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Investing in Nature as the true engine of our economy

A 10-point Action Plan for a Circular Bioeconomy of Wellbeing

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Foreword by
His Royal Highness
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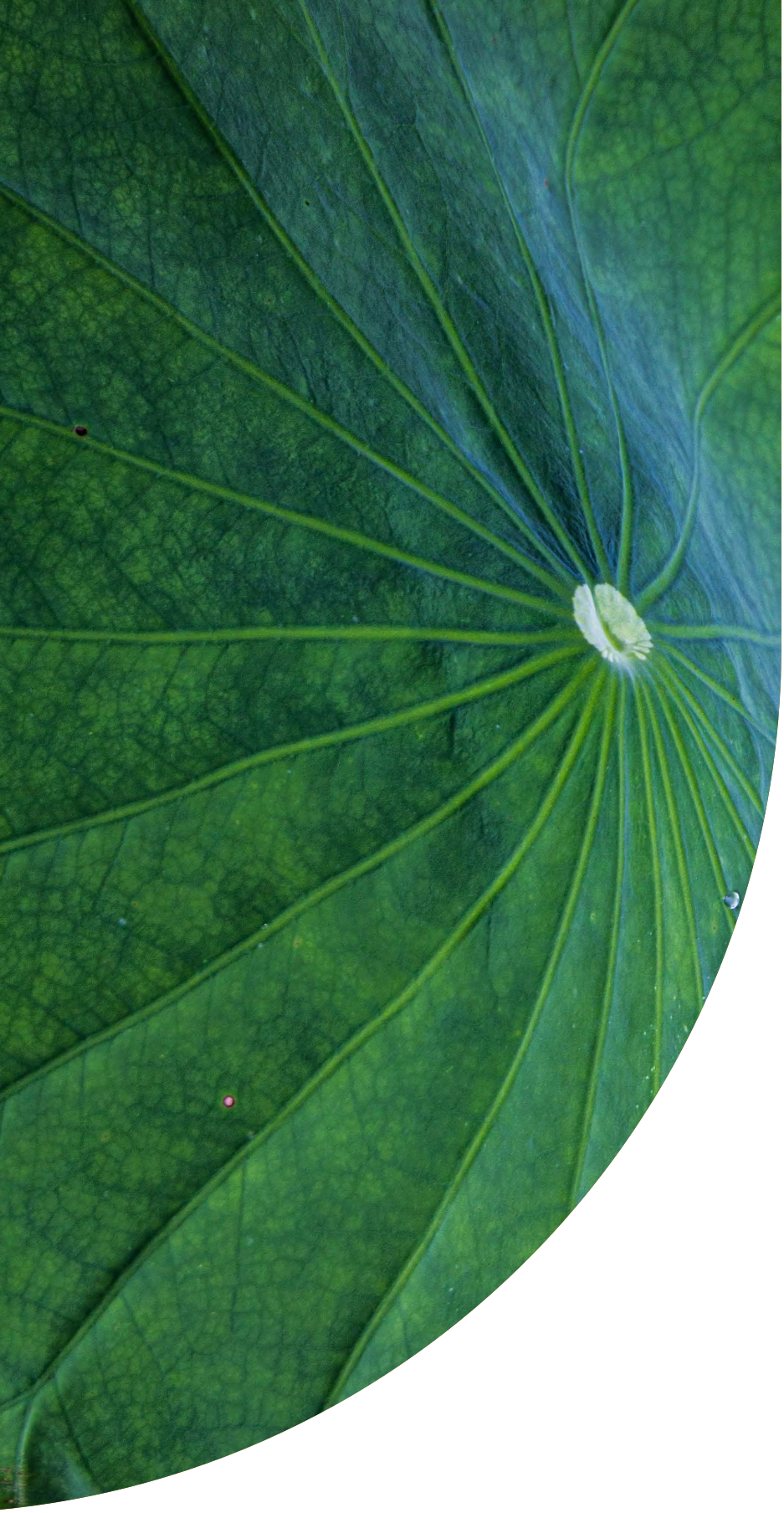
KNOWLEDGE TO ACTION



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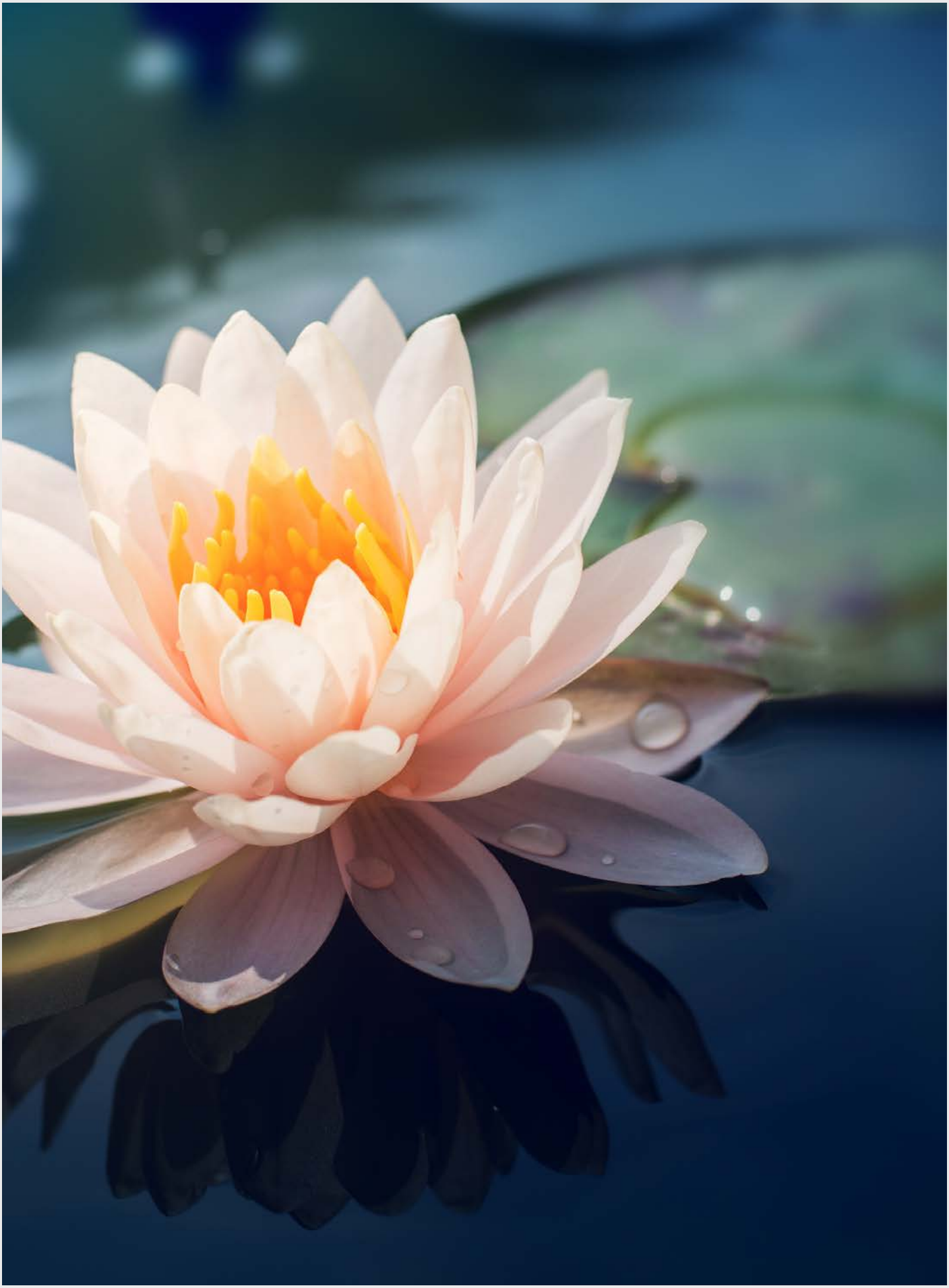

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Foreword
HRH The Prince of Wales

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Modern science tells us that today we sit at the pinnacle of some 3.5 billion years of evolutionary refinement. The finely woven tapestry of life is undoubtedly one of the greatest marvels of our universe. For this complex web of life to work harmoniously, it relies on the richness of Nature and biological diversity. Crucially, no one element can survive for long in isolation, as Nature is herself rooted in wholeness. This is something indigenous peoples, elders and traditional knowledge-keepers know all too well.

When we recognise that the modern world and our Natural systems are fundamentally interconnected, it seems to me that our response to the terrifying number of emerging 'planetary emergencies', including pandemics, climate change, biodiversity loss, public health and food insecurity, needs to be interconnected as well. This has been the motive behind my Sustainable Markets Initiative which aims to put people and planet at the heart of global value creation, while accelerating the transition to a sustainable future.

With solutions increasingly available, I strongly believe that it is time to put Nature back at the centre of our economy. Our world is connected by common laws and principles which find expression in mathematical laws, in geometry, physics and above all, in Nature. By combining traditional sustainable practices with Nature-based, biomimetic and regenerative solutions, we can shift the economic system to build, rather than destroy, Natural capital. This approach presents an inspiring opportunity for innovation and new ways of thinking about future economic growth. A few key principles that I would encourage us to keep in mind include:

- We need to see that we are Nature, not apart from it. Nature, beauty, health and wellbeing are all deeply interconnected.
- We need to work systemically, seeing connections and relationships and the consequences of our actions now and in the long-term.
- We need to think in cycles and create no waste or pollution. We need all our waste to feed back into the cycle (e.g. the circular (bio) economy).
- We need to value diversity in all things; to understand that diversity is a strength that gives resilience to a system or organisation.
- We need to make health our goal; individual health, community health, the health of our Natural resources (e.g. soil, air and water).
- We need to focus on local – local traditions and culture, local food products, local jobs and local sustainability and how these 'locals' connect and support each other in the wider tapestry of regional and global systems.

In order to shift towards an economic model that protects and builds Natural capital, we need to look at the system as a whole and align our incentive structures to propel us in the right direction. With this in mind, having a common roadmap, standards and metrics would greatly help drive and accelerate common action and scaled results. While there are many examples we could point to, I believe two could rapidly make significant and systemic difference.

Firstly, we need to start accounting for Natural capital on our balance sheets. Without this we cannot tell the true value of our asset base, nor how damaging our operations are on the Natural world. These mispriced externalities only accelerate the continued destruction and exploitation of our planet. They also prevent consumers from making informed and sustainable choices, thus limiting the demand for sustainable goods and services and skewing the model of supply and demand. To seize the enormous economic opportunity that a sustainable future affords, and to unlock entirely new sustainable jobs and industries, there are practical steps we can take to rebalance the equation. These include introducing

a ‘polluter pays’ principle and exploring how best to implement carbon-pricing and carbon market systems.

Secondly, industrialised food systems are having a profoundly negative impact on biodiversity, climate change and Natural ecosystems due to large scale production methods and highly centralised processing and distribution systems. To restore balance and to create the marketplaces of the future, there needs to be a significant shift towards more a mosaic of distributed, diverse and regenerative production systems, bringing food production closer to the communities where it is consumed. This requires that we increase small-holder organic farming and cooperative approaches which will, in turn, create an increasing number of employment opportunities.

With the enormity of these opportunities, our science-based and economic systems are vital to finding and scaling the solutions we so desperately need. To make progress, we cannot each work on our own individual pieces of the puzzle; we must bring these pieces together if we are to see the big picture. Achieving a sustainable future, rooted in science-based targets, is the growth story of our time and can, in fact, fuel our post-pandemic recovery in a way that pays dividends for decades to come.

With impending climate and biodiversity catastrophe, we simply cannot wait any longer to restore the delicate balance with the Natural world. This is why I have been deeply encouraged by the number of scientists and practitioners who have come together to develop a 10-point Circular Bioeconomy Action Plan inspired by my **Sustainable Markets Initiative** and its **Circular Bioeconomy Alliance.** It is time for leaders, across all disciplines, to step forward, be bold in their ambition and demonstrate what is possible so that others can follow. There is, I fear, simply no time to waste.

His Royal Highness
The Prince of Wales

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Content

Executive Summary

The 10-Point Action Plan to catalyse a Circular Bioeconomy of Wellbeing is a call for collective and integrated action to global leaders, investors, companies, scientists, governments, non-governmental and intergovernmental organisations, funding agencies and society at large to put the world on a sustainable path.

The 10-Point Action Plan is guided by new scientific insights and breakthrough technologies from a number of disciplines and sectors. It is articulated around six transformative action points (1–6) and four enabling action points (7–10), which mutually reinforce each other and need to be implemented in an integrated manner.

1. Focus on sustainable wellbeing

The current fossil-based economy, addicted to “growth at all costs”, as measured by Gross Domestic Product (GDP) should be replaced by an economy aiming at sustainable wellbeing centred around people and our natural environment. This means replacing current economic indicators such as GDP, which focus only on market transactions, with new indicators of sustainable wellbeing, including human health, which should include the broad range of non-market contributions from natural and social capital.

2. Invest in nature and biodiversity

Investing in nature and biodiversity via two interdependent strategies is essential for a Circular Bioeconomy of Wellbeing. The first strategy should foster more species-rich systems in agriculture, aquaculture, and forestry. The second strategy should protect large contiguous biodiverse systems to prevent species extinction and the erosion of biodiversity.

3. Generate an equitable distribution of prosperity

Biological resources like agriculture or forest resources, are usually owned and managed by many more people, and distributed across wider parts of the territory, when compared to fossil resources. The circular bioeconomy, if co-developed with the participation of local communities, has great potential to generate an equitable distribution of prosperity across a wider geography.

4. Rethink land, food and health systems holistically

Food systems are responsible for 21-37% of global greenhouse gas emissions and a major driver of deforestation and land degradation, yet there is still widespread food insecurity and malnutrition. Managing the land sector (agriculture, forestry, wetlands, bioenergy) sustainably and holistically could contribute up to 30% of the global climate mitigation effort while, at the same time, addressing urgent health challenges.

5. Transform industrial sectors

Globally, industry is responsible for over 30% of all greenhouse gas emissions, of which the majority arise from the production of bulk materials like cement, metals, chemicals and petrochemical products. It is urgent to transform industry to scale up resource-efficient, circular and low carbon solutions based on both renewable energy and sustainable biological resources.

6. Reimagine cities through ecological lenses

In 2018, the UN projected 2.3 billion new urban dwellers by 2050. A shift to biomaterials (based on engineering wood or bamboo) for the volume of new housing required could substantially reduce both the amount of materials used and the carbon footprint of our cities while creating durable carbon pools. The use of nature-based solutions such as urban forests, trees and vegetation has positive impacts on the health of urban populations while reducing the urban heat island effects.

7. Create an enabling regulatory framework

An enabling policy framework at different scales (business, city, regional, national, global) is needed, that ensures coherence across policy areas, incentives and strategies on nature conservation, climate, land management, waste and industry.

8. Deliver mission-oriented innovation to the investment and political agendas

Purposeful and mission-oriented innovation is crucial to design the circular bioeconomy future with common purpose. It is guided by nature and engages communities to become involved through processes that encourage the co-creation of solutions.

9. Enable access to finance and enhance risk-taking capacity

Access to finance and risk-taking capacity are key to bring the circular bioeconomy from niche to norm. This is because it integrates a multitude of economic actors along complex value chains: everything from the protection and management of natural ecosystems, the production of biomass and food, to the deployment of new and sustainable high-tech solutions with high capital needs.

10. Intensify and broaden research and education

Circular bioeconomy research and development needs to be transdisciplinary, combining technology and engineering with complex systems thinking. This research needs to integrate science with traditional knowledge, business, arts, design and humanities, as well as involve relevant stakeholders in the process.

Circular Bioeconomy of Wellbeing

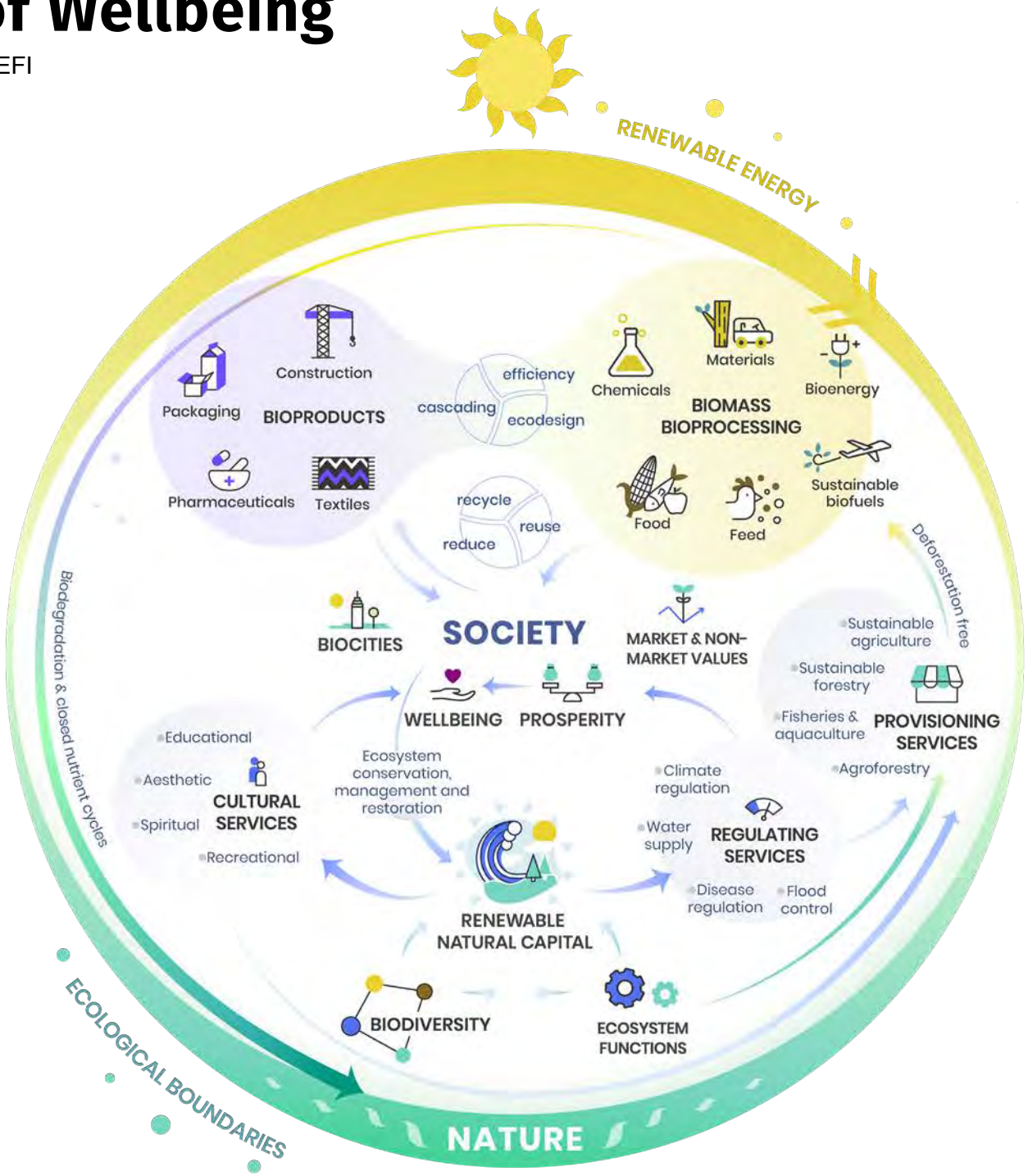
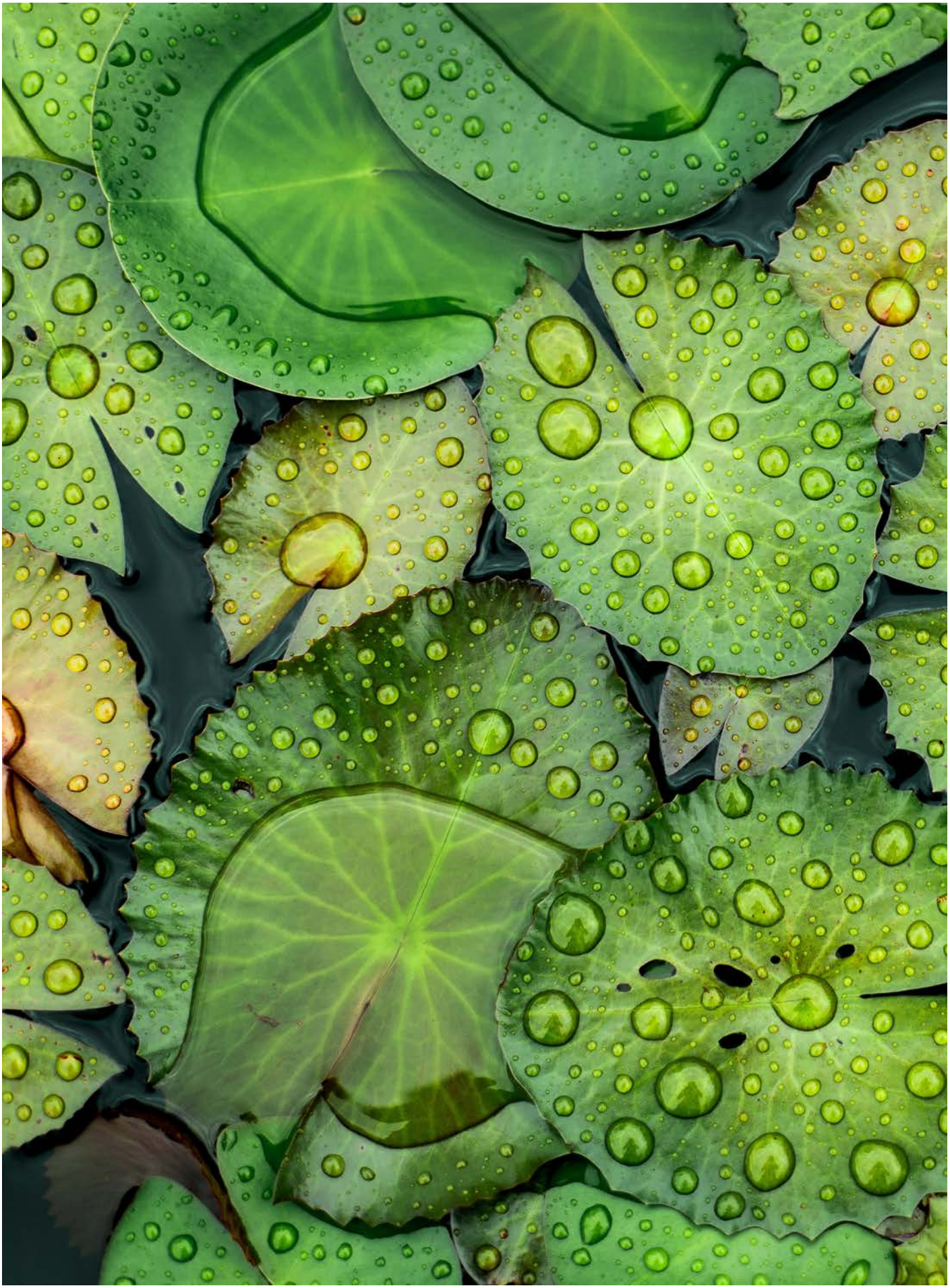


Figure 1. The Circular Bioeconomy of Wellbeing



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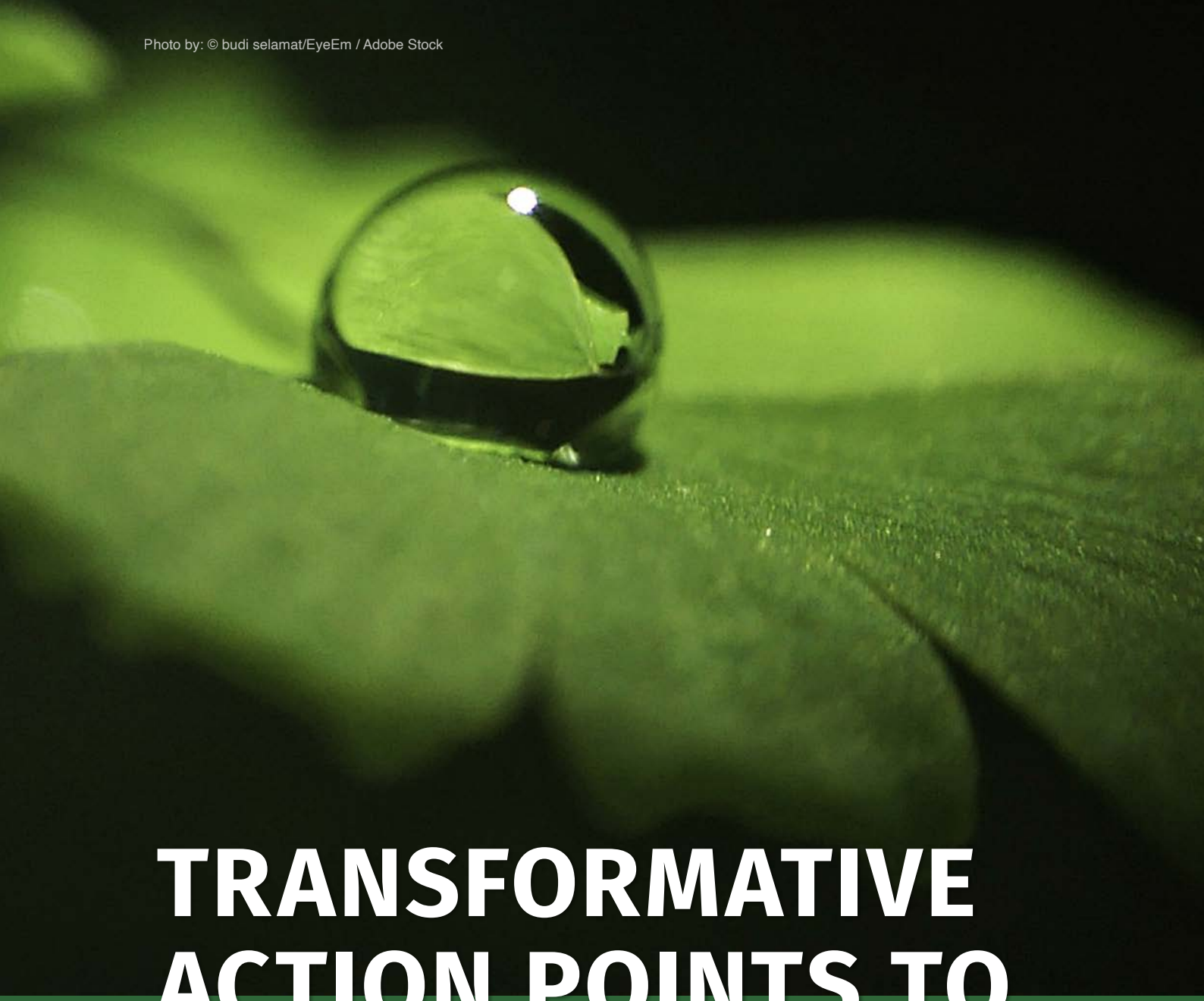
Introduction

A 10-Point Action Plan to catalyse a Circular Bioeconomy of Wellbeing is proposed below. The plan is guided by new scientific insights and breakthrough technologies from a number of disciplines and sectors. Throughout the plan, reference is made to those technologies and findings. It is articulated around six transformative action points (1-6) and four enabling action points (7-10), which mutually reinforce each other and need to be implemented in an integrated manner (see Table 1).

Contrary to our extractive and linear fossil-based economy, the circular bioeconomy (see Figure 1) relies on healthy, biodiverse and resilient ecosystems and aims to provide sustainable wellbeing for society at large. This is achieved through the provision of ecosystem services and the sustainable management of biological resources (plants, animals, micro-organisms and derived biomass, including organic waste) and its circular transformation in food, feed, energy and biomaterials within the ecological boundaries of the ecosystems that it relies on. The circular bioeconomy is powered by renewable energy and includes, and holistically interlinks, the following systems and sectors:

- Land and marine ecosystems as well as green infrastructures such as urban forests and trees and the services they provide in cities
- Primary production sectors (agriculture, forestry, fisheries, aquaculture and aquaponics)
- Economic and industrial sectors relying on biological resources and nature-based solutions (food, wood industry, bulk and speciality chemicals, construction, packaging, textiles, pharmaceuticals, bioenergy and all sectors benefiting from biobased solutions or ecosystem services such as nature tourism or water supply).



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TRANSFORMATIVE ACTION POINTS TO MOVE TOWARDS A CIRCULAR BIOECONOMY OF WELLBEING

1. Focus on sustainable wellbeing

The current fossil-based economy, addicted to "growth at all costs" as measured by Gross Domestic Product (GDP), should be replaced by an economy which aims for sustainable wellbeing centred around people and our natural environment. This means rethinking the essence of our economic model and the way we produce and consume, including the need to value nature.

It also requires the replacement of current economic indicators such as GDP, which focus only on market transactions, with new indicators of sustainable wellbeing including human health, which should include the broad range of non-market contributions from natural and social capital (e.g., Genuine Progress Indicator (Kubiszewski et al. 2013), or Sustainable Wellbeing Index (Costanza et al. 2016). The Sustainable Development Goals provide an internationally agreed framework to develop these new indicator approaches and integrate them in the national accounts accordingly. The System of National Accounts (SNA), first developed in response to the economic crisis of the 1930s and used by statistical offices worldwide to record economic activity, does not make explicit either inputs from the environment to the economy or the cost of environmental degradation. Reversing the ongoing degradation of our natural capital while providing incentives for a Circular Bioeconomy of Wellbeing requires us to move SNA measurement "beyond gross domestic product (GDP)", in order to provide timely and detailed monitoring of natural ecosystem change and uses. It is now technically possible to understand and measure the impact of developing a circular bioeconomy in terms of sustainable wellbeing while accounting for the trade-offs and synergies between different SDGs (Costanza et al. 2016).

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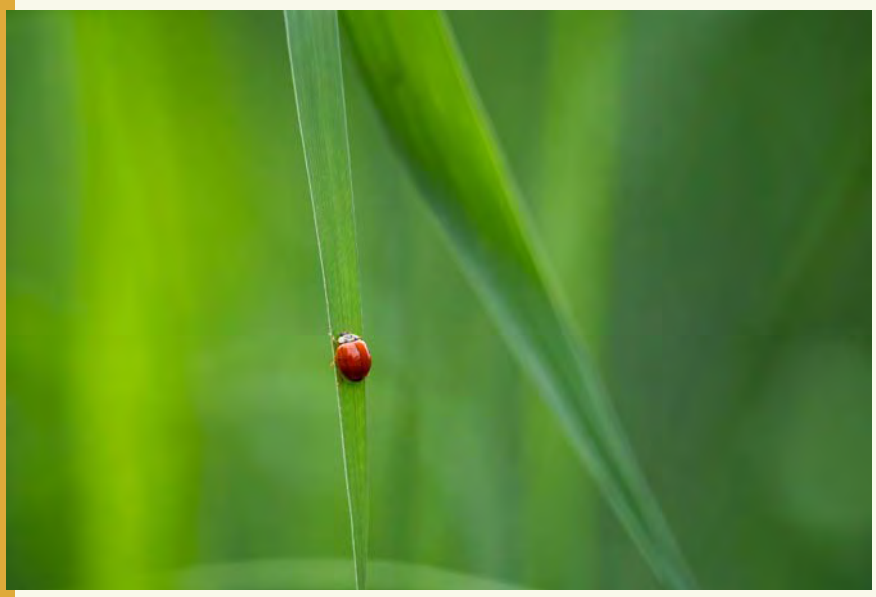
Box I:
Gross Domestic Product versus Genuine Progress Indicator



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Gross Domestic Product (GDP) was never designed to measure social or economic welfare, nor human wellbeing. It disregards key components that are crucial to our welfare.

Firstly, it leaves out many aspects that enhance welfare but are outside the market. For example, the services that are provided to society by natural capital, such as clean air and water, carbon sequestration, pollination and other ecosystem services, do not adequately show up in GDP. A parent staying at home to raise a family, is not included in GDP, but it has a major impact on individual wellbeing.

Secondly, GDP interprets all transactions as positive, not distinguishing between welfare-enhancing activity and welfare-reducing activity. For example, an oil spill increases GDP because of the associated cost of clean-up and remediation, but no one would argue that an oil spill contributes to overall wellbeing.

Thirdly, GDP does not account for the distribution of income among individuals, which has major impacts on both individual and social wellbeing. GDP does not care whether a single individual or corporation receives all the income in a country, or whether it is equally distributed amongst the population.

The Genuine Progress Indicator (GPI) takes some of the GDP's faults and adjusts for them. The GPI starts with personal consumption expenditures (a major component of GDP) and adjusts it using about 25 different components, including income inequality and other natural, social, human and built capital aspects.

Comparing GDP and GPI for the world (Figure 2) shows that while GDP has steadily increased since 1950, with the occasional dip or recession, GPI peaked in about 1978 and has been flat, or gradually decreasing, ever since. From the perspective of the real economy, as opposed to just the market economy, we have been in a global recession since 1978.

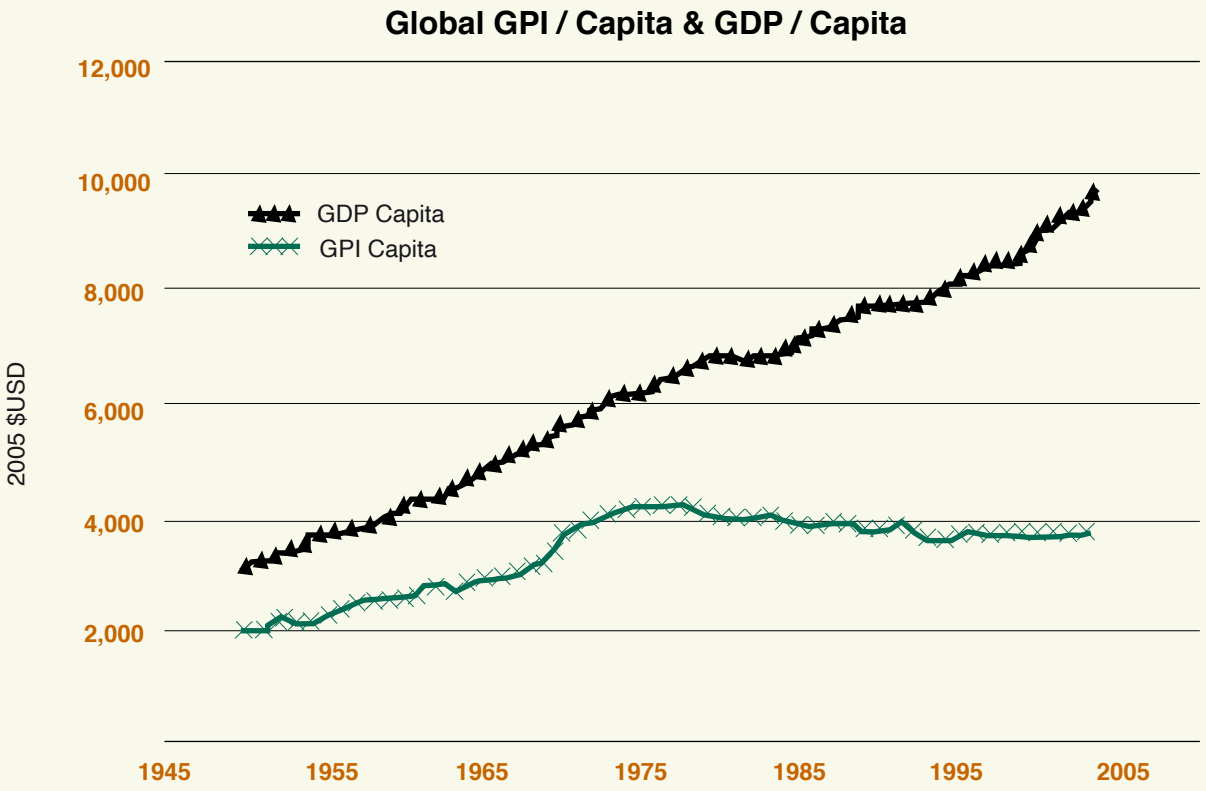

Figure 2. **Gross Domestic Product/capita and Genuine Progress Indicator/capita from 1950 to 2004.**
Original figure from Kubiszewski et al. (2013)

More information

Kubiszewski, I., R. Costanza, C. Franco, P. Lawn, J. Talberth, T. Jackson, and C. Aylmer. 2013. Beyond GDP: Measuring and Achieving Global Genuine Progress. Ecological Economics. 93:57-68. https://doi.org/10.1016/j.ecolecon.2013.04.019

2. Invest in nature and biodiversity

Nature is essential for human existence. It offers us health and good quality of life, as it plays a critical role in providing water, food and feed, energy, materials, medicines and cultural services. Biodiversity is the essential, complex and functional infrastructure that supports all forms of life on earth, including human life.

It also provides the building blocks for organisms and ecosystems to adapt and evolve in a changing environment and maintains humanity's ability to benefit from ecosystem services and biological resources in the face of an uncertain future. However, biodiversity is declining faster than at any time in history and nearly 1 million species are currently at risk of extinction (IPBES 2019). Investing in nature and biodiversity is therefore urgent and essential for long-term sustainable wellbeing, human health and a resilient circular bioeconomy. At the same time a circular bioeconomy powered by nature recognises the value of natural capital, and provides incentives for investing in the biological systems that it relies upon.

Measures to protect and enhance biodiversity and our natural capital via two interdependent strategies are essential for a sustainable and resilient circular bioeconomy. The first strategy is based on massive research evidence

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(bottom) Photo by: © KHBlack / Adobe Stock

showing how fostering more species-rich systems can support productive and resilient agriculture, forestry and aquaculture (Tilman et al. 2014), while avoiding the pitfalls of climate change, land degradation, resource depletion, pollution and insect decline. The second strategy aims to protect large, contiguous biodiverse systems across different ecoregions to prevent the deterioration of global ecosystem services, species extinction and the rapid erosion of biodiversity (Dinerstein et al. 2019). A concerted global action to maintain and restore highly biodiverse natural ecosystems over large land areas is required to save the diversity and abundance of life on Earth (Dinerstein et al. 2019). Both types of measures require new business models and institutional instruments like payments for ecosystem services (Farley and Costanza 2010) or common asset trusts aiming at the protection of biodiversity and the provision of ecosystem services. Food and human health depend on many of them. For example: more than 75% of the global food crop types rely on animal pollination with insects playing a key role; around 4 billion people rely primarily on natural medicines for their health care; and some 70% of drugs used for cancer are either natural or synthetic products inspired by nature (IPBES 2019).

Box II:
Renewable natural capital and nature-based solutions are key for a circular bioeconomy

Photo by: © Brandon Green / unsplash

Renewable natural capital provides us with a wide range of services. The most obvious include the food we eat, the water we drink, and the biomass we use for fuel, building materials, chemicals, clothing, etc. These are all part of a classical bioeconomy. Renewable natural capital also includes the many, less visible, ecosystem services, such as climate regulation, flood prevention provided by forests, or the pollination of crops by insects. The challenge is that in classical economics most of these ecosystem services are not assigned a monetary value. As a result, their importance and cost savings potential are mostly neglected, and overconsumption poses high threats on the renewable bio-capacity.

The natural capital accounting approach seeks to also put a monetary value on these. Although some may object in principle to putting a monetary value on nature, not doing so leads to ignoring natural capital in societal decisions and to the depletion and irreversible destruction of natural capital.

Investment in nature-based solutions (NBS) offers multiple opportunities to unlock new revenue streams and to increase customer engagement. The development of business activities and models that have no or positive impact on biodiversity and ecosystem services requires making natural capital measurable and accountable. It is important to develop these solutions in a consistent and biodiversity-friendly way. To help assure this, IUCN has developed an NBS standard that is currently being tested in different sectors to determine how it can be applied and integrated in private investment decisions.

The recent EU Green Deal and proposed Green Recovery Plan of the European Commission hold high hopes for transformational change. However, integrating natural capital accounting and supporting investments in nature-based solutions reducing overall consumption should be central to achieve a sustainable circular bioeconomy.

More information
The Economics of Ecosystems and Biodiversity:
http://www.teebweb.org/
The IUCN Global Standard on Nature-based Solutions:
https://www.iucn.org/theme/ecosystem-management/our-work/a-global-standard-nature-based-solutions

Box III:
Connecting private forest owners for collective biodiversity protection in Denmark

Most of Denmark's lush forests are on private land whose ownership is distributed among nearly 25,000 individuals, foundations and firms. As this large number of owners suggests, the parcels are mainly small patches of forest land, posing challenges to consistent forest management at a landscape scale. Nevertheless, Denmark's private forest land is home to some of the most unique and interesting populations of endangered animal and plant species locally, and fosters the highest overall forest biodiversity in Denmark, despite large regional variations. Research shows that private forest owners are ready to participate in biodiversity creation and protection if given appropriate incentives. Traditional government subsidies for biodiversity protection do not always effectively accommodate private forest owners.

A pilot project in Denmark seeks to re-think existing public grant schemes for biodiversity protection on privately owned land. The innovative mechanism is a "reverse auction", whereby forest owners offer biodiversity conservation measures they are willing to implement on their land, which are bid on by public entities. In this way, rather than taking the form of prescriptive measures imposed or compensated by a government entity, this mechanism places emphasis on stakeholders' agency to offer their forest services, within limits set only by their own imagination and expected outcomes.

Photo by: © unsplash

This experience shows that a competitive bidding process can improve the coordination and cost-effectiveness of nature conservation efforts, as well as the engagement of landowners. This is important to bring privately-owned forest areas into broader forest management frameworks, connecting small forest parcels into a larger patchwork of ecosystems in order to connect suitable habitats and preserve biodiversity.

More information

Thorsen, B. J., Strange, N., Jacobsen, J. B., Termansen, M., & Lundhede, T. 2018. Auction mechanisms for setting aside forest for biodiversity. University of Copenhagen. IFRO Report, No. 267. https://static-curis.ku.dk/portal/files/194648689/IFRO_Report_267.pdf

Reverse auctions for biodiversity protection: https://sincereforests.eu/reverse-auctions-pilot-for-biodiversity-protection/

3. Generate an equitable distribution of prosperity

Unlike fossil resources, biological resources like agriculture or forest resources are usually owned and managed by multiple people, communities and entities. This offers the circular bioeconomy the possibility to generate more beneficiaries via an equitable distribution of related income, jobs, infrastructure and prosperity across a wider geography (Hetemäki et al. 2017).

The circular bioeconomy challenges the current global economy model and provides arguments for a "glocal" economy based on reconciling global efficiency considerations with local resilience and equality aspects.

To do that, circular bioeconomy value chains need to be co-created with the participation of local communities, properly addressing questions of resource access rights. This means that the role of local populations, including indigenous people where pertinent, should not be limited to supplying traditional knowledge or harvesting biological resources, but should include their participation in strategic decision-making, governance and benefit sharing (IRP 2019). At the same time, the empowerment of women, including microfinance for women's enterprises, should be explicitly addressed to guarantee inclusive governance, poverty alleviation and overall sustainable development. Finally, we should not forget that our highly urbanised societies have become increasingly disconnected from nature and rurality. This means that an inspiring, science-informed narrative is necessary to gain long-term societal engagement from urban areas to support the transformative policies and rural actions required to create a circular bioeconomy. This narrative should overcome the past dichotomies of ecology and economy, as well as rural and urban areas that very much characterised the 20th century.

Photo by:

Box IV:
Payments for watershed protection in Ecuador

In 2000, after a long and severe drought and ineffective hydraulic infrastructure, the Municipality of Pimampiro in the Northern Andes of Ecuador needed new measures to improve the level of drinking water for its 12,951 inhabitants. Inspired by experience from Costa Rica, they established a local Payment for Ecosystem Services (PES) scheme, to protect native vegetation in the Palaurco River upper watershed which delivers the city's drinking water.

The NGO CEDERENA designed the PES as part of a forest management plan, including also ecotourism. Worried citizen and urban water users accepted to pay a surcharge on their monthly water bill to improve watershed management and secure water. These funds are paid to 19 mostly indigenous upstream households that had been deforesting for pasture and potato crop expansion.

Payments per hectare were relatively small (6-12 USD), but applied to quite large remaining forest holdings by the resident families, providing a secure cash income for landowners. Hydrological modelling indicates that a hypothetical resumption of 'business as usual' deforestation (some 100 ha extra being cleared) would increase sediments by more than 50% and reduce dry-season flow by 0.5%, figures which underpin the economic rationale for the PES scheme.

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More information

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Box V:
Bioplastics as a means for territorial regeneration in Italy

Photo by: © pixabay / Pexels

Biodegradable and compostable bioplastics are specifically conceived to help contribute towards returning clean organic matter back to soil in the form of high-quality compost by avoiding contamination with persistent plastics. Bioproducts, such as biolubricants, biodegradable ingredients for cosmetics and bioherbicides, are designed to safeguard solid and liquid streams from pollution, while improving the quality of organic matter.

At the same time the production of circular bioeconomy products does not only provide solutions to environmental issues affecting soil and water, but it can also support the territorial regeneration of rural areas by the creation of new jobs and infrastructures that unlock the potential of local socio-ecological specificities based on the development of locally-tailored open innovation platforms and integrated agricultural and forestry value-chains.

Novamont is a good example of a leading Italian circular bioeconomy company with a territorial regeneration vision, which builds on the revitalization of decommissioned industrial sites, thus avoiding land-conversion for industrial use and greenfield exploitation. Mater-Biotech, a company 100% owned by Novamont, has for example reconverted a decommissioned industrial site to manufacture new biochemicals obtained from renewable local resources. This represents the world's first industrial plant that can produce butanediol directly from sugars. According to Novamont, the bio-butanediol saves 50% of greenhouse gas emissions compared to conventional butanediol. The plant has a production capacity of 30,000 tonnes per year and has been conceived to reuse by-products for its own energy purposes, thus optimising the life cycle of the entire process.

More information
Example of territorial regeneration, from the revitalisation of a decommissioned industrial site:
https://www.novamont.it/eng/materbiotech/

4. Rethink land, food and health systems holistically

Climate change, land-use change, food production and human health are all interconnected. This means that human interventions influenced by economic, social and political factors can cause amplifying feedbacks (positive or negative) among them.

Food systems are responsible for 21-37% of global greenhouse gas emissions, yet there is still widespread food insecurity and malnutrition, while food waste represents one-third of all food produced for human consumption (IPCC 2019). Food production is also a major driver of deforestation, which itself is responsible for 25% of the emissions related to food production and has negative consequences for biodiversity and the water cycle. This widespread deforestation has also contributed to the emergence of zoonotic diseases (Kahn 2017).

Transforming the land sector (agriculture, forestry, wetlands, bioenergy) towards more sustainable practices could contribute an estimated 30% of the global mitigation needed in 2050 to deliver on the 1.5°C target (Roe et al. 2019). To achieve this, scaling up sustainable agriculture practices, marine management systems such as seaweed cultivation, and climate smart forestry measures (Verkerk et al. 2020) are needed to meet the demand for food while providing key regulating ecosystem services climate cooling and the provision of water resources (Ellison et al. 2017) and sustainable feedstocks

Photo by: © Foodtank

for producing biobased products and bioenergy. A one-health approach (Kahn 2017) is also necessary to holistically address human and animal health in connection to climate change and land management, including the role of biodiversity in the search and production of biopharmaceuticals.

Regenerative agriculture, including practices such as organic and no-till farming to restore soil fertility, or using silvopastoral or agroforestry systems, could enable agriculture to become a net carbon sink, rolling climate change backwards profitably, as it revitalises rural communities and enhances human health. Sustainable forest management needs to be adopted and adapted regionally to ensure the sustainable provision of biomass for circular biobased solutions while supporting the role of forests as carbon sinks, biodiversity protection, human health, as well as in the sustainability of the water and soil resources (Verkerk et al. 2020; Ellison et al. 2017). Establishing new and resilient forests, stopping deforestation, protecting intact old-growth forests, restoring mangroves and peatlands, while ensuring sustainable forest management, requires an expanded set of policy and finance strategies (Verkerk et al. 2020).

Photo by: Save the Canadian Boreal

Box VI:
Regenerative agriculture

Regenerative agriculture nourishes the soil on which all life depends, especially the microbial life that sequesters carbon in the earth. This is of high relevance because increasing the carbon content of the world's soils by just 0.4% each year would remove an amount of CO_2 from the atmosphere equivalent to the fossil-fuel emissions of the European Union, i.e. 3–4 gigatonnes (Gt). It would also boost soil health: in studies across Africa, Asia and Latin America, increasing soil carbon by 0.4% each year enhanced crop yields by 1.3%.

Regenerative agriculture implies a systemic shift from high-external-input-dependent industrial farming towards mosaics of sustainable, regenerative production systems based on small-holder organic farming. Because more people are needed to do the work that the chemicals previously did, regenerative farming increases employment, helping meet demand for jobs. Regenerative agriculture recognizes that a farmer is not only a producer of agricultural goods, but also a manager of an agro-ecological system that provides a number of public goods and services (e.g. water, soil, landscape energy, biodiversity and recreation).

Regenerative agriculture, grazing and agroforestry practices help to restore soil structures, build healthy topsoils, nurture soil microbes, and promote biological activity, all of which contribute to long-term productivity

Photo by: © Pexels

and nutritious crops. Moving towards sustainable and regenerative agriculture requires a holistic system of farms, farmers, and customers that balances the relationship between all inputs. Because such agriculture blends the best of modern science with ancient culture, lives are rewarding and sustainable.

More information

Put more carbon in soils to meet Paris climate pledges:
https://www.nature.com/articles/d41586-018-07587-4
Make agriculture truly sustainable now for food security in a changing climate:
http://unctad.org/en/PublicationsLibrary/ditcted2012d3_en.pdf
A Finer Future, Creating an Economy in Service to Life:
http://ourfinerfuture.com/
Soil4Climate:
https://www.soil4climate.org/resources.html

Box VII:
Forests for water — from global to local

Forests use more water than other vegetation types because trees have more leaf layers and their roots reach deeper in the soil. However, this is largely compensated by their strong ability to prevent soil erosion and their high water use efficiency, providing many goods and services for a reasonable amount of water. In addition, recent discoveries have revealed the essential role of forests for the global water cycle and food security. The evaporative "water loss" by forests now proves to generate repeated water recycling over land, sending rain clouds from the Amazon to the cereal crops of Argentina, from the Euro Siberian taiga to the fertile lands of China and from the Congo Basin rainforest to the Sahel and Ethiopia, benefitting millions of people there.

The virtues of restoring tree cover for soil and water conservation are nowhere better illustrated than in Ethiopia. The heavily deforested country engaged in a 64% reduction of greenhouse gas emissions by 2030, mainly through activities in the forestry sector, including a pledge to restore 15 million hectares of forest in response to the Bonn Challenge. The long-term benefits of this policy can be seen in Tigray, in the dry north of Ethiopia. A massive programme of community-managed land restoration has been able to support forest regeneration in 1.54 million hectares or 29% of the land area from 1996 to 2013.

With the help of water conservation technologies like stonebunds and terraces, the re-growing trees increase the water infiltration, which feeds a positive feedback chain of benefits. Springs that died in the 1980s re-emerge, which reduces the walking distance to water sources and opens opportunities for irrigated horticulture and improved nutrition. The reduced surface run-off stopped the loss of fertile land and decreased sediment flow, which increased the lifetime of dams for irrigation and electricity production.

More information

Muys B, Nyssen J, du Toit B, Vidale E, Prokofieva I, Mavsar R, Palahi M, 2014. Water-related ecosystem services of forests: learning from regional cases. In: Katila P, Galloway G, de Jong W, Pacheco P, Mery G (eds.) Forests under pressure – local response to global issues. IUFRO World Series Volume 32, Part II – Chapter 27, 423-440

Exclosure with slowly restoring dryland forest vegetation on a former degraded grazing land in Tigray, Ethiopia. Although the vegetation remains sparse, the ecosystem services of the exclosure in terms of water infiltration, soil carbon sequestration, or support of pollinators are huge.

Photo by: ©Josef A. Deckers

Box VIII:
Agroforestry to support deforestation-free cocoa production

Côte d'Ivoire's deforestation rate is one of the highest in the world. The national forest cover dropped from 50% (16 million hectares) of the total country area in 1960 to 10% (3.4 million hectares) in 2016. The expansion of cocoa production is the key direct driver for this rapid forest cover loss.

Côte d'Ivoire has taken ambitious commitments to decouple cocoa production from deforestation and restore forest cover to 20% of its territory by 2030. To address these challenges, in 2016 Mondelēz International, Côte d'Ivoire's largest cocoa buyer, and the Government of Côte d'Ivoire entered into an innovative public-private partnership to test the practicalities of Payments for Ecosystem Services (PES). A local PES was introduced to contribute to forest cover restoration by promoting agroforestry, reforestation and conservation by mobilising and building support for local actors. The mechanism is based on voluntary contracts between local cocoa farmers or communities and the PES operator to implement zero-deforestation activities in exchange for technical and financial support.

As of October 2018, 156 agroforestry PES contracts have been signed, thereby covering a total pilot area of about 600 hectares. Three nurseries, run by local women cooperatives, with a total production capacity of 100,000 plants have been created to provide the necessary number of seedlings

Photo by: © EU REDD Facility

for the project. 611 cocoa farmers have received technical training on agroforestry practices, such as growing seedlings and caretaking of the trees. These trees give shade for the optimum growth of cocoa trees. By producing fruits or wood, they provide alternative sources of income for farmers.

More information
Deforestation-free supply chains: a PES pilot project in Côte d'Ivoire: http://www.euredd.efi.int/publications/deforestation-free-supply-chains-a-pes-pilot-project-in-cote-d-ivoire

Photo by: © chokniti / Adobe Stock

5. Transform industrial sectors

Globally, industry is responsible for over 30% of all greenhouse gas emissions, of which the majority arise from the production of bulk materials like cement, metals, chemicals and petrochemical products (Wesseling et al. 2017). At the same time the current industrial system remains too 'linear', resource intense, and based on non-renewable resources, as globally only 12% of the materials come from recycling (IRP 2019).

For instance, non-metallic minerals such as sand, gravel and clay account for about 50% (44 billion tonnes) of all resources that we extract from the Earth. Those non-renewable resources are mainly used to produce highly carbon-intense materials, such as concrete, and their extraction has important consequences in terms of biodiversity loss. A system change is urgently needed to decarbonise industry and decouple it from the consumption of non-renewable resources. This requires the deployment of scalable innovations and viable technologies to produce renewable, low carbon, biobased solutions within circular systems, that optimise resource efficiency by circulating products, components, and materials which are always employed at their highest utility, in both technical and biological cycles.

In a circular bioeconomy, one system's waste is the next system's input. This requires taking a system view of large value chains. The shift to renewable, biobased solutions is therefore an opportunity to rethink industries and create low carbon circular value chains because biological resources, including sustainably managed waste, are circular by nature and often easier to remanufacture. New biomaterials, including bioplastics, hold tremendous promise due to their lower carbon footprint and biodegradability compared to petrochemical products (Hillmyer 2017). For instance, new wood-based textiles have a climate mitigation effect of 5 kg CO_2 per kg of product used compared to polyester (Leskinen et al. 2018). Another good example is the first ever car made of nanocellulose, a biomaterial five times lighter and stronger than steel, produced in Japan in 2019. Finally, measures to encourage reusing and recycling of materials or the need for a 'right to repair' and to curb the built-in obsolescence of devices need to be promoted. There is, as well, a large potential for using waste more efficiently to produce higher value products. For instance, sustainable fuels processed from biowaste or even carbon emissions can be now used in aviation.

Box IX:
ReSOLVE Framework for circularity

Photo by: Shutterstock.com

The ReSOLVE Framework is a tool to understand the core principles of a circular economy. It can help businesses and countries to navigate away from a resource-intensive linear economy towards a resource efficient circular economy by decoupling economic growth from the consumption of finite resources. The framework consists of six levers for circularity: Regenerate, Share, Optimise, Loop, Virtualise and Exchange.

Each of the levers within the framework represents a circular business opportunity and/or growth initiative. The levers can direct organisations to take innovative approaches to retain the value of resources, shift resource use from finite to renewable, increase utilisation of assets, remove waste, and digitise products. This transition can allow organisations and countries to become more resilient and less exposed to risk as they reduce dependencies on external supplies and associated price volatility.

The ReSOLVE Framework is enabled by technology, specifically levers such as optimise (e.g., automation or technology to maximise resource use), virtualise (e.g., digitisation of products and processes), and exchange (e.g., swapping in new technologies).

An example of an exchange lever is Algix, a clean technology company developing products from algae, such as bioplastic products for packaging and biodegradable filaments for 3D printing. This shows that a combination of bioeconomy innovation with technology can create new products or embed new functions.

More information

Ellen MacArthur Foundation, SUN and McKinsey Center for Business and Environment, Growth Within: A Circular Economy Vision for a Competitive Europe (2015). https://www.ellenmacarthurfoundation.org/publications/growth-within-a-circular-economy-vision-for-a-competitive-europe

The ReSOLVE Framework for a circular economy: https://earthbound.report/2016/09/12/the-resolve-framework-for-a-circular-economy/

Figure 3.

ReSOLVE levers of the Circular Economy

REGENERATE

- Shift to renewable energy and materials
- Reclaim, retain and restore health of ecosystems
- Return recovered biological resources to the biosphere

SHARE

- Share assets (e.g. cars, rooms, appliances)
- Reuse/ secondhand
- Prolong life through maintenance, design for durability, upgradability, etc.

OPTIMISE

- Increase performance/efficiency of product
- Remove waste in production and supply chain
- Leverage big data, automation, remote sensing and steering

LOOP

- Remanufacture products or components
- Recycle materials
- Digest anaerobically
- Extract biochemicals from organic waste

VIRTUALISE

- Books, music, travel, online shopping, autonomous vehicles, etc.

EXCHANGE

- Replace old with advanced non-renewable materials
- Apply new technologies (e.g. 3D printing)
- Choose new products/services (e.g. multimodal transport)

Source: Ellen MacArthur Foundation, SUN and McKinsey Center for Business and Environment, Growth Within: A Circular Economy Vision for a Competitive Europe (2015). Based on Heck et al. Resource Revolution (2015).

Box X:
Wood-based textiles

Spinnova's textile fibres. Photo: © Spinnova

The production of textile fibres has more than doubled in the last 20 years due to population growth and the expansion of the global middle-class. In 2018, the total production was about 107 million tonnes. Fossil-based textile fibres, such as polyester, represent about two-thirds of the whole market. Cotton fibres have fallen to second place in terms of volume and represent today only about 25% of the global textile market. Wood-based textile fibres (i.e. man-made cellulosic fibres) are today about 6% of the market.

However, fossil-based fibres are carbon-intense and result in the problem of microplastics contaminating our oceans, whilst cotton production requires massive amounts of land and scarce water resources. In this context, the interest in sustainable low carbon wood-based fibres has increased in recent years due to their lower carbon footprint and renewability. Commercially available wood-based textile fibres rely on four production technologies: Viscose (the most common by far); Lyocell; cellulose acetate; and Cupro. From a sustainability perspective, Lyocell is preferred as it is processed in circular systems. This is reflected in the impressive relative growth of Lyocell production capacity worldwide. In addition to conventional technologies, an impressive number of new, more sustainable technologies are under development in Europe.

For example, the Infinited Fiber Company's main focus is on using recycled clothes, but wood pulp is also a conceivable raw material. Tree to Textile is a joint venture between H&M group, Inter Ikea Group, Stora Enso (wood pulp processing) and inventor Lars Stigsson. Spinnova is the first production technology that does not require the use of chemicals, while Ioncell™ is based on a novel green solvent, with the same basic idea in its demo phase by Metsä Group and Japanese textile company ITOCHU Corporation. Finally, re:newcell/Circulose is recycling cotton and wood-based Viscose clothes into pulp, which can then be converted into textile fibre again.

More information

Lyocell by Lenzing:
https://www.lenzing.com/
Infinited Fiber Company:
https://infinitedfiber.com/
Tree to textile: https://treetotextile.com/
Spinnova: https://spinnova.com/
Ioncell: https://ioncell.fi/
Textile fibre from paper-grade pulp:
https://metsaspring.com/project/textile-fibre-from-paper-grade-pulp/
Re:newcell/Circulose:
https://renewcell.com/
'Forest for fashion' showcase:
https://medforest.net/2019/02/21/spanish-fashion-designer-maria-lafuente-is-forest-forward/

Box XI:
Sustainable biofuel for diesel and jet engines

Contributing sustainably to the renewable energy mix is one of the main challenges for the bioeconomy. Several companies are currently developing advanced biofuels based on different feedstocks ranging from vegetable-based oils, wood and pulping residues to waste animal fats, municipal solid waste and bioprocessing of waste gaseous carbon oxides. Examples include UPM BioVerno for diesel engines, Neste MY for diesel engines and jet fuel for aviation, Swedish Biofuels for jet fuel, gasoline and diesel and LanzaTech for alcohol-derived jet fuel and diesel.

UPM BioVerno, for instance, is made from crude tall oil (CTO), a residue of pulp production. UPM has been producing renewable diesel and naphtha from CTO in its Lappeenranta Biorefinery since early 2015, and the plant has a capacity of 130,000 tonnes of advanced biofuels. According to studies by UPM, greenhouse gas emissions (CO_2) over the entire production chain are as much as 80% lower than those of fossil diesel fuel. Another example is the LanzaTech biological gas fermentation platform that produces fuels and chemicals from industrial waste gases. Gas fermentation, a form of carbon capture and utilisation (CCU), employs microbes that live on the carbon from gases rather than sugars. The first commercial facility is operating in China and, according to their own information, has mitigated 70,000 tonnes of CO_2 since operations began. LanzaTech also converts ethanol to sustainable aviation fuel (Alcohol-to-Jet (ATJ)) using a flexible approach as it can use ethanol from any source, including ethanol made from advanced non-food/non-feed sources; and it can be tuned to produce the desired ratio of drop-in jet and diesel fractions. The National Research Council (NRC) Canada demonstrated that, compared to conventional Jet A fuel, the LanzaTech ATJ-SPK blend reduced the contrails, particulate number and mass emissions behind a test Falcon jet by over 80% as sampled by the NRC CT-133 research aircraft.

Photo by: © Denis Belitsky

More information

UPM Biofuels factsheet: https://www.etipbioenergy.eu/fact-sheets/upm-biofuels-fact-sheet

What is renewable jet fuel (Neste My Jet): https://www.neste.com/companies/products/aviation

LanzaTech: https://www.lanzatech.com/

Box XII:
A nanocellulose vehicle

Photo: Ministry of Environment, Japan

The use of cellulose nanofiber (CNF) materials for vehicles makes them up to 50% lighter than conventional ones. In 2019 the Ministry of Environment of Japan unveiled the first ever vehicle made of a revolutionary biomaterial: CNF. The entire car is composed of CNF, or plant-derived material (including agricultural waste) that is one-fifth of the weight of—and five times as strong as—steel. By using CNF to compose most of the bodywork and part of the tub, the bonnet and roof panel are about half as light as in a conventional vehicle, with a 10% overall reduction in the vehicle weight. The production process also shows the reduction potential of carbon emissions associated with vehicle manufacturing.

More information

NCV project: http://www.rish.kyoto-u.ac.jp/ncv/uploads/en.pdf

Future car made from wood: http://www.rish.kyoto-u.ac.jp/ncv/pdf/conceptcar_en.pdf

6. Reimagine cities through ecological lenses

Cities consume most of the resources that we use, including energy, materials, and food, while also being the source of two-thirds of the world's greenhouse gas emissions. In 2018, the UN projected 2.5 billion new urban dwellers by 2050.

Producing the volume of new housing required could claim up to 20% of the remaining carbon budget for 2020-2050 if mineral-based construction materials such as steel and cement are used (Churkina et al. 2020). A shift to biomaterials, based on engineering wood, cork or bamboo, could substantially reduce both the amount of materials used and the carbon footprint of our cities while creating durable carbon pools (Churkina et al. 2020). Using wood in construction has a climate mitigation effect of 2.4-2.9 Kg CO_2 per Kg of product used when compared to concrete while also storing 1 tonne of CO_2 in each m^3 of products (Leskinen et al. 2018). Building with wood is also more resource efficient as it can reduce the total amount of materials used in construction by 50% (Churkina et al. 2020).

In addition, integrating Nature-based solutions such as farming, trees and forests into urban infrastructures and city landscapes can substantially reduce energy consumption in buildings for cooling or heating and minimising the urban heat island effect. Urban forests and trees are also essential for the physical as well as mental health and sustainable wellbeing of urban populations, especially during a pandemic (Willis and Petrokofsky 2017, Derks et al. 2020). Public procurement policies and legislation to support the use of sustainable biobased building materials, circular construction approaches and nature-based solutions in cities need to be unlocked. Urban populations and decision makers need to become aware of their cities' environmental footprint and develop strategic relationships with their rural surroundings, to stimulate local and regional circular bioeconomy value chains that make both cities and rural areas more sustainable and resilient. Harmonised and symbiotic relationships between nature and cities, as well as between rural and urban economies, need to be at the core of future sustainable urban development strategies.

Sustainable City aims to become Dubai's star tourist attraction for Expo 2020.

Photo by: © Diamond Developers

Box XIII:
Engineered wood products for reimagining building construction

Atelier N11 by N11 Architekten.
Photo by: © Thomas Sherman.

Large-scale timber construction is evolving rapidly to allow for multi-storey wooden buildings and hybrid-material construction. New wood engineering products such as cross-laminated timber (CLT), and industrial prefabrication approaches allow timber to be competitive, versatile, rapidly assembled and with a lower carbon footprint when compared with non-renewable materials such as concrete or steel.

For instance, Atelier N11, by N11 Architekten (in the photo), is a five-storey building in the Swiss Alps, constructed with CLT from regionally harvested Norway spruce. The building, heated only through passive solar energy, demonstrates how engineered timber can have high thermal performance compare to other materials. Brumunddal, Norway, Mjøstårnet is home to an 18-storey mixed-use timber tower which used 3,500 m^3 of sustainably sourced wood that will store 3,500 tonnes of CO_2 in the building. The main load-bearing structure consists of large-scale glued laminated timber trusses along the façades as well as internal columns and beams. CLT walls are used for secondary load bearing of three elevators and two staircases.

In November 2019, Stora Enso launched a new building concept that makes it easier for architects, engineers and developers to design office buildings from wood. The flexible, modular wooden office concept enables office adaptation and demonstrates how the building products and applications can be used in a way that meets fire safety and acoustics regulations.

While innovative technologies for wood construction are coming into the spotlight, companies already have expertise manufacturing quality modular apartment buildings with wood as the structure. Sustainable, cost-effective and custom-made housing with fixed furnishings is possible, and prefab construction can scale.

More information
Ibañez, Daniel, et al. Wood Urbanism: From the Molecular to the Territorial. Actar Publishers, 2019.
Stora Enso massive wood construction: https://www.storaenso.com/en/products/wood-products/massive-wood-construction
Swedish modular housing: https://architizer.com/blog/inspiration/industry/swedish-modular-housing/
Lindbacks: http://lindbacks.se/

Box XIV:
The association between urban green spaces and human health

An increasing amount of research demonstrates that access and exposure to urban green spaces such as street trees, parks, gardens and forests, improves human mental, physical, and social health. Findings from across the world suggest a relation between urban forests and a number of health outcomes, including: longer lives and better general perceived health; lower prevalence of some cancer forms, dementia and strokes; less cardiovascular disease; better birth outcomes; less childhood asthma; more happiness and lower prevalence of depression.

The reasons and pathways behind the health benefits from nature are likely to be multifaceted and interconnected. Many studies show that people inherently and immediately react with reduced stress when being in nature. This has also been confirmed by measuring biomarkers, such as the stress hormone cortisol. Other research indicates that people tend to be more physically active and socially connected in green neighbourhoods. In addition, urban greenery contributes to mitigating harmful effects of climate change. For example, the cooling effect of urban trees contributes to less heat-related morbidity and mortality.

Through the massive expansion of urban areas over the last century, children have become vulnerable to negative health effects from poor air quality and urban stress and they have become increasingly disconnected from nature, resulting in “nature-deficit disorder” among young people.

Photo: Education for climate / Pexels

Several studies now demonstrate that children benefit from having access to nature by, for example, decreased levels of behavioural disturbances, alleviation of attention-deficit/hyperactivity disorder (ADHD) symptoms, and improved academic performance.
Taken together, there is strong scientific evidence supporting the need for increased and equal access to urban green spaces with health benefits to be expected across the life course.

More information

WHO, 2016. Urban green spaces and health – a review of evidence. Copenhagen: WHO Regional Office for Europe. http://www.euro.who.int/__data/assets/pdf_file/0005/321971/Urban-green-spaces-and-health-review-evidence.pdf
van den Bosch, M. 2017. Natural Environments, Health and Wellbeing. In: Oxford Research Encyclopaedia of Environmental Science. Eds. Fleming, L. Morris, G, Oglesby, L. Oxford University Press. https://doi.org/10.1093/acrefore/9780199389414.013.333
Green Cities Good Health: http://depts.washington.edu/hhwb/

Photo by: © Shutter B / Adobe Stock

ENABLING ACTION POINTS TO MOVE TOWARDS A CIRCULAR BIOECONOMY OF WELLBEING

7. Create an enabling regulatory framework

Unlocking the potential of the circular bioeconomy to decarbonise the global economy while enhancing natural capital and ensuring greater social equality requires a deeply transformative set of policies.

The need to recover economically from the impacts of the COVID-19 pandemic offers a great opportunity to put forward audacious policy measures at different scales (business, city, regional, national, global). For instance, abolishing subsidies that support the use of fossil fuels, while shifting taxes from labour to resource and energy consumption could provide important incentives to move towards circular bioeconomy solutions.

A well-functioning policy framework needs to ensure proper coordination between different policies: from public procurement (e.g., such as the US BioPreferred programme), to common standards to reduce business risk and boost innovation, to incentives for retaining value through circular economy processes, to carbon pricing (carbon and fuel taxes, effective emissions trading schemes, etc.), as well as property rights and common asset trusts. Consistent predictable and long-term policies are important to guide the scale of private investments necessary to bring the circular bioeconomy from a niche to a norm. This requires coordination, consistency and synergy across relevant policy areas, including nature conservation and climate as well as land sector and industrial strategies (including food security) in order to support the emergence of sustainable bioproducts and circular value chains.

The circular bioeconomy simultaneously addresses two global crises, those of climate and biodiversity, while providing new economic and social opportunities. Therefore, effective global governance mechanisms and coordination efforts are needed to integrate the circular bioeconomy concept into the existing international conventions for climate, biodiversity and desertification. New ways for effective international coordination might include the creation of a coalition of like-minded nations that commit to strong steps to advance the circular bioeconomy as a strategy to address jointly economic prosperity, climate change and biodiversity conservation.

Photo by:
© Chermen

Box XV:
The US BioPreferred public procurement Programme

Managed by the U.S. Department of Agriculture (USDA), the goal of the BioPreferred Programme is to increase the purchase and use of biobased products to spur economic development, create new jobs and provide new markets for biobased products. The idea behind promoting the development, purchase, and use of biobased products was to reduce the US reliance on petroleum, increase the use of renewable resources, and contribute to reducing adverse environmental and health impacts. The Programme consists of two major parts: mandatory purchasing requirements for federal agencies and their contractors; and a voluntary labelling initiative for biobased products.

To date, USDA has identified 139 categories of biobased products (e.g. cleaners, carpet, lubricants, paints) for which agencies and their contractors have purchasing requirements. Each mandatory purchasing category specifies the minimum biobased content for products within the category. The BioPreferred Programme provides acquisition tools, the BioPreferred Catalogue and training resources to assist in meeting biobased purchasing requirements.

The USDA Certified Biobased Product label, displayed on a product certified by USDA, is designed to provide useful information to consumers about the biobased content of the product. A business with a biobased product that meets USDA criteria may apply for certification, allowing them to display the USDA Certified Biobased Product label on the product. This label assures a consumer that the product contains a verified amount of renewable biological ingredients.

Biobased Products include those derived from plants and other renewable agricultural, marine, and forestry materials that provide an alternative to conventional petroleum derived products. For the purposes of the BioPreferred Programme, biobased products do not include food, animal feed, or fuel.

More information
BioPreferred Programme:
https://www.biopreferred.gov/BioPreferred/faces/pages/USDALoansAndGrants.xhtml

8. Deliver mission-oriented innovation to the investment and political agendas

Moving to a circular bioeconomy requires transformation across the entire innovation chain: on the supply side through investments in purposeful innovation, and on the demand side through procurement policies and product labelling that guide consumption and investment patterns.

However, sectoral research and innovation are not enough to accelerate and scale up the circular bioeconomy at the necessary pace. Mission-oriented innovation, new types of innovation niches and collaboration between public and private actors from different sectors and disciplines: bio-, nano-, digital, robotics, business, etc. are needed to create new business models, products and value chains. Mission-oriented innovation is crucial to design the future in a new way with common purpose, using nature as a guide and engaging communities to become involved through processes that encourage the co-creation of solutions.

The digital revolution is transforming our capacity to understand nature, manage natural resources sustainably and unlock value from ecosystems. It also provides new tools to optimise the use and value of materials through circular industrial systems that minimise resource inputs and waste. The development and sustainability of the circular bioeconomy depends very much on its own capacity to innovate using new digital and biological technological advances in combination with traditional knowledge. These developments will pose fundamental questions in terms of ethics and human rights which need to be appropriately regulated.

Photo by: © Tom Wang / Adobe Stock

Box XVI:
The Bio-based Industries Joint Undertaking (BBI JU)

Photo by: © hiv360 / Adobe Stock

BBI JU is a €3.7 billion partnership between the European Commission and the Bio-based Industries Consortium (https://biconsortium.eu/) that supports the development of innovative and competitive biobased industries in Europe. Since 2014, BBI JU has funded 123 projects that replace fossil-based with biobased materials to develop new, better, sustainable products and bring them closer to the market. Nine of them are flagship biorefineries converting biomass, including organic waste, into different types of biobased products, such as feed, fibres, materials, chemicals and bioenergy.

Already more than 80% of BBI JU projects anticipate lower GHG emissions compared to fossil-based counterparts, while a vast majority of them contribute to waste reduction and valorisation, reuse and recycling.

BBI JU projects mobilise all relevant stakeholders – primary producers, large industries, SMEs, clusters, trade associations, academia, research centres and end-users – to develop technologies and business models advancing Europe's green economy, thus structuring the sector's value chains. Most importantly, the biorefineries are the first of the kind in Europe with a high capacity of replication.

The BBI JU concept has a high leverage effect. For €195 million of public funding, the industry has invested €1.2 billion, and they have already generated over 3,300 direct and 10,000 indirect jobs in both urban and rural areas. BBI JU projects are also expected to diversify and grow farmers' income allowing the maintenance of vibrant rural areas and sustaining of local communities.

BBI JU projects are well-balanced in terms of participation - around 35% of BBI JU's funding goes to small and medium enterprises (SMEs), 31% to large industries and 30% to research organisations and higher education establishments.

More information
BBI JU: https://www.bbi-europe.eu/

9. Enable access to finance and enhance risk-taking capacity

A circular bioeconomy integrates a multitude of economic actors along complex value chains: everything from the management of forest ecosystems, agriculture, food systems, and supply of biomass to the deployment of new and expensive high-tech solutions that need to be environmentally responsible while being economically competitive.

Financing such development requires massive investments and specific instruments to reduce and share the risks involved, as well as minimising the difficulties faced when entering the market. Access to finance represents a major challenge, especially for growth and late-stage projects, and companies with higher capital needs. Venture-capital funding, green bonds, dedicated national and international circular bioeconomy funds (e.g. the European Investment Bank and the European Commission's European Circular Bioeconomy Fund) and public–private partnerships (e.g. the Bio-based Industries Joint Undertaking) should be promoted at an international level to accelerate the circular bio-transition. At the same time, an increasing number of investment funds (see Box XVII) are looking for sustainable investment opportunities around the world, which calls for specific circular bioeconomy investment platforms.

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Box XVII:
The European Circular Bioeconomy Fund (ECBF)

Photo by: © Mintra Untharit

The European Circular Bioeconomy Fund (ECBF) invests in and partners with ambitious and visionary entrepreneurs to accelerate late-stage companies. Being a growth-stage venture capital fund, ECBF provides project financing as well as typical venture capital investments.

ECBF aims to identify the most promising investment targets in the European bioeconomy landscape and encourage private and public investors to join the financial rounds to finance innovative solutions.

ECBF seeks mature growth-stage companies in bioeconomy sectors with high technology readiness levels (TRL ≥6) and operating in one of the EU-27 or 16-HORIZON 2020 associated countries. A high-quality deal flow of sustainability-driven innovations is generated from venture capital investors and European bioeconomy networks, as well as the entrepreneurs' initiative. Potential investments are assessed according to a set of Environmental, Social and Governance (ESG) criteria during due diligence. Subsequently, portfolio companies will be further developed and monitored to achieve optimal compliance with ESG criteria used as key performance indicators (KPIs).

ECBF is a risk-sharing financial instrument. By pooling resources, investors in ECBF can participate in financial rounds with an attractive risk-opportunity profile. Raising funds from public and private investors is an essential activity to de-risk innovative technologies and business models in an emerging industry. ECBF's private and public limited partners could significantly benefit from favourable conditions granted by the EIB (ECBF´s anchor investor) and the European Commission.

More information
European Circular Bioeconomy Fund:
http://www.ecbf.vc/

10. Intensify and broaden research and education

Research on circular bioeconomy and related innovations has so far been very much focused on the technological and engineering aspects. The human and market aspects, such as social innovation, have been neglected.

This is understandable, given the urgency to innovate and create biobased solutions capable of replacing fossil-based products. While such efforts should be intensified in the future, we need to broaden circular bioeconomy-related research by integrating technical sciences with social sciences as well as business, arts, design and humanities in a multidisciplinary manner. Such research also needs to include relevant stakeholders as well as market participants in the R&D process in transdisciplinary ways. This is crucial if we want to tackle the interrelated environmental, economic and social questions linked to the transition to a circular bioeconomy. Transdisciplinary research integrating sustainability science, climate research, ecology, biology, agriculture, forestry, economics, sociology, political sciences, psychology, human health and epidemiology, as well as many others – such as traditional, timeless knowledge, wisdom and practical skills – is needed. This would help to understand better the trade-offs and synergies at different temporal and spatial scales between climate change mitigation and adaptation, biomass production and the provision of ecosystem services, and between different land-use options and their implications for biodiversity safeguards, food, water and the provision of ecosystem services, energy and materials.

Photo by: © Gorodenkoff / Adobe Stock

New science and technological advances relying on modelling, artificial intelligence and big data provide a good basis to better understand complex socio-ecological systems and address sustainability questions connecting different disciplines. Involving relevant stakeholders in the formulation of research questions is also important for a more transparent and fluent science–policy–practice dialogue to reflect, inform and support policy and decision making. Finally, it is also vitally important to anticipate the new knowledge and skills – let alone how to integrate them with relevant traditional knowledge and skills – that will be required in the future within the circular bioeconomy, and integrate them in primary education, vocational training, continuing education and in design and academic studies through new curricula. International educational programmes built around the best disciplinary competences and case studies in different countries would speed up the circulation of knowledge to advance the circular bioeconomy. Above all, education needs to become a true engine for the development of the circular bioeconomy, and also for a re-discovery of the importance of working in harmony with natural and universal principles.

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Box XVIII:
Amazonia 4.0

For decades, the debate on the development of the Amazon has been split between two opposing views on land use. On the one hand (the so-called 'First Way') is the vision of setting aside large tracts of Amazonian forests for biodiversity conservation purposes. On the other, the vision of development based on the intensive exploitation of natural resources, mainly through agriculture, energy and mining (the so-called 'Second Way').

The Amazon Third Way Initiative proposes an innovative alternative to these opposing views. With the implementation strategy called Amazon 4.0, this "disruptive" initiative is designed with new research, technologies of the Fourth Industrial Revolution and learning opportunities to valorise and protect Amazonian ecosystems and to serve the interests of local populations, indigenous and traditional peoples alike, who are their guardians. Amazon Third Way aims to develop an equitable and socially inclusive "green economy" that is biodiversity-oriented, harnessing the value of nature through sustainable products from tropical forests standing with flowing rivers.

Amazonia 4.0 has two complementary capacity development strategies: Amazon Creative Labs and the Rainforest Business School.
The ambition of the Amazon Creative Labs is to enable state-of-the-art solutions that add value to existing, biodiversity-based value chains, and to explore new ones, all the way to

high-end genomics and biomimetic technology inspired by nature. Such labs are being currently developed for three value chains: cupuaçu-cocoa; Brazil nuts and fine cooking oils; and one lab on high tech for genomics.

The world's first Rainforest Business School is being designed to structure a new field of business knowledge – which can attract participants from Amazon communities — industry and business communities, administrators of public programmes and policies, and specialised civil society enterprises that relate to sustainable forest and fisheries management.

More information
Amazonia 4.0 Project:
http://www.amazoniaquatropontozero.org.br/

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A CALL TO ACTION!

Global challenges like climate change, and biodiversity loss, coupled with a growing and highly urbanised population call for ***new ways of producing and consuming within the planetary boundaries.*** *At the same time, the need to achieve sustainability while ensuring equitable prosperity, and the health and wellbeing of our citizens constitutes a strong incentive to rethink our land, food and health systems, transform our industries and reimagine our cities.*

To tackle these challenges a Circular Bioeconomy of Wellbeing is urgently needed. But to be successful, the circular bioeconomy needs to be explicit about its sustainability, measuring it and monitoring its progress.

A circular bioeconomy relying on and providing renewable energy and low carbon biobased solutions while enhancing natural carbon sinks is necessary to build a carbon neutral future in line with the climate objectives of the Paris Agreement. This contribution should be in synergy with other Sustainable Development Goals related to the need to enhance biodiversity, restore ecosystems and reverse land degradation, all necessary to ensure the sustainability and resilience of the natural capital upon which the circular bioeconomy and human wellbeing rely. For instance, biobased, biodegradable alternatives to plastics are key to achieving plastic-free seas and oceans which put at risk marine ecosystems and also human health. At the same time, it has become clear that the principal drivers of emergent zoonotic infectious diseases are associated with human activities, including changes in ecosystems and land use, intensification of agriculture, urbanisation, and international travel and trade. A circular bioeconomy which is based on a synergistic relationship between economy and ecology is in line with a One Health approach that recognises the interconnection between people, animals, plants, and their shared environment to address human health challenges.

The circular bioeconomy also supports the modernisation and transformation of industry through the creation of new value chains and greener circular and cost-effective industrial processes. Capitalising on unprecedented advances in life sciences and biotechnologies, as well as innovations merging the physical, digital and biological worlds, the circular bioeconomy can lead the modernisation of industry through the substitution of fossil raw materials by biobased solutions in significant industrial sectors (e.g. construction, packaging, textiles, chemicals, pharma ingredients, consumer goods). The development of new biobased value chains can support a more equitable distribution of prosperity across territories while helping to rethink our cities. Cities should be reimagined through the lenses of the circular bioeconomy: wood, trees and forests should become common nature-based solutions to support urban wellbeing and prosperity in harmony with nature.

Realising the potential of the circular bioeconomy through the six transformative action points requires an enabling environment. This is described in the four enabling action points, which include targeted and mutually coherent policies and strategies, innovation, investments, and research and education in order to trigger the necessary transformative changes across sectors and systems. Table 1 summarises the key recommendations.

The Action Plan for a Circular Bioeconomy of Wellbeing is a call for collective and integrated action to global leaders, investors, companies, scientists, governments, non-governmental and intergovernmental organisations, funding agencies and society at large to put the world on a sustainable path.

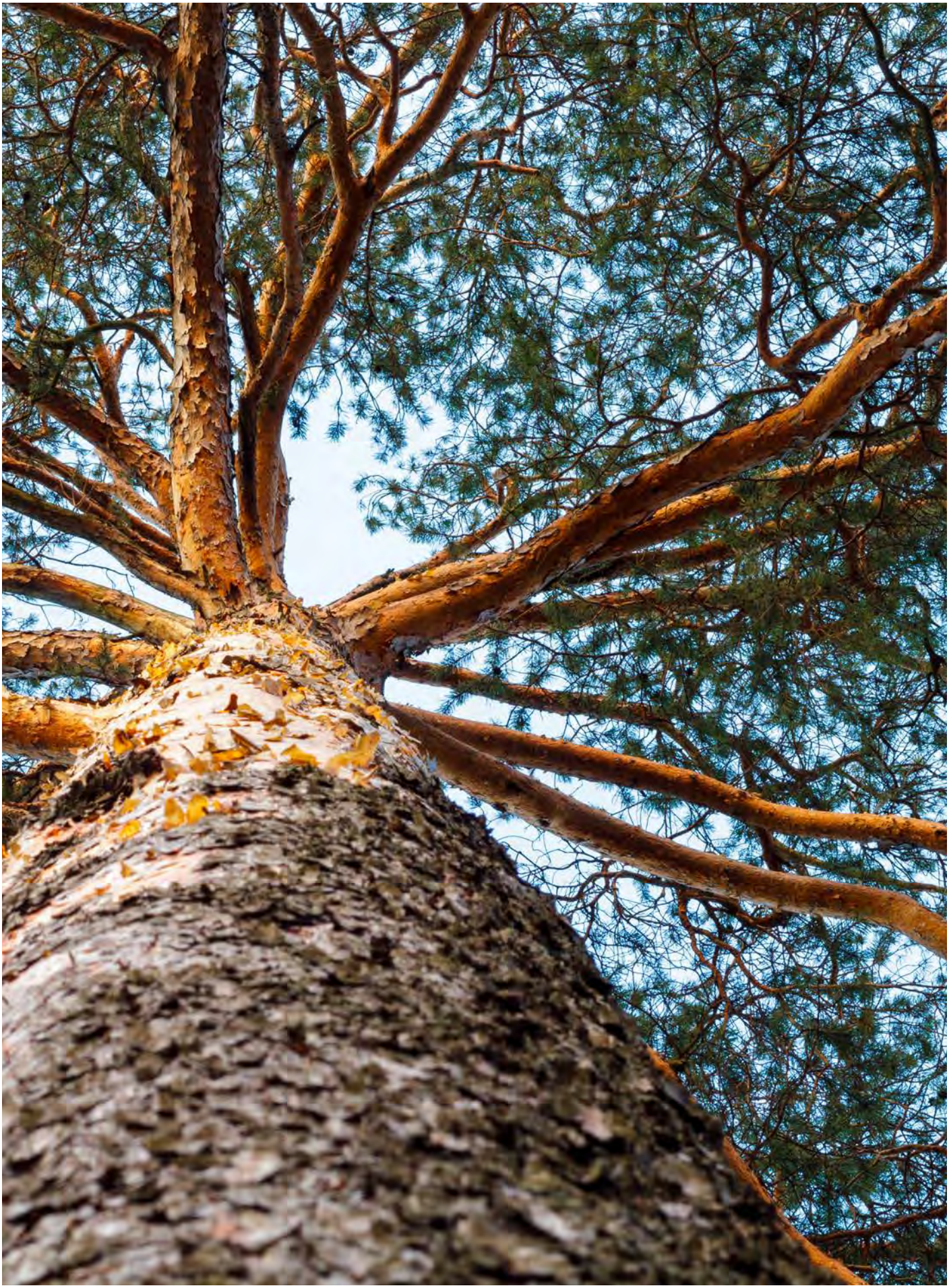
As highlighted by His Royal Highness The Prince of Wales at the World Economic Forum in Davos 2019:
The only limitation that we have is our will to act, the time to act is now!

Table 1.

Key recommendations within four enabling action points targeting transformative actions for a Circular Bioeconomy of Wellbeing.

ENABLING ACTION POINTS	KEY RECOMMENDATIONS	TRANSFORMATIVE ACTION POINTS TARGETED
7. Create an enabling regulatory framework An enabling policy framework at different scales (business, city, regional, national, global) that ensures coherence across policy areas, incentives and strategies on: nature conservation, climate, land management, waste and industrial.	Abolish subsidies that support the use of fossil fuels, while shifting taxes from labour to resource and energy consumption.	3, 5
	Develop public procurement (e.g. the US BioPreferred programme) and common standards, including labelling, to create a new market for circular bioproducts.	5, 6
	Put forward carbon pricing mechanisms to create a level playing field for biobased solutions and primary producers.	3, 4, 5
	Shift waste regulations from treating waste as an environmental hazard to a source of valuable materials and products.	5
	Design local to international integrated land governance and ecosystem restoration strategies, including effective governance of the global commons.	2, 3
	Integrate the circular bioeconomy concept into the existing international conventions for climate, biodiversity and desertification as well as the SDGs narrative.	All
8. Bring purposeful innovation to the investment and political agenda Purposeful and mission-oriented innovation is crucial to design the circular bioeconomy future with common purpose, using nature as a guide and engaging communities to become involved through processes that encourage the co-creation of solutions.	Create innovation niches and collaboration between public and private actors from different sectors and disciplines: bio-, nano-, digital, robotics, business, etc. to reimagine business models, products and value chains.	2, 3, 4, 5, 6
	Develop new platforms (e.g. IPocean), institutions and policies related to information, patents and copyrights that provide incentives instead of hindering progress.	3, 5
	Anticipate, address and regulate ethical and human rights questions.	3

ENABLING ACTION POINTS	KEY RECOMMENDATIONS	TRANSFORMATIVE ACTION POINTS TARGETED
9. Ensure access to finance and enhance risk-taking capacity Access to finance and risk-taking capacity are key to bring the circular bioeconomy from niche to norm. This is because it integrates a multitude of economic actors along complex value chains, everything from the protection and management of natural ecosystems, the production of biomass and food, to the deployment of new and sustainable high-tech solutions with high capital needs.	Establish venture-capital funding, green bonds, and dedicated national and international circular bioeconomy funds (e.g. the European Circular Bioeconomy Fund).	3, 4, 5
	Support public–private partnerships at national and international level (e.g. the Bio-based Industries Joint Undertaking, between the EU and the Bio-based Industries Consortium) to restore and manage ecosystems as well as demonstrate new technologies, creating new cross-sector clusters and setting-up flagship plants that deploy new technologies and demonstrate cost and performance improvements.	3, 4, 5
	Create a specific circular bioeconomy investment platform to address the increasing number of investment funds looking for sustainable investment opportunities around the world.	2, 5
10. Intensify and broaden research and education Circular bioeconomy research and development needs to be transdisciplinary, combining technology and engineering with complex systems thinking. Research needs to integrate science with traditional knowledge, business, arts, design and humanities, as well as involve relevant stakeholders in the process.	Support mission-oriented research and development in selected breakthrough projects that benefit from an international scale covering food systems, land-use, biocities, solid and liquid waste management, biorefineries, biodiversity, one health, social equity and women empowering.	2, 3, 4, 5, 6
	Create transdisciplinary research programmes and facilities including local communities to better understand the local trade-offs and synergies at different temporal and spatial scales between climate change, land-use options and the provision of ecosystem services, including biodiversity.	2, 3, 4
	Anticipate and design the new knowledge and skills on complex systems that will be required in the future within the Circular Bioeconomy of Wellbeing, and integrate them in primary education, vocational training, academic studies and business schools, through new curricula.	All



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