forecast: famine, increased prevalence of poverty-related diseases and emergence of new ones. These consequences will be most likely followed by social unrest, regional conflicts and massive displacement of populations.

#### *From an “empty planet” to a “full planet”*

Until the arrival of the Industrial Revolution, towards the second half of the 18th Century, the human population had remained stable and below one billion. It was only at the beginning of the 19th Century that the population reached one billion. Since then, the human population has dramatically increased, currently reaching a population of 7.7 billion. This trend is according to the UN to continue reaching

nearly 10 billion by 2050 and 11 billion by the end of this century [17]. A large part of this increase is expected to take place in Africa, whereas in the two most populated countries, India and China, population is expected to stabilize towards the middle of this century.

There are several reasons for the sharp increase in human population: Bricker and Ibbitson [2] are of the opinion that the growth was due to the scientific and technological developments during the Industrial Revolution [2]. Another important element in increasing life span and, therefore, human population has been the establishment of sanitation in cities, increase of hygiene practices and the discovery and manufacturing of antibiotics and vaccines. It is evident that a steady increase of population, particularly in the already most fragile areas of our planet, would aggravate the consequences of climate change and food security. Obviously, taking initiatives to encourage diminishing fertility rate in certain regions of the world is politically and socially very delicate. It has been demonstrated that increasing standard of living, education and wellbeing are concomitant with lower birth-rate, lower child mortality and increase of lifespan. This is a clear indication of how to proceed.

#### *Preserving the environment and the biodiversity*

In current utilitarian societies, the environment is considered in some quarters to be a nuisance, as an obstacle for economic development. The environment is considered in this perspective as a commodity waiting to be converted into goods and products with high added value and economic return. Although the environment has been estimated to create enormous economic value annually, the previously mentioned economic perspectives attach no value to the environment unless it is transformed in merchandise with a price tag on it. In this process, the natural, pristine environment is shrinking and converted into urban areas, agricultural fields, industrial parks, and a little domesticated nature. *Homo sapiens* has been doing this since the invention of agriculture with the limited technology available. However, since the Industrial Revolution and the concomitant human population growth, this process has accelerated exponentially.

The continuous degradation of natural ecosystems leads to a loss of biodiversity. One aspect that passes almost unnoticed in the mass media is the rate of biodiversity loss, accelerated by the disappearance of many of natural ecological systems and habitat losses. Nevertheless, when a species is extinguished universally, it disappears forever. It is estimated that the combination of the effects of global warming and human pressure on the biosphere has caused the extinction of several thousand species annually [18] and forecast that by 2050 between 30–50 % of all species will have become extinct [19]. The importance of such a loss will never be assessed in the proper dimension, as it will be a loss not only for the current world but for humanity forever. Many of the species could have disappeared even before they are known and described by scientists. This is particularly serious concerning microbial diversity as it is well known that it largely exceeds the limited number of “culturable” microorganisms [20]. Its loss is an irreversible handicap for the progress of science and for its potential applications in biotechnology, agriculture, medicine, etc. [21].

#### **Bioeconomy facing the global challenges**

The concept of bioeconomy has evolved rapidly over the last 15 years. In 2005, the EU coined the term KBBE, Knowledge-Based Bioeconomy in Europe. The emphasis was to promote a strong and solid science and technology basis across different disciplines and bioindustries. Gradually, other elements were incorporated such as socio-economic impact, industrial commitment and implication in research activities, exploitation and dissemination plans, etc. [22]. In 2009, the Organisation for Economic Co-operation and Development (OECD), published the white paper: The Bioeconomy to 2030: Designing a Policy Agenda [23]. Essentially, it focussed on biotechnological applications in

primary production, health, and industry and considered bioeconomy to be “the set of economic activities relating to the invention, development, production and use of biological products and processes” [23]. An important contribution to the evolution of the concept was the incorporation of areas such as sustainability, growth and job creation in the 2012 EU Strategy on Bioeconomy [24–26]. Almost in parallel, the USA launched a similar initiative mostly geared towards reducing dependence on imported fossil fuels by renewable fuels [27]. In the following years, many countries have developed national or regional strategies on bioeconomy, each adapted to their own specifics. These strategies were critical in triggering the discussions on the transition from a fossil-fuel dependent economy to a bio-based economy with substantial investments in research and development and the creation of public-private partnerships [28]. However, it was not until 2018, when the EU published its Updated Bioeconomy Strategy, that the concepts of sustainability, circular economy and the need to understand the ecological limits of bioeconomy became integral parts of the bioeconomy concept [29]. This strategy marked an important milestone in the transition from a society largely dependent from fossil fuels towards a more sustainable one making a smart use of renewable biological materials. However, bioeconomy strategies have not yet been able to fully integrate with other global initiatives such as the sustainable development goals (SDGs) or other initiatives on climate change, despite the willingness of some bioeconomy stakeholders, such as the Global Bioeconomy Summits (GBS).

### Economic and uneconomic growth

There is an element that despite being obvious, does not appear in the political agenda about climate change. It is the perception, largely shared by many economists, that we still live in an ‘empty planet’ and that the negative externalities can largely continue to be passed onto society and the environment. However, the theoretical economic foundations that govern the Western world have continued to remain essentially the same although we are currently living in a ‘full planet’ and will be becoming an ‘overcrowded planet’ in the coming decades. However, several new economic theories are being established taking these issues into account. One of them is environmental economics [30]. Another school of thought is ecological economics, in which the economic system is viewed as a subsystem of the global environment [31]. In contrast with orthodox economists, who claim that every technology can be improved upon or replaced by innovation and that there will always be a substitute for any and all scarce materials, ecological economists favour economic sustainability and argue that the stock of natural resources and ecological functions are limited and irreplaceable. It is beyond of the scope of this article to overview the different economic schools of thought, but rather to derive some lessons on how to best tackle global challenges. This also includes the complicated fabric of international factors, like conflicts, wars and their origins, cultural and historical features, etc. Nevertheless, it is important to realize that successful and sustainable circular bioeconomies, need to promote vibrant and evidence-based education systems leading to responsible and empowered citizens to cope with this complicated fabric.

Currently, there is a broad consensus on the illusion of unlimited economic growth derived by a limitless increase in the extraction and production of natural resources. In pursuing this trend, some societies have evolved a dystopian course towards what some economists now call “uneconomic growth”, when “increases in production come at an expense in resources and well-being that is worth more than the items made” [32]. The concept is closely linked to that of negative externalities. This is a common industrial practice and happens when the true cost of a product or a service is not reflected by the final price paid by the consumer. Typical examples of negative externalities are air, water or noise pollution originating at a factory, and those burdens are passed onto the society which must take on the costs of remedying or

reducing them. As consequence, diseases may appear, the environment may be further degraded, the market value of houses may decrease, etc. Thus, an uneconomic growth in society may easily result from an otherwise profitable economic system. Such situations are frequent, particularly in developing countries where environmental regulatory measures are still to be developed. Even if uneconomic growth is drastically reduced, it is important that economic growth, which primarily measures the increase of gross domestic product (GDP), is translated into a broader economic development, which takes into account, not only of GDP per capita, but also issues such as education, environmental standards, healthcare and life expectancy among others.

### Towards a global biodiplomacy

Currently, diplomacy is a key instrument of statecraft used to manage the goals of the foreign policy of a state and international organisations [33]. Historical approaches to the evolution of diplomacy are available elsewhere [34]. In a little over two centuries, diplomacy has experienced a dramatic evolution. In the 19th century, an imperialist concept dominated diplomacy; statements such “War is diplomacy by other means” [35] were commonly accepted and shared as a norm to rule the world. Nevertheless, nowadays diplomacy is mainly oriented to identifying common points of interest among sovereign states. Whether in academic or military circles, there is general agreement that the complexity of international relationships demands more investment in diplomacy [36], together with its presence more actively as the most effective way, firstly to understand and then to prevent international conflicts and wars [37].

The world needs biodiplomacy now. The global challenges that threaten humanity cannot be solved by addressing climate change alone. Other global challenges are connected with the impact of climate change, but their combined effects, however, and mutual synergistic impacts reach much further than that described within the climatic effects signalled by the IPCC. The clear political and scientifically backed messages from government leaders and civil society committed to confront the challenges of climate change at the different UN climate action summits do need to be supported and help pave the way towards more profound changes in other areas. This is the correct way to proceed, but on its own, will be insufficient to tackle other key challenges facing mankind. Here, we propose biodiplomacy as a catalyst to address the global challenges more comprehensively.

### *Evolution of the biodiplomacy concept*

The term biodiplomacy has already appeared in the literature with different meanings. Here, a very brief outline of the different meanings of biodiplomacy is given in order to clarify the context in which it has been used in publications as opposed to its use here. One of the first publications appeared in 1994 [38] and focussed on negotiations regarding the conservation and sustainable use of the world’s living resources, particularly from developing countries. The issue of a dual use of biotechnology as the main goal of biodiplomacy has been considered [39], whereas others [40] considered that the focus should be on the discussions of technological advances of biotechnology and on the trade regulatory issues of genetically modified organisms (GMOs). Other approaches have been biased towards ethics and anthropology [41] and on international cooperation in environmental protection [42]. Despite the recurrent appearance of the biodiplomacy concept over three decades in learned journals, there is no consensus on the meaning of the term. On each occasion it has always pointed towards a different challenge and objective. So far, none of those publications have been followed up by the development of deeper insights into, and a unified view of the concept. Recently, the term has been advanced as a way of developing a novel approach to governance of natural resources to address the global challenges, including, but not limited to climate change [43]. In this way, biodiplomacy is considered part of classical

diplomacy, but different in the sense that it considers the need to adopt a global and an integrated approach for the management of global challenges affecting the biosphere. In contrast, the objective of national diplomacy is to defend, and if necessary, to impose national interests. Likewise, the EU has anticipated some of these issues by addressing systematically, in terms of innovation, health and societal impact, the synergistic effects of health, environment and the bioeconomy [44]. In a recent publication of the Club of Rome [45], the authors developed their ideas around these issues, and although biodiplomacy is not explicitly mentioned, the message is to generate a new social catharsis, and to encourage the formation of a new social dynamic on which a more rational and sustainable society is built.

Here it is considered that the core of the biodiplomacy lies in the absolute need for a holistic approach for the effective and enduring global management of natural resources of the planet, as opposed to the nationally driven approach of classical diplomacy. This means shifting from the current economic paradigm of limitless increase of production, towards more inclusive societies, reducing unnecessary production and consumption of goods and by promote a circular sustainable bioeconomy.

Biodiplomacy must be global and integrative. Global in its geographical coverage and in its ambition to address the challenges affecting the biosphere and, integrative as it must reconcile and fully involve different societal, political and economic interests, skills, scientific and technological disciplines and industrial sectors, ensuring that it promotes more inclusive societies. It must also strive to achieve global cooperation, being mindful of the boundaries and potentials of living resources, supporting sustainability and a circular bioeconomy able to contribute to a vibrant planet full of life for future generations. In addition, biodiplomacy must take into account the specificities of “Bio”, i.e. to cope with the special biological features such as renewability, certain closeness to climate neutrality and important elements of circularity. Biological resources also have enormous potential for new functions such as longer life, less or no toxicity, less consumption of resources, etc. All of these are important factors to contribute and optimize the achievement of SDG and the need for resource efficiency. The linking element of these special features would be a new paradigm, namely, thinking, planning, acting and operating in cycles or chains, in a similar way that process improvement is performed in industrialized environments and not simply linearly. This will have an important impact on the target groups of bio-diplomats, emphasizing their immense diversity, but will also require new preparatory skills in the education and training of the diplomat of tomorrow.

Europe is leading the move towards an integrated and inclusive approach to global challenges by creating the basis for shared values which are the foundations of biodiplomacy. One relevant example is the GBS, a German initiative aiming at developing a “competent and significant bioeconomy voice in global policy fora related to innovation, sustainable development and the Paris Agreement, providing a holistic perspective and considering the interdependencies between individual SDG in the bioeconomy” [46]. The overall aims of the GBS are to internationalize bioeconomy, discuss how bioeconomy issues could be merged into global discussions and how to contribute to achieving the SDGs. In this context, bioeconomy should be included in international and global fora on innovation, climate, biodiversity and sustainable development policy [46]. It is hoped that GBS 2020 will be successful in including elements of a sustainable circular bioeconomy into the agendas discussing global challenges through a standing strategic approach. If successful, it will have accomplished an important step towards building a biodiplomacy [47]. A second example is the adoption in 2019 by the EU authorities of the European Green Deal, of a very ambitious package of measures that should enable European citizens and businesses to benefit from a sustainable green transition [48]. The European Green Deal is a comprehensive political response to most of the global challenges, such as: climate change; loss of biodiversity; protect the health and well-being of its citizens from environment-

related risks and impacts; transform its economy and society to put it on a more sustainable path.

The time has arrived to deploy a global biodiplomacy. The EU is in a unique position to lead this process. It will not be created in a solemn foundational act, but through examples of credible action and the realization of small achievements. Other countries, possibly pressured by their citizens, will join in this process that will become increasingly more and more universal. Unifying political initiatives, such as the GBS and the EU Green Deal, are critical as catalysts to launch and start the process and to put in place the means for its execution. However, the main support and encouragement needs to come from society at large. Everybody should be encouraged to form part of this new ‘catharsis’ of how to make the planet sustainable for future generations, while reconciling sustainable wellbeing in life in advanced societies with the intelligent use of natural and renewable resources.

#### *Common elements for a biodiplomacy*

It is evident that a mature and efficient biodiplomacy must show an intelligent and delicate balance between dialogue and determination: on the one side, dialogue and cooperation to achieve jointly defined objectives while, on the other, determination to convince those that do not share those objectives, not to undermine the political and economic systems of the rest and become committed to moving forward towards a sustainable planet.

The biodiplomacy, as described in this article expands and advances further the concept initially sketched elsewhere [43]. Modern biodiplomacy develops a basic understanding of all the factors affecting the wellbeing of our planet and humankind. It illustrates several elements that need to be discussed, understood and shared in order to build and live the benefits of a successful and efficient biodiplomacy. A non-exhaustive list of these factors and these elements for a credible biodiplomacy is as follows:

- Develop science and evidence-based policy decisions and qualitative and quantitative development criteria.
- Acknowledge the ecological boundaries of growth considering the potential of biological resources.
- Balance issues of national sovereignty *versus* global governance in such a way that legitimacy of national sovereignty must be respected, but global decisions should be made concerning all matters that affect the entire world, such as health, food security and others.
- Develop an integrated versus compartmentalized approach to policymaking.
- Insist on global approaches and initiatives to tackle global challenges.
- Demand, with respect to economic and uneconomic growth, the need for a new concept of growth beyond the GDP considering other socioeconomic and scientific approaches.
- Develop mechanisms to promote a circular and sustainable bioeconomy which is socially inclusive.
- Work out global approaches for human migrations due to climate change, water, agriculture, food security, availability of arable land.
- Reduce the use of fossil fuels, developing sustainable alternative energy sources.
- Include into the economic costs of products the negative externalities. Highlight the difference between value and cost, avoiding in this way that manufacturers charge all environmental, social costs to society.

#### *Bioeconomy and biodiplomacy: the way forward*

This article has outlined some of the less visible interactions amongst global challenges and the multiple forms with which they impact the biosphere and populations. Most of those challenges cannot be prevented, but they can be confronted and mitigated through a

global biodiplomacy, empowered by more conscious societies, enabled by sustainable production and consumption. There is a will among increasing societal sectors to harness the desire for integrated actions that lead us to a reasoned and healthy social, economic and environmentally friendly future. There are formidable hurdles on the road towards a global biodiplomacy. Many people are still reluctant to modify their 'way of life'. The whole industrial and agriculture sectors must accelerate the incorporation of innovative and environmentally friendly processes to anticipate and adapt to the global challenges. Finally, political leaders should be inspired by those that have a global vision and long-term strategies. Broad sectors of society, particularly young people, are revolting against the *status quo* received from their elders. New paradigms are needed to increase social awareness, and to take urgent measures to prevent an irreversible situation. Coping with the times and challenges of COVID-19 urgently demand such a way forward.

Throughout this article it has been repeatedly stated that the resources of the biosphere are limited, both in the availability of products as well as in its capacity of increasing productivity beyond certain limits. However, this statement should now be modulated. In fact, mankind has two unlimited resources: the energy coming from sunlight and human innovation. We are in the process of harnessing the former. Our survival as a species depends on developing the second to guarantee the global sustainability of our planet.

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