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Number 45

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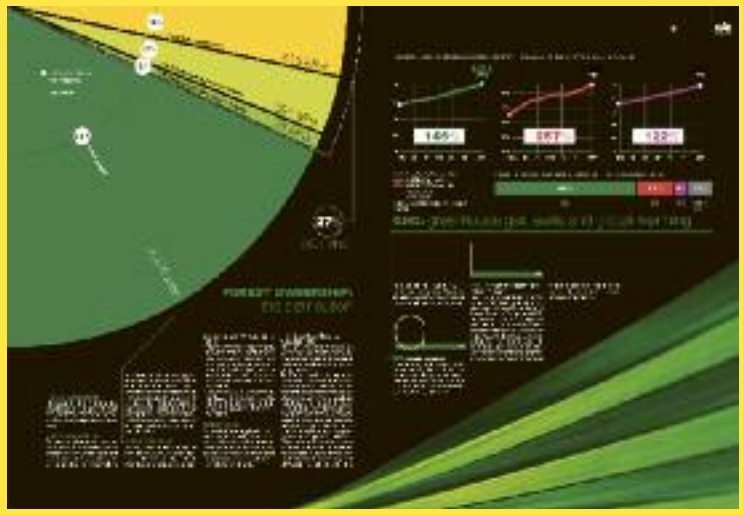

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by Danae Maniatis

- All opinions expressed in *WE* represent only the personal viewpoints of individual authors.
- All the maps are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

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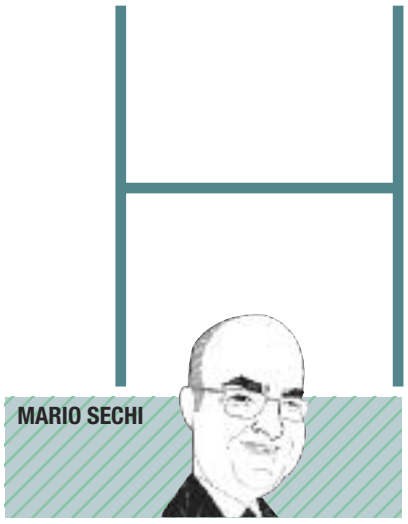
Editorial/The role of humans in the climate challenge

Roots, not Wings

The answer to our biggest global challenge will come neither in seeking a green utopia nor in following a neo-Malthusian trajectory. Instead, it must come through hard work and conscious effort →



ow can we support the environment without falling into the trap of the -isms? How can we be environmentally friendly without falling into the utopia of miserable decline? How can we cultivate ecology without becoming illogical? This issue of *World Energy* takes as its starting point the roots of plants, the strength of trees, to give robust answers, with its feet firmly rooted to the ground. We do not inhabit the dream of Icarus, we do not fly with wax wings, we do not maintain a discussion for its own sake. This is the time to be *Homo faber*, where we look for an effective solution to a genuine problem. By 2050, there will be 10 billion people on Earth. Every one of us aspires to well-being, to a dignified life, to the availability of basic goods, food and energy above all. There is a theory that this growth leads to an inevitable trend of decline in consumption, production and even demographics via strict birth control. We have simple questions in our notes: who decides how the model of wealth production and distribution on Earth should change? Who will give up on their own model of development? Who will tell the Western middle classes—they are the target—to give up their increasingly precarious affluence in the name of a neo-Malthusian policy (discussed in the last issue of *WE*), which would end up affecting them personally and pushing many more into poverty? Which world government will decide what to grow and what to eat? Who can ever put pen on paper to state which nations can have children and which can't?

Literary dystopia and reality

We are faced with a dangerous idea, because it inevitably leads to the engineering of life itself. We are in the field of a literary dystopia that is becoming a reality. We start with the rationing of food, and end up with the selection of births, thus making a reality of the nightmare society of Aldous Huxley's Brave New World, a place where emotions are controlled and people are reduced to mass production, forged by eugenics, where humans are a factory product, released into life like a software download, according to world government quotas. As we can see, this is an illusion of happiness that naturally contradicts itself, as in the words of one of Huxley's protagonists: "The optimum population is modeled on the iceberg—eight-ninths below the water line, one-ninth above." Those below it drown. It is not a matter of a directionless utopia to save the Earth. The solution lies in the concrete actions of the influencers, of politics, institutions and industry. First of all, a circular economy is possible. This is now a topos, not the only one, but the most immediate and urgent of all, referred to many times in the last presentation at the World Energy Outlook in Rome. Claudio Descalzi, CEO of Eni, said it is necessary to "grow organically and at low cost, to promote technology and the circular economy." The Chair of Eni, Emma Marcegaglia, recalled that the organization's governance is "attentive to the energy transition," while Fatih Birol, Director of the International Energy Agency, noted that within a couple of years, Africa "will become the most populous region in the world" and will need everything, not least food, and will therefore use more fertilizers. The Italian Prime Minister, Giuseppe Conte, stated the necessity of "providing full access to energy to about one billion people in the world who are still without it, to promote new industrial policies that can satisfy the growing global energy demand, all the while safeguarding the environment." There is no disagreement. It must be done. The agri-food sector, the food production needed for the survival of the human species, is responsible for 37 percent of global greenhouse gas emissions. 13 percent comes from tropical deforestation, 11 percent from agricultural production and a further 13 percent from food waste and processing. These figures conceal multiple man-made errors, which can be rectified, although we cannot overlook what the -isms see as a problem: the existence of man on Earth. We need to make better use of our resources, consume less soil and respect the sea and its natural cycle. Humans must not turn back; instead we must learn to use our great inventions and discoveries, above all plastics, the discovery of an Italian genius, Giulio Natta, a Nobel laureate for chemistry. The key to using plastics is to re-use them, and to include them in the circular economy. Recyclable materials are safer than others, the future of which is unclear when abandoned into the ecosphere. The concentration of the planet's population in urban areas is an inexorable phenomenon: where there is work, there are great internal and external migrations. Just think of China and the phenomenon of the "floating population." In 1978, the population of urban areas was 170 million, by 1990 it was 221 million, then 523 million in 2003 and 810 million today. Since 1978, 640 million people have migrated from rural to urban areas. What is all this? It is a massive revolution with global impact. Fifty percent of the world's population now lives in urban areas, producing 70 percent of human CO_2 emissions. The world's daily challenge is the emergence of metropolises, many of which have undergone a process of deforestation and now have too few green spaces. We must plant trees. Trees are one of the most accessible and effective tools for achieving the Sustainable Development Goals (SDGs). They benefit the air, the temperature, the cityscape and social life.

SUSTAINABLE DEVELOPMENT GOALS

End poverty in all its forms everywhere.

End hunger, achieve food security and improved nutrition and promote sustainable agriculture.

Ensure healthy lives and promote well-being for all at all ages.

Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

Achieve gender equality and empower all women and girls.

Ensure availability and sustainable management of water and sanitation for all.

Ensure access to affordable, reliable, sustainable and modern energy for all.

Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.

Other elements then come into play, those of urban planning and architecture. Human design. Intelligence at the service of everyone's well-being. Stefano Boeri, the originator of the "vertical forest" in Milan, tells this issue of WE how "trees are able to absorb pollutants such as fine dust and—via their shade—to mitigate the "heat island" effect typical of dense and congested urban centers, cooling the air temperature by 2-3°C and bringing a significant reduction in electricity consumption for air conditioning in urban interiors." When everyone turns on the aircon, the Earth gets hotter. What can we do?

The solution must be political

Plant. Don't uproot. Grow. Don't destroy. Is deforestation in Latin America to produce raw materials a Brazilian issue, one for South America or is it down to the entire international community? When President Jair Bolsonaro tells the UN that "it is wrong to state that the Amazon is a World Heritage Site," is he right or wrong? Where does sovereignty over one of the Earth's lungs begin and end? These are political issues for which political solutions must be found. The United Nations are doing sterling work, but they must now provide concrete answers, not resolutions that fall on deaf ears. Unfortunately, the loss of natural forests continues, with irreplaceable virgin forests still in danger. Solutions must be found for the unresolved issues of global governance, its limitations and the real topics of the noises off of the standard-bearers of an unresolvable -ism. Where there is a backhand, there is a forehand too, so if the warning light is flashing for vital areas of the Earth such as the Amazon rainforest, we must remember that Europe pursues an effective reforestation policy. Forested land in the European Union increased by around 11 million hectares between 1990 and 2010. It could work, but a grand coalition for the environment is required. Singular behavior can apply to everyone. Great oaks from little acorns grow. Let's recall the words of Pope Francis in his "Laudato si'" encyclical letter of 2015: "Education in environmental responsibility can encourage ways of acting which directly and significantly affect the world around us, such as avoiding the use of plastic and paper, reducing water consumption, separating refuse, cooking only what can reasonably be consumed, showing care for other living beings, using public transport or carpooling, planting trees, turning off unnecessary lights, or any number of other practices. All of these reflect a generous and worthy creativity which brings out the best in human beings. Reusing something instead of immediately discarding it, when done for the right reasons, can be an act of love which expresses our own dignity." Pope Francis is not recommending a decline, a stop to civilization nor that humans should retreat into caves. It is not the end of humanity that he seeks, nor our transformation into a decadent community, but a conscious way of living, the portrait of a society of abundance that must learn not to waste its wealth and to share it with the last inhabitants of the Earth. It is the same spontaneous, humble and regal gesture as we see in the Basilica of Assisi, in a sublime fresco by Giotto, in which St. Francis gives his cloak to a poor man. Planting trees is a humble and regal gesture. A wonderful metaphor that helps us understand how to move forward. Look around you, look up from the screen of your smartphone, forget about life's futile distractions for a moment and go for a walk. You will see trees bowing their foliage, but you will also see pride and beauty. They are letting themselves be blown by the wind. There is an African proverb that goes: "the wind does not break the tree that bends." Bending is not surrender. Instead it is adaptation to the world around us, to changing conditions, to life. Planting trees is a great start to life. Your author, dear reader, planted an acorn with his children many years ago. It has now grown into a magnificent oak. It was one of the finest things I have ever done.

Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

Reduce inequality within and among countries.

Make cities and human settlements inclusive, safe, resilient and sustainable.

Ensure sustainable consumption and production patterns.

Take urgent action to combat climate change and its impacts.

Conserve and sustainably use the oceans, seas and marine resources for sustainable development.

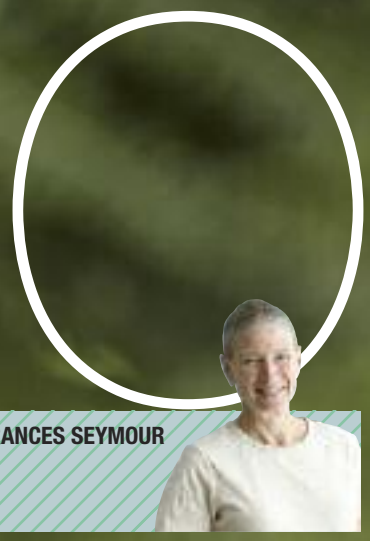
Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.

Strengthen the means of implementation and revitalize the global partnership for sustainable development.

The Hidden Value of Forests

Many services provided by forests are invisible—and unpriced by markets—but are nevertheless economically significant and relevant to the UN Sustainable Development Goals (SDGs). For the sake of climate and development objectives, it's time for forests to take their rightful place as a high priority and attract the level of attention and finance they deserve



FRANCES SEYMOUR

Distinguished Senior Fellow at the World Resouces Institute (WRI) since 2017, Frances Seymour is one of the world's foremost authorities on sustainable development. She was a Senior Fellow at the Center for Global Development and before that served for six years in Indonesia as the Director General of the Center for International Forestry Research (CIFOR).

ver the last few months, the connection between land-use change and climate change has gotten a lot of attention. In August 2019, the Intergovernmental Panel on Climate Change (IPCC) published a special report on climate change and land. In September, so-called "nature-based solutions" featured prominently at the United Nations Secretary General's Climate Action Summit in New York.

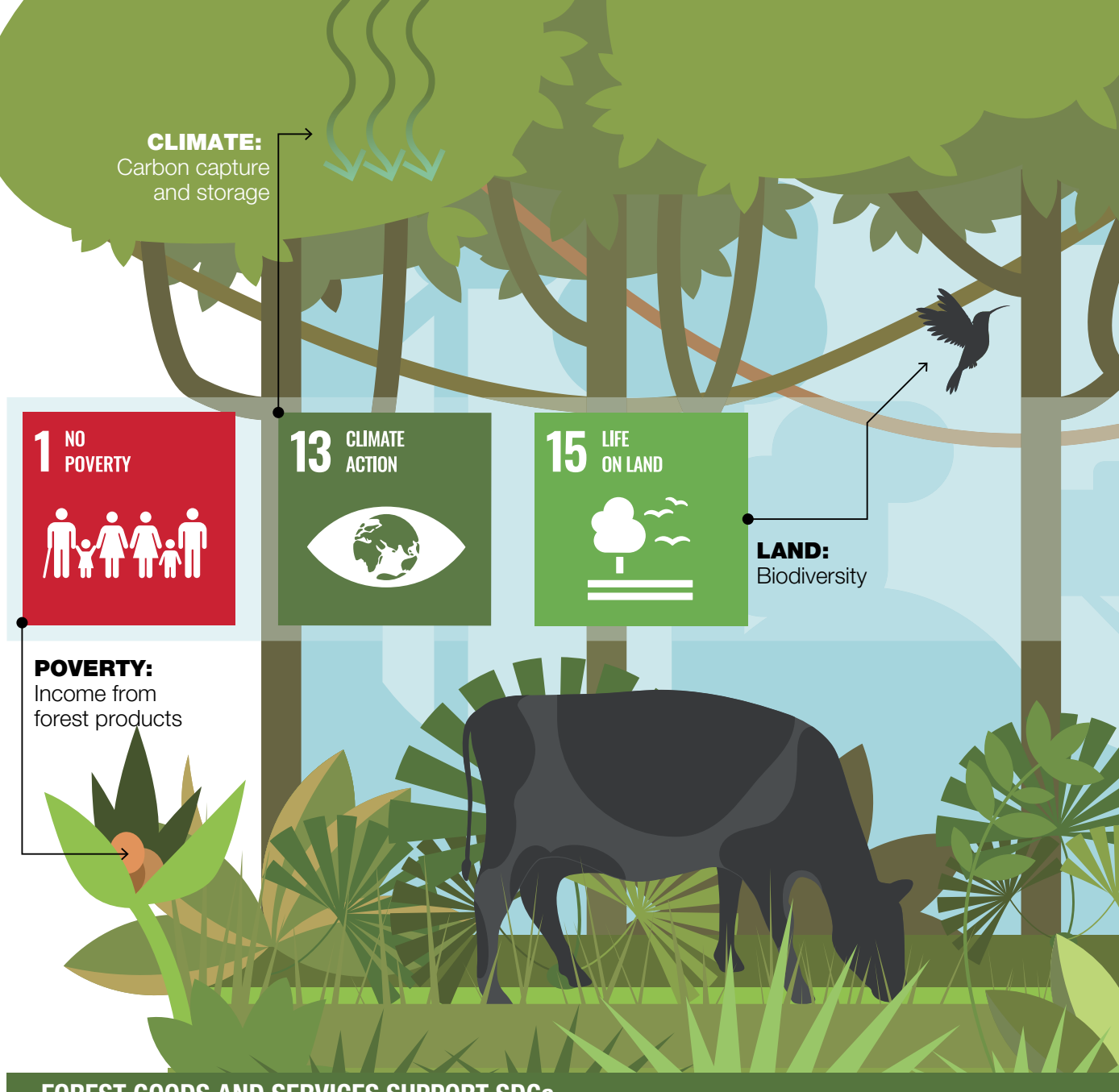
This broader focus on land is welcome, as the problem of climate change is often framed exclusively in terms of emissions from burning fossil fuels and discussion of climate solutions limited to increasing energy efficiency and renewable energy. However, it's important to highlight the special role of forests among nature-based solutions for achieving both climate objectives and SDGs.

The goals of the Paris Agreement cannot be reached without forests

Forests—especially tropical forests and peatlands—store vast amounts of →

ESSENTIAL TO MEETING SDGs

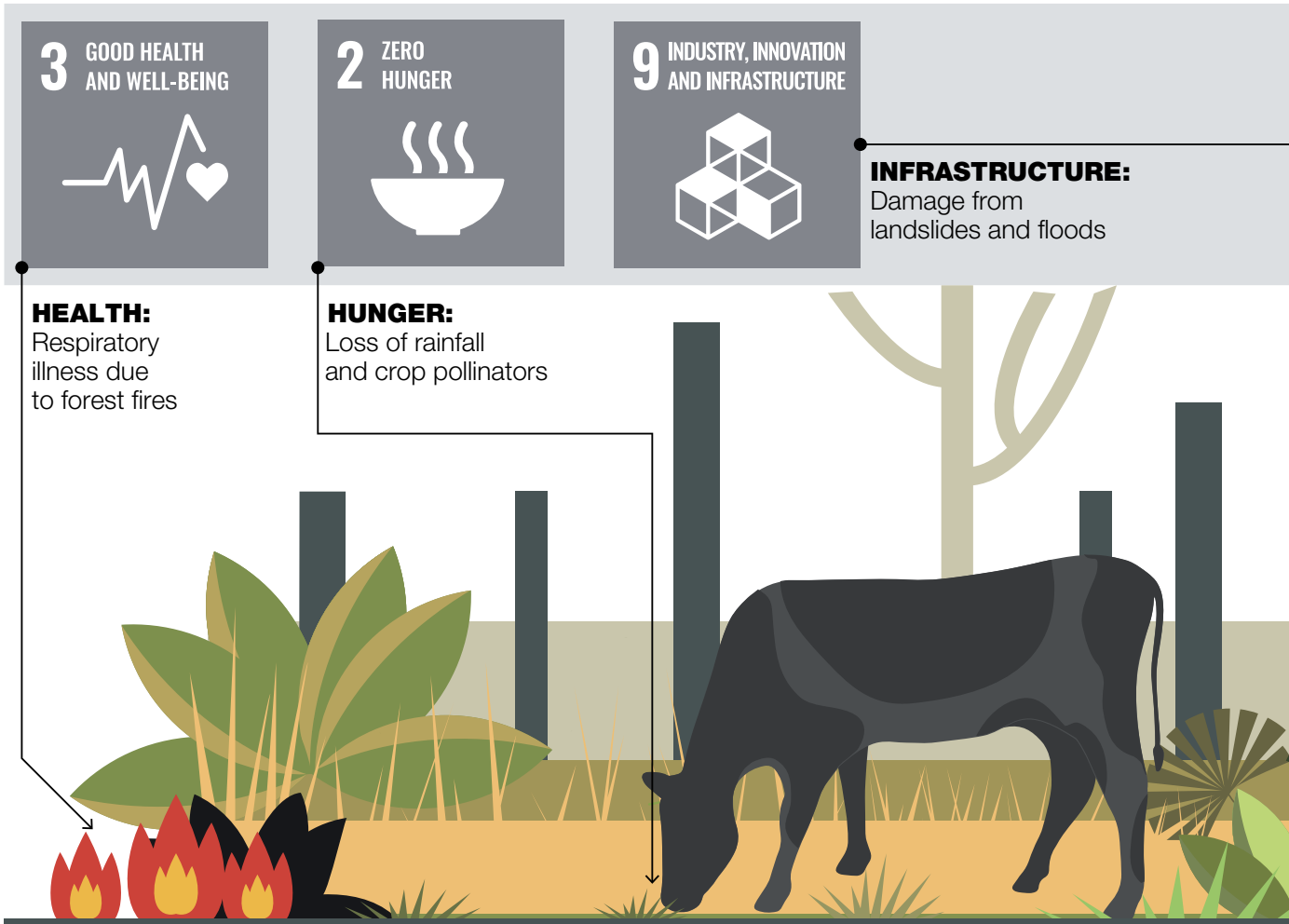
The presence of healthy forest ecosystems contributes to the well-being of human beings by providing essential goods and services for the achievement of different SDGs, such as the elimination of hunger and poverty, health protection and the fight against climate change. Conversely, the loss of forests can lead to high costs. The deforested landscapes are more vulnerable to extreme weather events and fires, whose devastating effects affect people's health and income.



FOREST GOODS AND SERVICES SUPPORT SDGs

carbon in their vegetation and soils. When forests are degraded, cleared or burned, that carbon is released into the atmosphere. In recent years, gross CO_2 emissions from tropical tree cover loss have averaged almost five gigatons per year. As a result, if tropical deforestation were a country, it would rank third after China and the United States as a source of the emissions that cause climate change. And that's not all: standing forests represent a natural carbon sink, as trees continue to sequester carbon as they grow, with larger trees absorbing carbon at the highest rate. When a mature forest is lost, future mitigation potential is also lost.

It would be virtually impossible to meet the goals of the Paris Agreement to keep global warming well below 2 degrees Celsius without addressing forest-based emissions. The September IPCC report concluded that "reducing deforestation and forest degradation represents one of the most effective and robust options for climate change mitigation, with large mitigation benefits globally." Yet despite the clear need to end deforestation, recent years have seen record-high levels of primary forest loss, with spikes in 2016 and 2017, and an area →



HIDDEN WAYS DEFORESTATION UNDERMINES SDGs

Source: Why Forests? Why Now? (Center for Global Development, 2016)

the size of Belgium lost in 2018.

One reason we continue to lose forests is the lack of finance to protect them. Despite lucrative economic opportunities available from logging or clearing forests for pasture or agricultural crops, financial rewards for conservation are scarce. Forest-related finance accounts for less than three percent of global development funding related to climate mitigation, an order of magnitude less than forests' mitigation potential.

But it would be a mistake to think of forests only in terms of their carbon storage capacity; they deliver many other benefits as well.

Forests contribute to many SDGs, including climate resilience

Healthy forest ecosystems contribute to human well-being by providing a myriad of goods and services relevant to the SDGs. On average, forest products—especially fuelwood—supply more than 20 percent of household income for local communities (SDG 1). Fruits, nuts, mushrooms, and bushmeat collected from the forest supplement diets (SDG 2), while medicinal plants treat illness (SDG 3). Tropical forests shelter the streams that provide habitat for freshwater fisheries and are home for most of the world's terrestrial biodiversity (SDG 15).

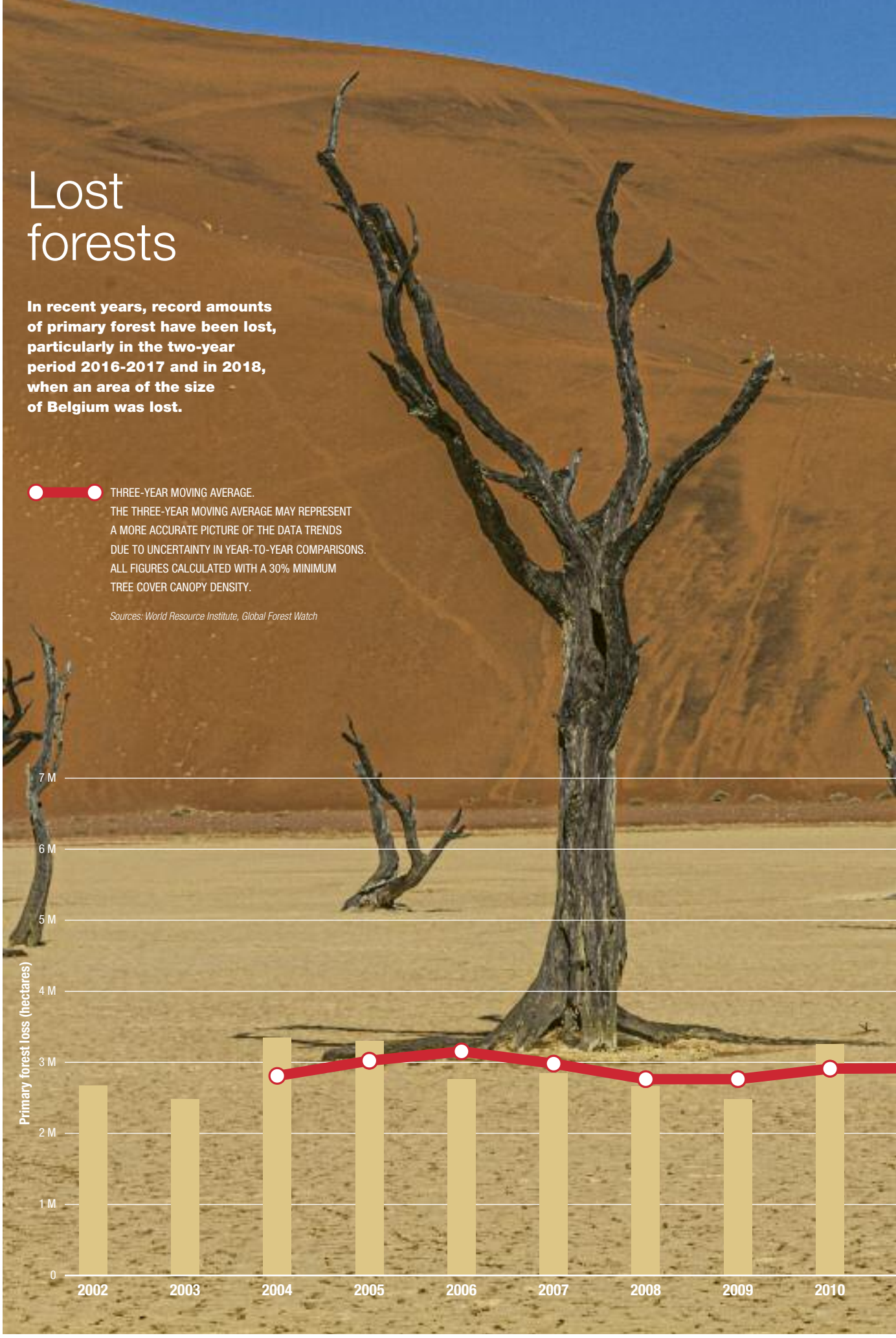
Many services provided by forests are invisible—and unpriced by markets—but are nevertheless economically significant. Forest-based bats, bees and birds provide pollination services to nearby agricultural fields. Forested watersheds further support agricultural productivity through hydrological regulation necessary for irrigation, while also providing clean water for municipal water supplies. Recent research suggests that the evapotranspiration function of forests generates rainfall across great distances.

Loss of forest-based ecosystem services can result in high costs. Without forested watersheds to control erosion, reservoirs behind hydroelectric dams are more vulnerable to sedimentation, shortening their useful life and affecting access to clean energy (SDG 7). Degraded forests are more vulnerable to fires that threaten respiratory health. The 2015 fires in Indonesia resulted in 100,000 premature deaths in the region and a USD 16 billion hit to the economy.

Deforested landscapes are more vulnerable to the extreme weather events that are likely to become more frequent and severe with climate change. In addition to contributing to global climate stability through carbon storage, forests contribute to local climate stability, for example, by moderating extreme temperatures on adjacent agriculture fields. Stripped of the "green infrastructure" provided by forest cover, deforested landscapes are less resilient to landslides, floods, and other natural disasters that damage brick-and-mortar infrastructure (SDG 11). Such natural disasters can knock a nation off its income growth path for decades (SDG 1).

Lost forests

In recent years, record amounts of primary forest have been lost, particularly in the two-year period 2016-2017 and in 2018, when an area of the size of Belgium was lost.



What can be done?

Thanks in large part to dramatic advances in remote sensing technology, we know quite a lot about the drivers of deforestation and the effectiveness of various strategies to reverse it. These vary from place to place, so there is no one-size-fits-all solution and the appropriate policy mix must be customized to each jurisdiction. Nevertheless, the evidence is clear that reducing deforestation requires some combination of:

- reducing the amount of forested land available for deforestation, for example, by establishing protected areas and by recognizing and defending indigenous peoples' customary land rights;
- increasing the cost and risk of converting forest to other uses, for example, by enhancing law enforcement, and ensuring corporate compliance with commitments to get deforestation out of commodity supply chains;
- reducing the demand for converted forest land, for example, by intensifying agricultural production and removing perverse subsidies for bioenergy.

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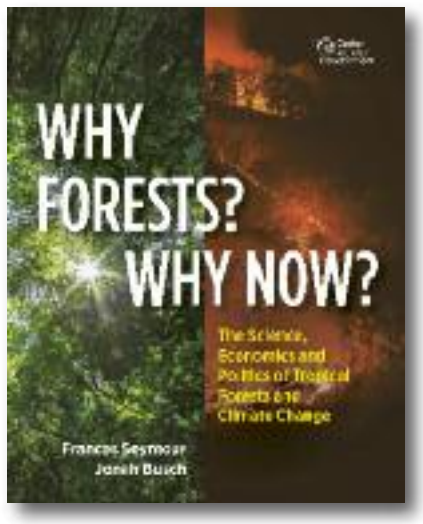


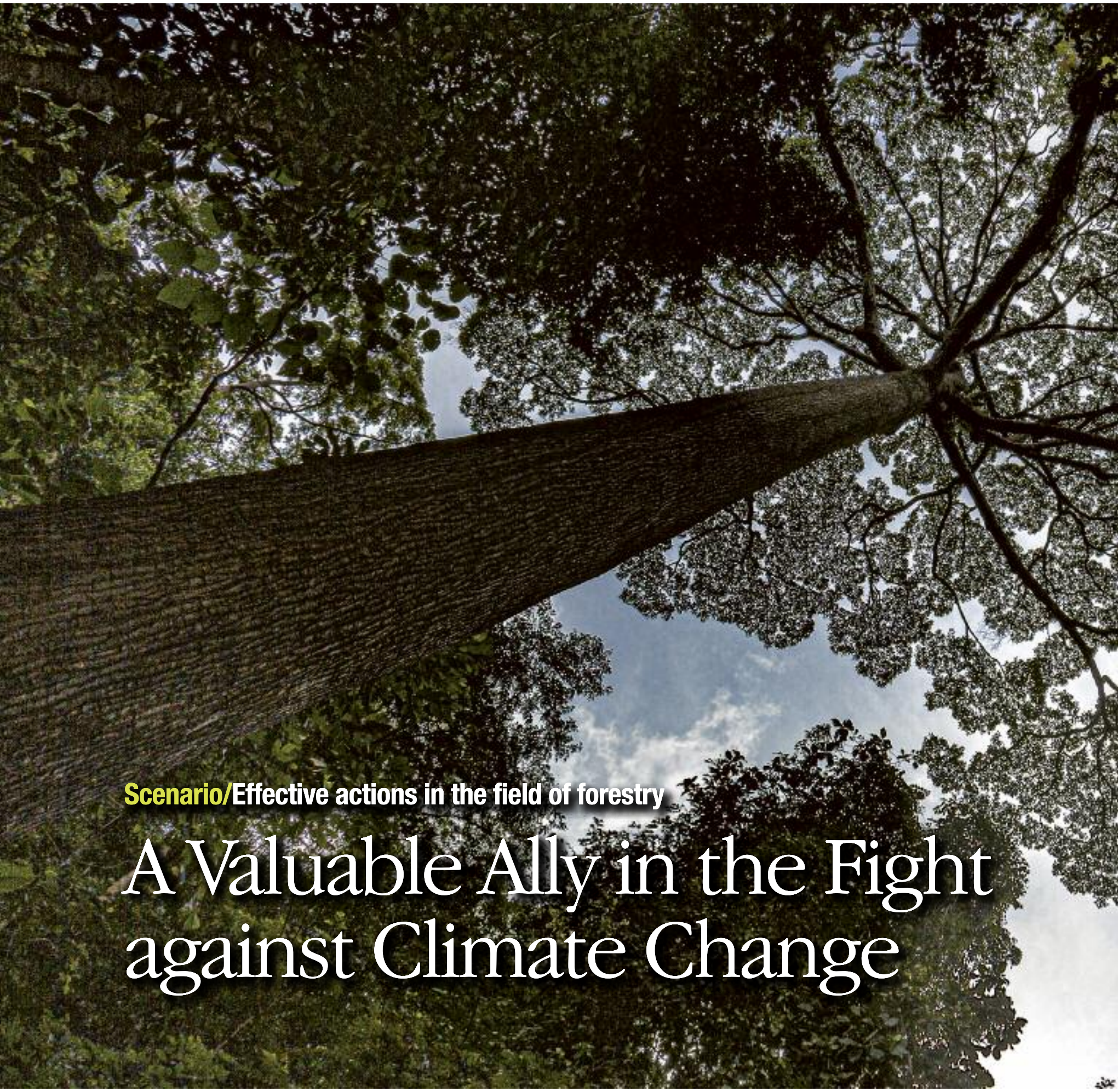
Published at the end of 2016, *Why Forests? Why Now? The Science, Economics, and Politics of Tropical Forests and Climate Change* has become a reference book for those dealing with climate change and sustainable development. Based on scientific and economic evidence, the book explains in accessible language the importance of forests and underlines the urgency, feasibility and convenience of increasing funding to reduce deforestation in developing countries.

Title: *Why Forests? Why Now? The Science, Economics, and Politics of Tropical Forests and Climate Change*
Authors: Frances Seymour, Jonah Busch
Pages: 429
Publisher: Center for Global Development

However, implementing these policies is difficult for governments, as deforestation-as-usual is often backed by strong vested interests and reforms to forest management must overcome significant political economy barriers. In order to provide incentives to governments for undertaking such reforms, negotiators under the United Nations Framework Convention on Climate Change (UNFCCC) developed a framework called REDD+ (for Reducing Emissions from Deforestation and forest Degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries). Under REDD+, rich countries provide financial reward to developing countries for their performance in reducing forest-based emissions.

Although the framework for REDD+ was completed in 2013 and incorporated into the 2015 Paris Agreement, and many forest-rich countries have made significant progress in fulfilling REDD+ eligibility requirements, the large-scale finance needed has lagged behind. Nevertheless, lessons from REDD+ implementation to date provide a sound basis for future performance as new sources of finance become available.

For the sake of climate and development objectives, it's time for forests to take their rightful place as a high priority and attract the level of attention and finance they deserve.



Scenario/Effective actions in the field of forestry

A Valuable Ally in the Fight against Climate Change

The principal challenge is the energy transition towards non-fossil sources. However, the mitigating role of forests is essential if global warming is to be limited to 2 °C by the end of the century, even more so if the target is 1.5 °C

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ESSENTIAL FOR EVERYONE

Forests contain around 90 percent of all living animal and plant species on the planet, covering an area of 3.9 billion hectares, equal to 30 percent of the Earth's surface. This is why they are essential for protecting the planet's biodiversity.

RICCARDO VALENTINI

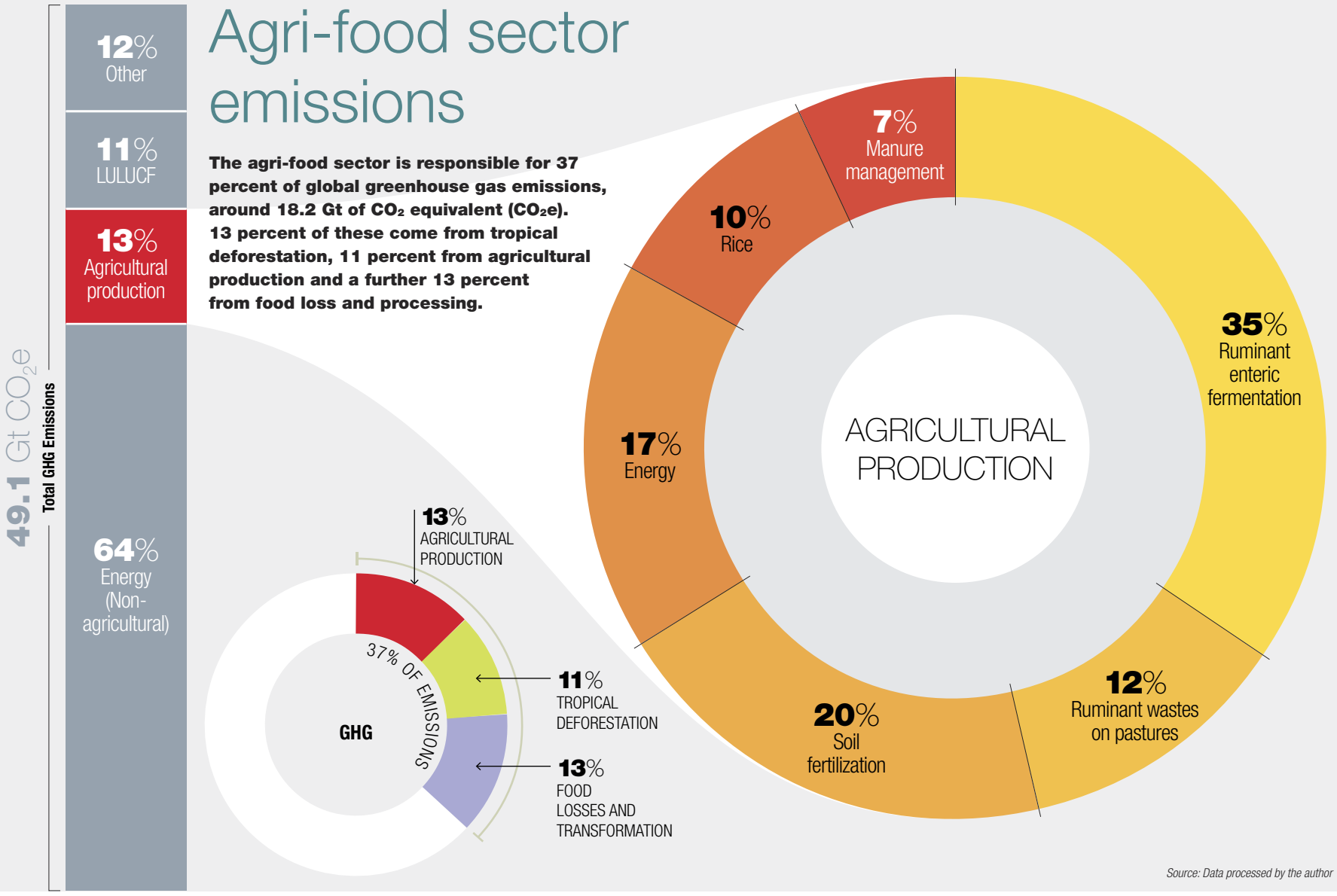
Full professor at Tuscia University since 2000 and Director of the Impacts Division of the Euro-Mediterranean Center on Climate Change. Valentini's research is mainly concerned with ecology, forests and the problems connected with the implementation of international conventions for the protection of the global environment. He is the co-author of the IPCC report that won the Nobel Prize.

Forests are one of the richest forms of expression of the earth's three million years of evolution. They contain about 90 percent of all living animal and plant species on the planet and cover an area of 3.9 billion hectares, equal to 30 percent of the Earth's surface. Tropical and subtropical forests account for 56 percent of the world's forests, while temperate and boreal forests account for 44 percent. Forests are therefore essential for protecting the planet's biodiversity. Altogether, tropical, temperate and boreal forests offer a multitude of habitats for plants, animals and microorganisms, hosting the vast majority of the earth's species. They provide a wide range of goods and services, from wood products to non-wood products, and they also provide livelihoods and jobs for hundreds of millions of people around the world. The biological diversity of forests has an important economic, social and cultural role to play in the lives of many indigenous communities, and they also fill a fundamental role in global climate dynamics, playing a significant role in climate mitigation as carbon sinks. When forests are destroyed, especially as a result of tropical deforestation, they release large amounts of carbon, which reaches the atmosphere and contributes massively to the greenhouse effect.

As human society has evolved, the perception of the relationship between man and nature has changed enormously. In the Middle Ages, and even before, man was afraid of the forest. In the collective imagination, the forest represented the fear of the unconscious, of the unknown, and was represented in many paintings and stories as a place of mysterious presences (fauns, elves, witches and orcs) or dangerous animals, dreamlike and legendary creatures (dragons, griffins and centaurs). Many well-known fairy tales and legends still evoke that representation, witness the tale of Snow White. Over the last 50 years, however, men have altered ecosystems more quickly and more intensely than at any other time in human history, so much so that we can say we are no longer afraid of forests, indeed we have learned to destroy them even in the most remote corners of the planet. What artists and writers like Chretien de Troyes, Ariosto and Collodi saw, always paying great respect and attention to forests and nature, no longer exists today. The speed with which man has appropriated nature has led to a substantial and irreversible loss of many of his functions. More land has been converted to agriculture since the 1950s than in the eighteenth and nineteenth centuries, at the expense →

Agri-food sector emissions

The agri-food sector is responsible for 37 percent of global greenhouse gas emissions, around 18.2 Gt of CO_2 equivalent (CO_2e). 13 percent of these come from tropical deforestation, 11 percent from agricultural production and a further 13 percent from food loss and processing.



Source: Data processed by the author

of the planet's natural capital, and we have gone from around 15 billion hectares of forests in the 1950s to four billion today. Population growth from 2.5 to 7.5 billion inhabitants in just 60 years and the consequent food requirement have resulted in our using 73 percent of dry land (with the exception of that covered by ice), putting a heavy burden on future generations, who will have only the remaining 27 percent of land available, an area insufficient to meet expected further population growth of around 2 billion by 2050 (IPCC-SRCCL, 2019).

Deforestation and CO_2

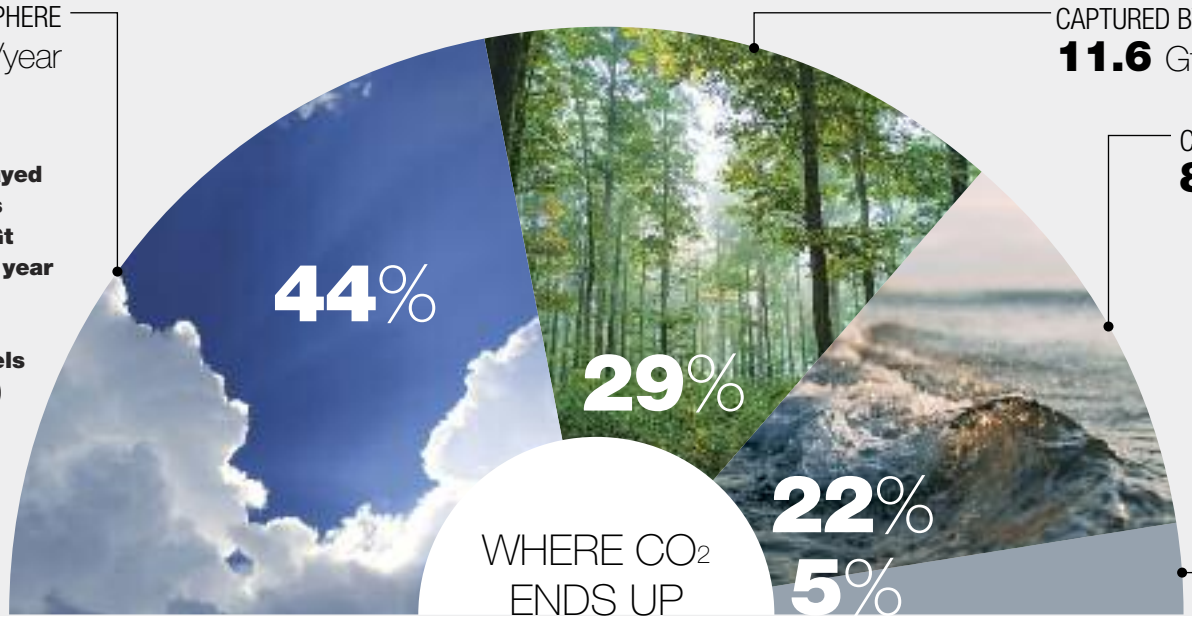
The pace of tropical deforestation is currently running at around 13 million hectares a year, a huge amount if we consider that in Italy forests cover 10 million hectares of land. Tropical deforestation contributes 5.3 billion tons of CO_2 emissions, an amount equivalent to 13 percent of total greenhouse gas emissions. This contribution increases greatly if we consider that deforestation is linked to the expansion of agriculture, which contributes 6.4 billion tons of CO_2, equivalent to the global greenhouse gas balance with 11 percent of global emissions. Furthermore, if one considers the entire food chain (deforestation, agricultural production and food consumption), the contribution of the sector rises to 37 percent of global emissions (IPCC - SRCCL, 2019).

However, forests also balance the planet's climate system. As shown in figure 2, while fossil fuel emissions amount to 34.4 billion tons (1Gt = 1 billion tons) of CO_2 per year and the emissions from tropical deforestation amount to 5.3 Gt of CO_2 per year, only 44 percent of these emissions remain in the atmosphere thanks to the role played by forests and oceans, which capture 11.6 Gt and 8.9 Gt of CO_2 per year (29 and 22 percent of total emissions) respectively. If there were no forests and oceans, the quantity of atmospheric carbon dioxide would have almost doubled, resulting in very dramatic conditions for the global climate today.

The need to activate effective atmospheric carbon capture systems as quickly as possible is well illustrated by the emission scenarios contained in the fifth report and in the subsequent IPCC special report on global warming of 1.5 °C by the end of the century (IPCC SR1.5, 2018, IPCC SRCCL 2019). In both cases, if we want to limit global warming by the end of the century to 2 °C or 1.5 °C, we must achieve zero emissions and then negative emissions by 2060 in the first case and by 2050 in the second. In any case, both scenarios envisage the achievement of negative emissions and the maintenance of atmospheric carbon sequestration far beyond the zero emission point until the end of the century. The term negative emissions is fairly unique from a scientific point of view but is used to indicate the absorption of atmospheric carbon, to make the complementarity of the two processes more understandable to policy makers. The achievement of negative emissions or carbon absorption can be implemented through atmospheric carbon storage technologies. The latter are receiving considerable attention and numerous studies and pilot projects that explore them are beginning to appear. For example, the pumping of emissions from large energy production plants and cement plants into geological cavities or the capture of CO_2 from the air by chemical-physical processes are technologies currently being studied quite intensively, and pilot projects already exist. However, the scalability of these methods, costs and the permanence of stored-carbon are still critical elements that prevent their spreading more quickly.

Recourse to natural systems, a real option

For this reason, mitigation policies are increasingly looking at the possibility of increasing the capacity of natural systems to absorb excess atmospheric carbon due to human activities. Oceans, for example, have a fairly constant capacity in the medium term to capture carbon dioxide, but it is very difficult to increase their carbon absorption rate. Interesting suggestions about climate engineering (e.g., ocean fertilization) have been made, but, due to their size, volume and costs they are considered impractical. However, reducing tropical deforestation and increasing the forested area through reforestation is certainly more practicable for the sequestration of atmospheric carbon and is now a real mitigation option. Through the process of photosynthesis, net of the oxidative processes of decomposition of the organic substance, under normal conditions a forest can store 12 to 24 tons of CO_2 per hectare per year. In general, tropical forests have a greater capacity to absorb atmospheric carbon, but decomposition processes and anthropic



Thanks to the role played by forests and oceans (which capture 11.6 Gt and 8.9 Gt of CO_2 per year respectively), only 44 percent of emissions produced by fossil fuels (34.4 Gt CO_2 per year) and tropical deforestation (5.3 Gt CO_2) remains in the atmosphere.

disturbances (deforestation) can reduce their contribution to atmospheric absorption to zero. Tropical forests can contribute about 3.7 Gt of CO_2 per year in carbon sequestration, but unfortunately tropical deforestation, including regrowth after disturbance, produces emissions of around 5.3 Gt of CO_2, negating the absorption role. For this reason, reducing deforestation could make a very significant contribution to the global carbon balance and does not require any particular investment. In boreal areas, the growth of forest biomass is limited by climatic conditions, although decomposition rates and the consequent release of carbon are slowed down. Their net balance is, however, positive in terms of carbon sequestration, particularly in view of their considerable size, contributing with about 1.8 Gt of CO_2 seized per year. Temperate forests like Italy's have good CO_2 absorption capacity and contribute globally by absorbing about 2.8 Gt of CO_2 per year. Overall, the role of forests is significant in reducing the absorption of atmospheric carbon, and protecting them is fundamental for the future of humanity.

In summary, what could be the most effective forestry-related measures to counter global warming? There are certainly several ways to increase the carbon absorption of forests. The most effective and inexpensive action, with significant environmental benefits, is to reduce tropical deforestation. The recent IPCC report on Land and Climate tells us that the mitigation potential of forest deforestation reduction is between 0.4 and 5.8 Gt of CO_2 per year. By comparison, the energy sector is worth approximately 33 Gt of CO_2, and that of coal alone contributes 10 GtCO_2 per year. Secondly, much can still be done to improve the management of existing forests and protect them from adversities and the risk of fires. This is the case in Italy, where, despite having a significant forested area (about 10 million hectares), our forests are abandoned and subject to various forms of degradation. Another very direct solution is to plant trees on degraded land that is not used for agriculture. A recent study (Bastin et al., 2019) shows that it would be possible to globally reforest about 900 million hectares of degraded land and thus contribute to absorbing about 758 Gt of CO_2 at maturity, or 25 percent of the current carbon content in the earth's atmosphere. Finally, significant contributions can be made by the use of forest plantations for bioenergy production, and therefore the replacement of fossil fuels, as well as the replacement of material produced with fossil energy, with renewable ones (for example the replacement of cement or steel in buildings with wood). In any case, attention must be paid to promoting large-scale reforestation work, given the potential conflict over land use for the necessary production of food. Food security is a topical issue due to global warming and the land available for agriculture today being very limited. Moreover, large-scale reforestation might affect the regional climate which, at high latitudes, might lead to localized heating of the climate due to changes in surface energy exchanges. In essence, the challenge is still that of making the energy transition to non-fossil sources, and it would be dangerous to consider forests as the only alternative to combating climate change. However, the mitigating role of forests is absolutely essential to limit global warming by the end of the century to 2 °C and even more if the target is 1.5 °C.

Geoengineering/Is it an alternative to fight climate change?

Full-scale Action

The responses to the climate crisis have been so inadequate that we must now use all the resources at our disposal to deal with it. No single response, political action, technology or miraculous reform alone will suffice

MOISÉS NAÍM

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The numbers are in. Humanity needs to cut global greenhouse emissions by 7.6 percent every year for the next decade to meet the 1.5 degrees Celsius target agreed upon in the 2015 Paris accord. This is just one of the alarms sounded by the 2019 Environment Emissions Gap Report recently released by the United Nations. Each year the report assesses the difference between "where we are likely to be and where we need to be" with regards to greenhouse emissions. The report also notes that, in the past decade, global emissions of greenhouse gases have increased 1.5 percent each year on average and confirms that the world has warmed more than 1 degree Celsius from what it was in pre-industrial times.

If current trends continue, surface temperatures are likely to increase 3.9 degrees Celsius, or 7 degrees Fahrenheit, by the end of this century. To keep warming below 2 degrees Celsius, nations will need to triple their current emission goals. Even more daunting is the estimate that in order to contain temperatures at levels below 1.5 degrees Celsius, countries will have to quintuple their efforts to contain greenhouse gases.

We know the cataclysmic scenarios that result from assuming higher average temperatures. Regions that are currently home to hundreds of millions of people would be below the high-tide line by 2050. Large areas of cities such as Alexandria, Bangkok, Shanghai, Mumbai, Miami and Ho Chi Min City could become uninhabitable. Jakarta is already being flooded by a combination of rising sea levels and ground sinking, forcing an urgent move of the capital to the island of Kalimantan. Large-scale forest and urban fires are raging in diverse areas of the planet, from Brazil and Bolivia to Indonesia and California, generating changes that could be largely irreversible. Hurricanes and tornados that cause large-scale damage have increased in frequency. The projections of average global temperature point to an increase in a range between 4 to 4.9 Celsius by year 2100, in contrast with the targets of less than 3 degrees centigrade originally set at the Paris agreement or,

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even worse, with the modified current targets of 3 to 3.4 degrees Celsius. If impactful mitigation efforts are not significantly increased, global temperatures are bound to reach levels that will eventually make most of the planet inhabitable.

Climate change is happening much faster than scientists anticipated while political actions aimed at containing the climate emergency have been much slower. As a result of the seemingly structural incapacity of governments to take the actions needed to steer the planet away from this perilous trajectory, a growing number of scientists now fear that the planet's cataclysmic climate crisis is unavoidable. Others are looking for radical new ideas to avoid this outcome.

Enter technology

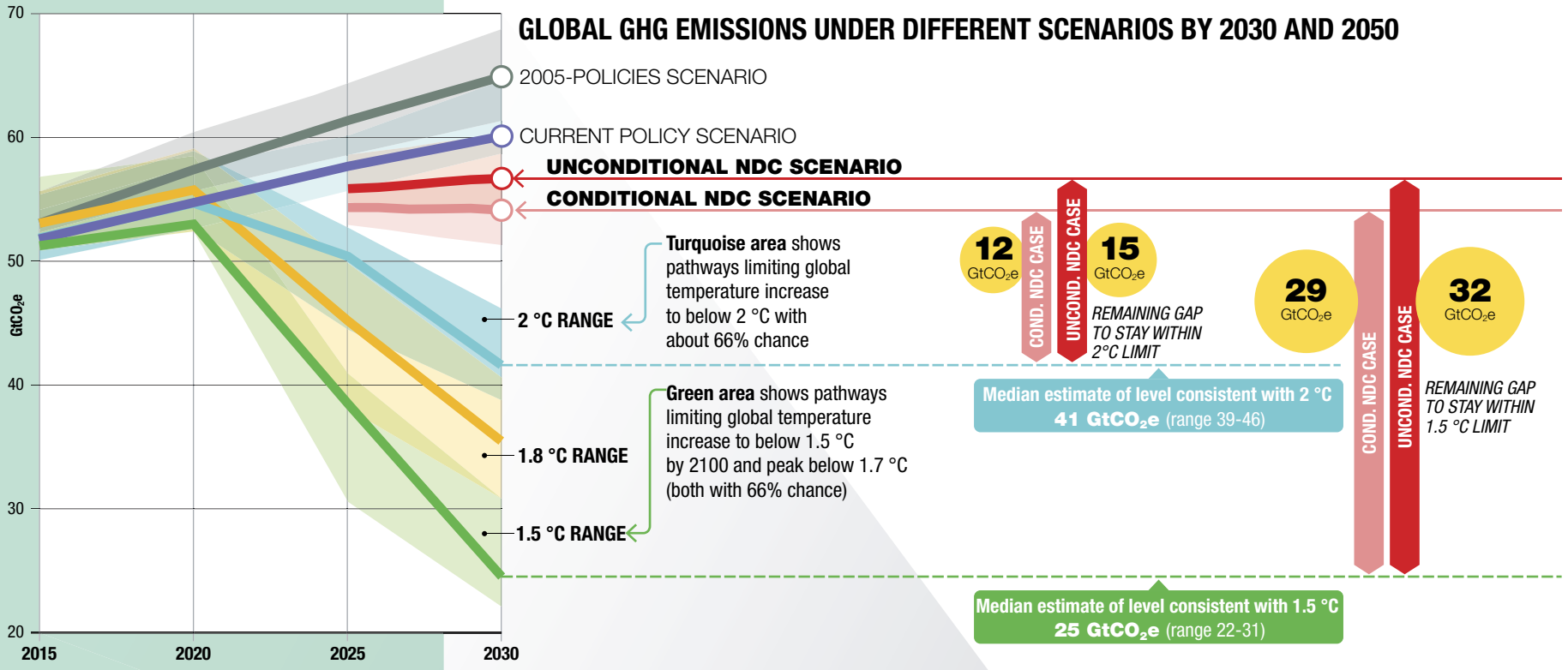
As mitigation efforts fall significantly below the necessary targets for the preservation of desirable global temperatures, increasing attention has been paid in the last few years to geoengineering. The term is used for the large scale, technological driven interventions of natural processes aimed at containing the rise of global temperature. For years geoengineering was dismissed by experts as too risky, uncertain, full of dangerous unintended consequences and prohibitively expensive. Critics also stressed that the science was not there yet and all results were speculative and in need of stronger evidence. The technology was also not sufficiently developed. But as Fred Pierce, a British author has noted, "Human intervention with the climate system has long been viewed as an ill-advised and risky step to slow global warming. But with carbon emissions soaring, initiatives to study and develop geoengineering technologies are gaining traction as a potential last resort."

Some geoengineering ideas

The geoengineering options being discussed are very diverse and are at different stages of research and development. Some illustrative examples of these projects are the creation of an artificial cloud cover to limit the intensity of solar rays, the massive dumping of iron or limestone into the oceans to increase their capacity to absorb carbon dioxide, the building of wall containments of ice sheets to minimize sea level rise, mirrors to deflect sunrays or the use of Biochar to promote soil absorption of carbon. Biochar is a charcoal-like substance that's made by burning organic material from agricultural and forestry wastes (also called biomass) in a controlled process called pyrolysis.

Geoengineering ideas fall into two broad categories. One is designed to increase the albedo effect, which refers to the ability of surfaces to reflect more heat than dark surfaces. The idea is to find ways to boost the capacity of the earth's surface to reflect solar rays and thus reduce global temperatures. Since the main generators of albedo are ice and clouds, and the melting of the ice sheets has weakened the albedo effect, the possibility to create additional protective cloud cover has become much more enticing. This can be accomplished by the large-scale spraying of aerosols into the stratosphere, thus seeking to reproduce the effects of large volcanic eruptions, which are known to decrease the amount of sunlight reaching the surface of the earth, thereby lowering average global temperatures.

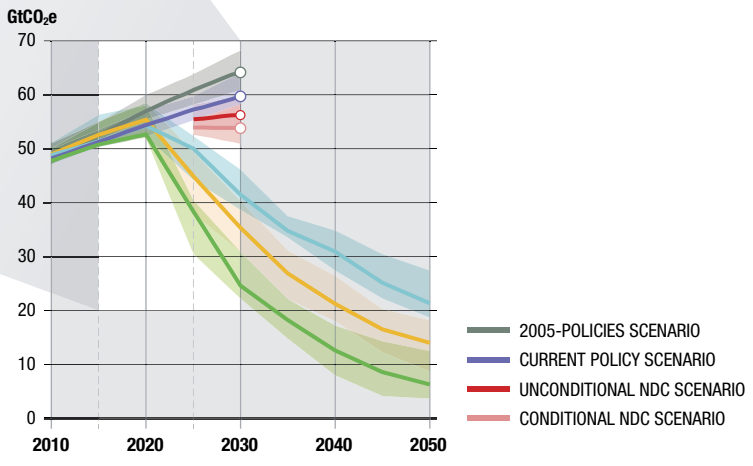
The other category of geoengineering ideas consists of promoting the removal of more carbon dioxide from the atmosphere than nature and, especially, human activities generate, in order to come up with a net negative emissions effect. There are several techniques that are being tried to accomplish this, such as extensive afforestation, carbon underground storage and direct air capture.



A still large gap

The gap between estimated total global emissions by 2030 under the NDC scenarios and under pathways limiting warming to below 2 °C and 1.5 °C is large. Full implementation of the unconditional NDCs is estimated to result in a gap of 15 $GtCO_2e$ (range: 12–18 $GtCO_2e$) by 2030, compared with the 2 °C scenario. The emissions gap between implementing the unconditional NDCs and the 1.5 °C pathway is about 32 $GtCO_2e$ (range: 29–35 $GtCO_2e$).

Source: UN Environment Programme



Current outlook

The alternatives mentioned above promise different degrees of impact on global temperature. The increase in the albedo effect seems to have the largest potential for impact, but the technologies needed to implement these ideas are still in their infancy. Carbon removal technologies are in a more advanced stage of development but seem to offer less of an impact and would probably require the simultaneous use of several different initiatives in order to have the desired effect.

A comprehensive 2015 study titled "Climate Intervention" by the National Research Council of the National Academies of the United States with the collaboration of the U.S. Department of Energy indicates that the modification of albedo at a sufficient scale to alter climate is too risky a proposition at this time. Its potential to cause massive, unanticipated and largely unmanageable harm is significant. Increasingly, reports about the different engineering options in this category carry stern warnings about their hazards.

Heroic decisions might become unavoidable

As the planet continues on its path to severe environmental deterioration an increasing sense of urgency is spreading amid the scientific community and some policy makers to adopt measures that can have a significant impact, even if they carry substantial risks to the planet. Decision-making on this all-important issue will be fiendishly difficult. A highly polarized debate is already taking place concerning the costs, benefits and risks of geoengineering versus those of the current approach, which essentially rests in the hope that governments will finally act decisively to curb emissions, an option that also carries enormous costs and risks given the current political stalemate . Similarly fierce debates are also bound to occur in deciding which type of intervention should be adopted.

Inevitably, these debates will become more urgent as soaring human suffering resulting from catastrophic climate events becomes more frequent and massive.

What to do?

Everything. The climate crisis is so consequential and the reactions to it have been so inadequate that we now need to deploy all the resources at our disposal to deal with it. No single answer, policy, technology or silver-bulleted reform alone will be enough.

What will become increasingly clear—and hopefully will lead to the adoption of more effective policies—is that there will be no solution without a substantial change in our collective mindset and behaviors. The approach should be similar to that recommended by honest nutritionists to dieters wishing to lose weight. The most effective approach is not a temporary diet but a permanent change in lifestyle.

Inevitably, climate change will force us to change our mindsets, lifestyles and habits. What remains to be seen is if these changes will be driven by decisions taken by humankind or will be brutally forced upon us by Mother Nature.

A Hybrid Solution

Transitioning from fossil fuels to alternative energies is tantamount to giving up the great potential of energy stocks in favor of a flow economy. We need to consider a flow-stock collaboration. Renewables are good, but the possibility of storing CO_2 seems to offer the most viable solution to maintain our level of civilization and the economy of the stock that gave us modernity

FRANCESCO GATTEI

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Stock or flow? To be or not to be? The debate over the future of the energy mix of human civilization is taking on an increasingly philosophical and existential aspect. In fact, any discourse on transition cannot ignore the need to understand the fundamental structures of which human and, ultimately, industrial civilization consists. And then to consider whether, and under what conditions, it will actually be possible to switch from fossil fuels to other forms of energy.

According to the American mathematician Alfred Lotka, the father of the early 20th century "biophysical economy," the success of individual species in evolution is related to their ability to maximize the availability of energy and their ability to use that energy. In short, all species fight for survival. And the ones that capture the greatest amount of energy with maximum efficiency to produce heat →

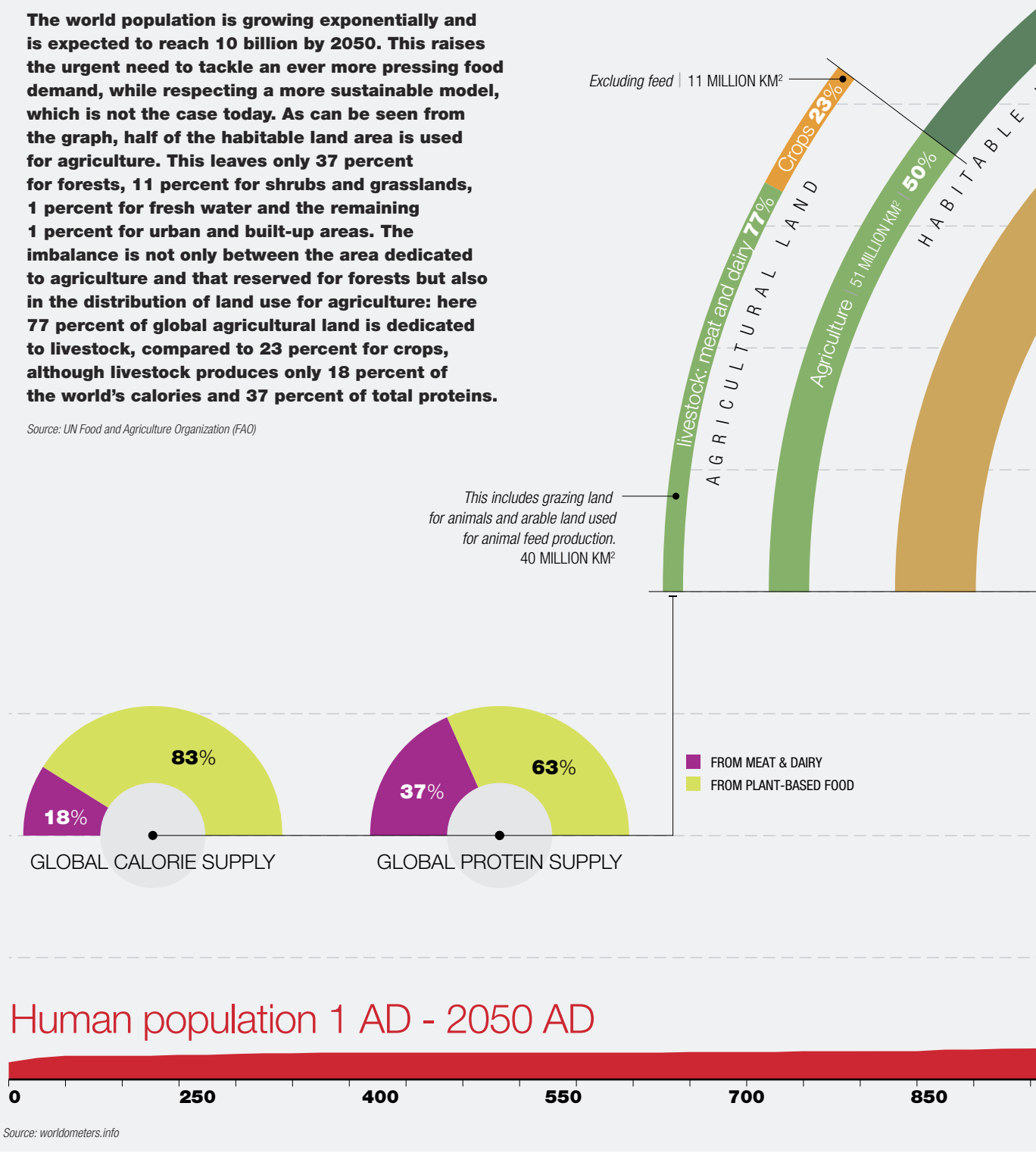
and movement are the winners. Human evolution also reflects this race for energy storage, both compared to other animals and in relation to the various societies that have evolved over time. For millennia, humans and other animals have played the same game. A couple of biological advantages (opposable thumbs and frontal lobes) guaranteed us technological superiority, but the energy source remained predetermined.

Before Newcomen and Watt and their inventions, the only energy available to humanity was that of the energy flow that existed on the surface. Sheer brute force, heat from wood or charcoal and the motion of wind or water for the mills. Energy availability was dependent on the ability to capture and store solar energy converted from photosynthesis into wood and transformed into proteins and calories by animals or the flow of water. Much of the energy was organic and living. We were able to implement certain innovative techniques, but we remained constrained by the flow on the surface. And its seasonal, daily, climatic volatility. In an organic world, the constraints on growth are overwhelming. This was immediately obvious to the earliest economists of the late 18th century. David Ricardo, a landowner, focused on the dampening effect of the declining productivity of the land. Meanwhile, Thomas Malthus, an Anglican pastor and demographer, pointed out that the geometric growth rate of the population and the arithmetic rate of agricultural yields would prevent perpetual well-being. In short, the law of diminishing returns and ever-increasing appetites kept the world stuck in a narrow rut. As environmental or technical conditions gradually allowed for rapid population growth, this led to a deterioration in the availability of food per capita. Famines and diseases would then restore order, returning the system to its usual long-term balance.

The food security challenge

The world population is growing exponentially and is expected to reach 10 billion by 2050. This raises the urgent need to tackle an ever more pressing food demand, while respecting a more sustainable model, which is not the case today. As can be seen from the graph, half of the habitable land area is used for agriculture. This leaves only 37 percent for forests, 11 percent for shrubs and grasslands, 1 percent for fresh water and the remaining 1 percent for urban and built-up areas. The imbalance is not only between the area dedicated to agriculture and that reserved for forests but also in the distribution of land use for agriculture: here 77 percent of global agricultural land is dedicated to livestock, compared to 23 percent for crops, although livestock produces only 18 percent of the world's calories and 37 percent of total proteins.

Source: UN Food and Agriculture Organization (FAO)



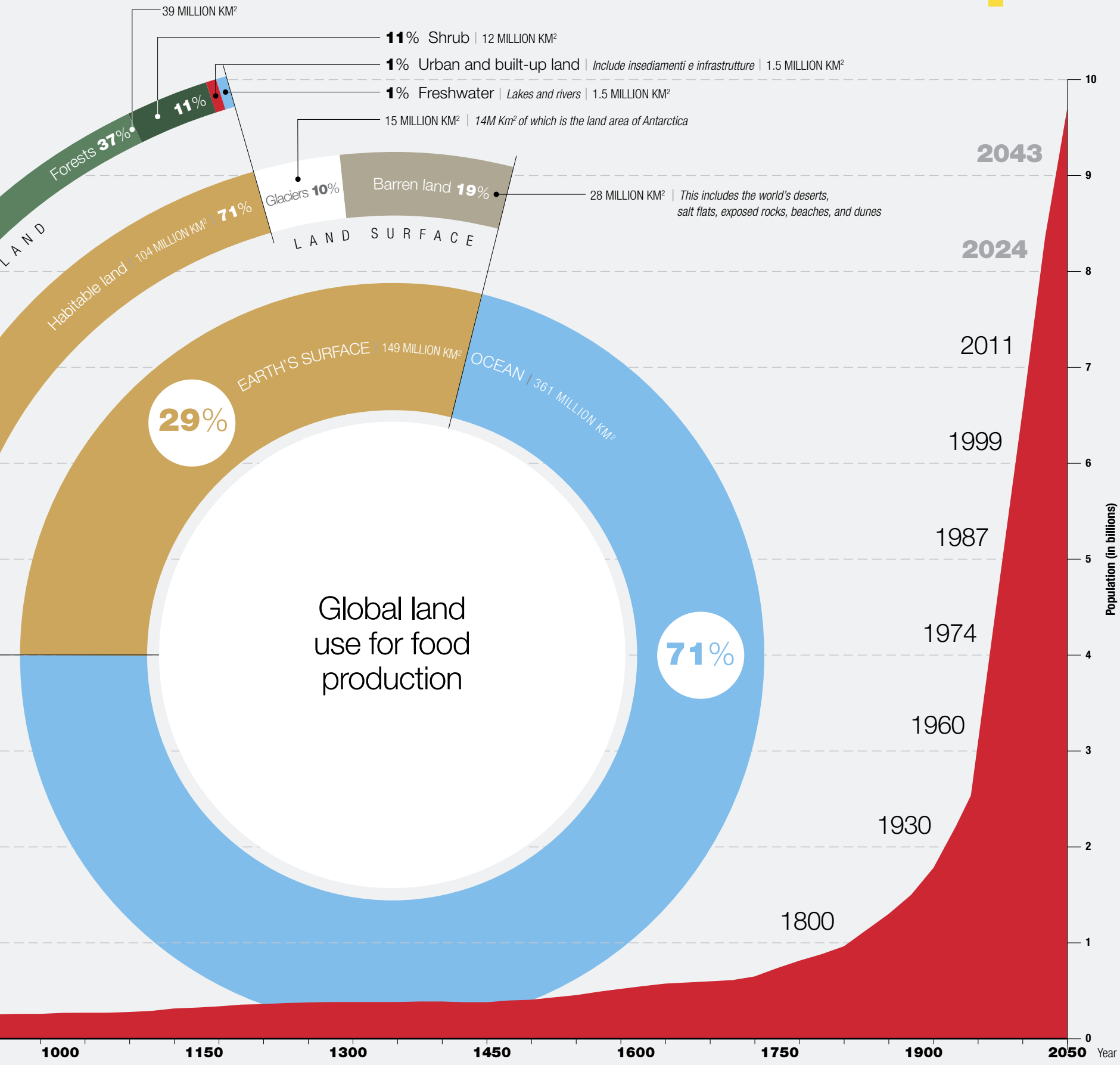
Source: worldometers.info

An economy based on energy stocks

For millennia, the flow economy had maintained its iron fist and the human population remained at between 400 and 800 million people. We were the dominant animals, but, like all other beings, we are exposed to the fickleness of the seasons and the risks of overpopulation. Two of the four horsemen of the Apocalypse, Famine and Pestilence, struck with alarming regularity. We produced the other two, War and Violence, ourselves, sometimes due to the need to find new spaces for growth. But just as Malthus and Ricardo were publishing their treatises, the world of organic flow was beginning to give way to a new reality. The real change was not related to the discovery of a new source (coal) and a new machine (the steam machine), but on the transition to an economy based on fossil fuels for the energy stock. The transition was from today's photosynthesis to that of prehistory, with its insensitivity to climate, its wide availability and its versatility of use. The possibility of extracting more coal by draining the water that sullied the mines through use of the steam engine would have made available to the British economy and therefore to the world an energy source of previously unimaginable dimensions.

This source was not constrained by the availability of land, although the law of diminishing yields might apply even deep beneath the surface. A huge and concentrated energy supply, so flexible that it managed to increase human and animal productivity via its conversion into work through the new machines. These new machines tapped into other energy stocks, oil and gas, to create new industrial processes. There was therefore renewed access to an additional stock in terms of the minerals necessary to build new materials. In short, positive, continuous and unimaginable feedback.

The stock economy, powered by high-cost energy and new machines, runs at an evolutionary speed far greater than the slower transformations of its predecessor model. It also eschews the limitations resulting from the production of food, via the benefits of chemical fertilizers and in accordance with Ricardian law. Bones, manure and guano were the organic solution of the flow civilization. But relying on the secretions of seabirds scattered across a few hundred islands was an insufficient solution to the development of real pop-



ulation growth, at least until the arrival of Fritz Haber and the creation of liquid ammonia.

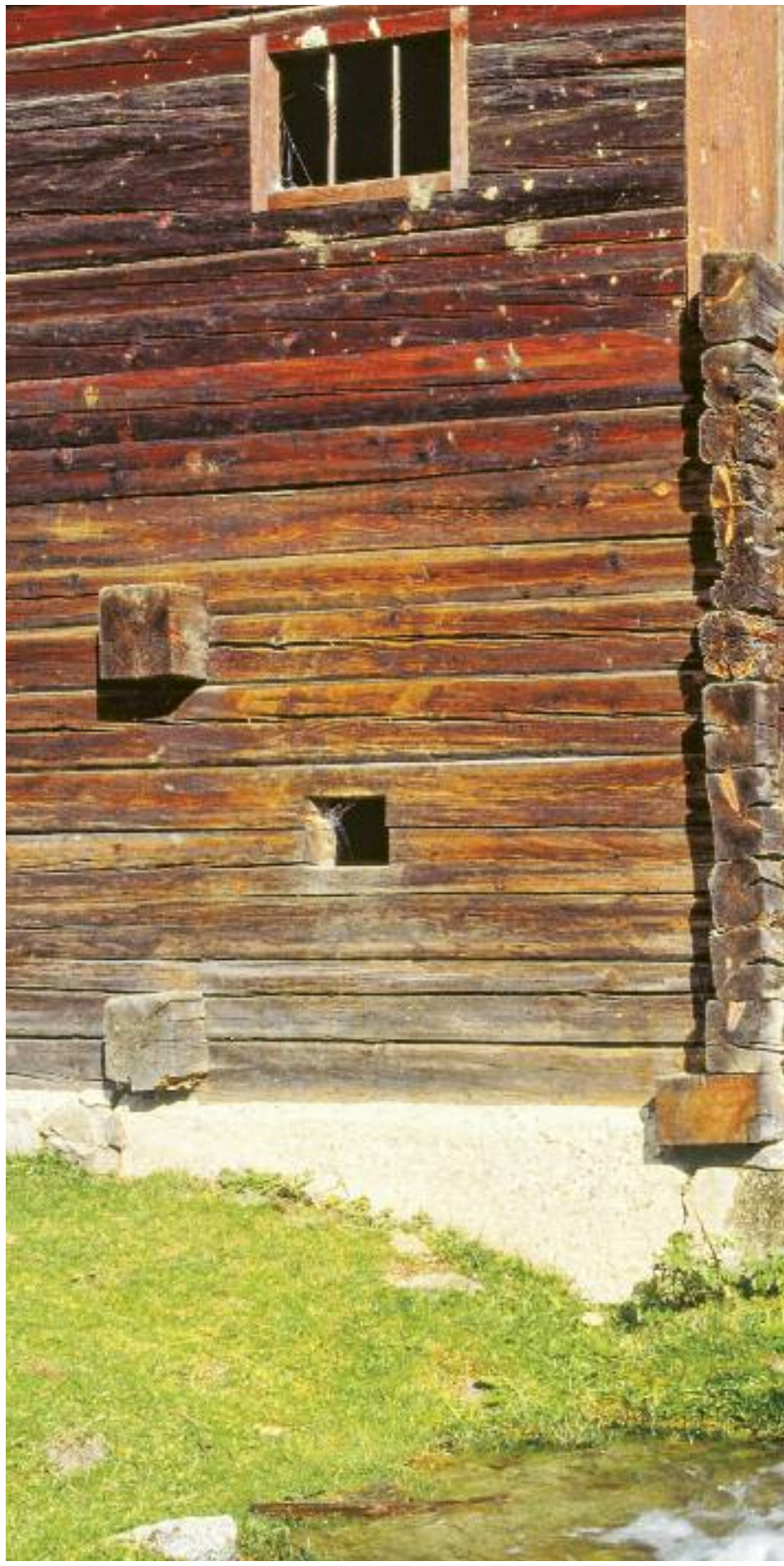
The discovery was also facilitated by the availability of fossil energy, which allowed the forging of metals resistant to the high temperatures and pressures necessary for the catalytic process. The stock economy also benefits from new forms of communication that broaden creative potential. Without this development we would not have mass education and would have had to continue employing most people as energy sources in manual and agricultural work. The changes are so rapid that even the new millennial prophecies are almost wrong as soon as they appear. Stanley Jevons applied the principle of diminishing yields to British coal production, imagining an inevitable return to the constraints of the past within a century. But deeper coal mines and the development of international trade and oil fossil fuels, which appeared at that time, led to a new defeat for an overly deterministic view of the stock's potential. Likewise the most recent predictions of the Club of Rome (a non-governmental association of scientists, economists, senior international public officials and heads of state from all five continents, founded in Rome in 1968, ed.) on the end of resources failed as did those of *The Population Bomb*, a late-1960s book by Paul Ehrlich. According to these prophecies, *Homo sapiens* should have been decimated at the end of the century by food shortages.

Instead, the industrial revolution accelerated the pace, decade after decade, bringing with it the only correct prediction: that of exponential population growth, perhaps driven by irrepressible instincts, but even more by the improvement in medicine and hygiene conditions. And by development in economic and food terms.

Another stock rising back to the surface

However, the process of extracting and converting this underground energy has an additional effect. Another stock is rising back to the surface: the carbon footprint stored by plants before their fossilization. This was the carbon in the Carboniferous (when it was exceptionally low because of there being so many plants and trees, which absorbed it), Permian and Jurassic Periods. The stock warms the surface and has highly →

transformative effects on the climate. This is why it is so urgent to reconvert our energy system, with widespread application of renewable sources, and to stymie carbon emissions by avoiding using the sources that generate them. But such a change has very radical implications. A return to exploitation of flow would entail a number of critical issues, which are often underestimated. First, it would decrease energy availability due to the low performance of our flow capture techniques. Solar panels are only able to capture 20 percent of the light spectrum to generate electricity. The remainder, including infrared, passes through the material without activating any electric fields. The normal cycle of day and night must be added to this element, despite it often being ignored. In fact, it is just as important in both summer and winter. In Italy, for example, the proportion of electrical energy production by solar power is under four percent in January, compared to 12.5 percent in August. In terms of wind, however, the Betz limit, the theoretical potential that can be captured by one turbine, is estimated under ideal conditions and without attrition at 60 percent. In fact, maximum efficiency is only 40 percent. Daily and seasonal dynamics must also be added into the mix as these determine the intermittency of the wind source. In Italy, wind, mainly onshore, covers nine percent of winter electricity consumption, but only three percent in summer. The low capture capacity would also result in the recurrence of the bottlenecks that have plagued us for millennia. The low density by surface area of electricity produced by sun and wind ("power density") would require huge areas to be reserved for this purpose, with progressive competition with other uses. For example, to supply London with an onshore wind farm, 7,500 turbines would be required over an area of 1800 km^2. In the meantime, gas would only require 2.5 km^2. Currently, world wind power capacity is 570 Gigawatts (GW), powered by 500,000 turbines. This capacity covers five percent of world electricity generation and only two percent of energy consumption. The installed capacity of solar panels is 490 GW, with a two percent contribution to power and one percent to primary consumption. To think that we can replace fossil generation capacity, which today makes up 64 percent of electricity production, with widespread, low-energy and seasonally variable sources seems more like a biological nightmare than a utopian prospect. At this point we are facing an impasse: the fossil stock emits CO_2, but the energy flow from renewables is too poor to ensure industrial sustainability. And it would restart the trade off with land use. The real options available should therefore be very different from those usually put on the table. Energy flow can only add to the stock, not replace it. Solar and wind power generation is only efficient during the day or in the seasons when wind and solar can bring the most benefit. But they cannot provide a complete overhaul. In winter, contribution from these sources reaches a nadir in many areas of consumption, just as energy needs tend to grow. We could implement smarter and more efficient forms of consumption, but it will not be possible to generate the required amounts of energy (with a world population of nine billion by the mid-21st century, Malthus permitting) without continuing to maximize power density. Requirements related to computerization and robotics, which seem to be the basis of the next industrial cycle, must also be added to the mix. The Lotka principle will continue to punctuate its evolutionary diktat, so we must continue to tap into stock, cleaning up its CO_2 emissions as much as possible. However, there are more options for electricity. We can use more nuclear (with new fusion-focused technologies to prevent waste), which ensures high energy density, and make carbon capture technologies associated with fossil use more widespread. This could be done by increasing the use of gas instead of coal to reduce the pressure.



An immediately practicable measure? Carbon capture via plants

All heat-intensive processes or those involving the extraction of minerals, which power industry and construction (including the entire upstream cycle and the installation phase of the renewable energy, batteries, networks and artificial intelligence that power energy systems), will remain tied to fossil fuels for many years to come. Likewise for the air, maritime and heavy freight sectors. Replacement with electrical processes remains almost impossible in these areas. The use of forms of carbon capture is therefore imperative. Many of the technologies available will take decades more to mature and become usable en masse. But one source can already be implemented straight away: carbon capture via plants. In the Carboniferous Period, a boom in plants and trees brought CO_2 levels to just 50 ppm (compared to 410 ppm today). The air was rich in oxygen (32 percent vs. 21 percent today) and insects and worms were of horror movie dimensions. According to a study published in *Science*, by increasing forested surface area by 25 percent, two-thirds of the total carbon emissions of the last two centuries could be reabsorbed. Plants would be the most effective and low-cost solution we have available to develop more technological alternatives in the meantime. In short, it would be a question of transforming the stock of CO_2, which we are forcing to travel through time by the use of fossils, from their gaseous to their physical forms, which would be stored in trunks and shrubs. Progress could be made with alternatives such as nuclear fusion, artificial carbon capture and electrical storage.

In conclusion, the energy transition that we are now debating in public is an issue with a very broad economic

IN THE PAST

Before Newcomen and Watt and their inventions, the only energy available to humanity was that of the energy flow that existed on the surface. Sheer brute force, heat from wood or charcoal and the motion of wind or water for the mills.

and social impact. Transitioning from fossil fuels to renewables is tantamount to giving up the great potential of stocks in favor of a flow economy. It would be a matter of going from a world with high energy density to one that requires more land use and is seasonally volatile. This process would contradict the Lotka principle, and would be difficult to pursue. Such a conversion would, however, be partial, given the impossibility of electrifying both many end uses and the need to extract minerals and transform them through processes that would still require extensive use of fossil fuels. We must therefore consider a hybrid solution. One of a flow-stock collaboration. The flow of renewables may represent an optimization, but it is not the silver bullet of the transition. Maximizing available energy remains an essential requirement of our evolution, and with it access to energy from stocks. The possibility of storing CO_2 naturally and eventually artificially seems the most viable solution to defend our level of civilization and minimize emissions. We can but wait for a technological breakthrough.

Strategy/The key components of Natural Climate Solutions (NCS)

A Toolkit for Fighting Climate Change

This portfolio of twenty land stewardship options provides natural solutions for climate mitigation designed to help meet the goals of the Paris Climate Agreement. It also brings significant benefits to human well-being and quality of life

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In 2015, the Paris Climate Agreement, an accord within the United Nations Framework Convention on Climate Change (UNFCCC) signed by 195 states parties, established a commitment to hold the increase in the global average temperature to well below 2 °C above pre-industrial levels. In order to achieve this objective, the Natural Climate Solutions (NCS), a portfolio of twenty land stewardship options, is one of the main international strategies to increase climate mitigation and an important tool that acts on the three pillars of sustainability: economic viability, environmental protection and social equity.

In particular, the NCS can counter climate change in three main ways:

1 | reducing carbon dioxide (CO_2) related to land use and changes in land use;

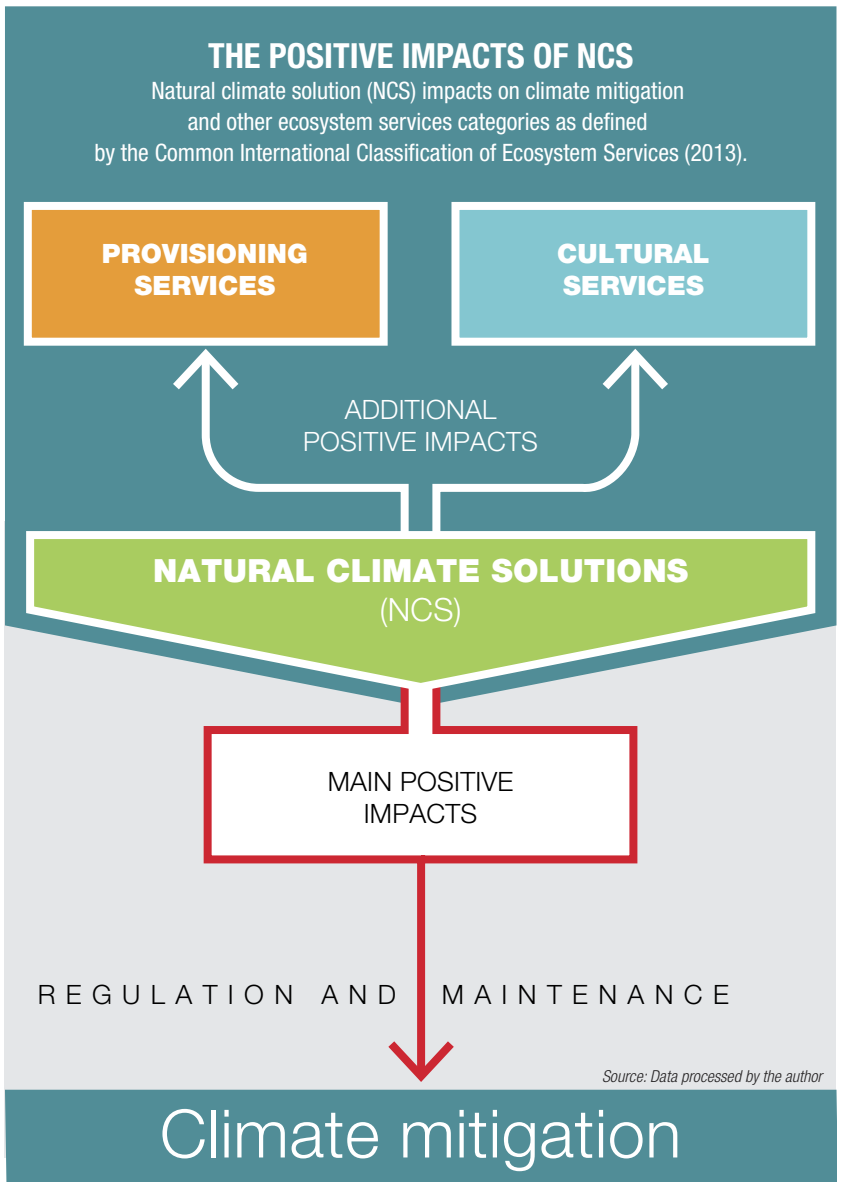
2 | capturing and temporarily storing additional CO_2 from the atmosphere;

3 | improving the resilience of natural ecosystems.

The land stewardship options related to the NCS include conservation, restoration, and improved land management actions that increase carbon storage in forests, grasslands, agricultural lands and wetlands. Forests can be considered the land stewardship option with the highest climate mitigation potential by 2030. Considering a maximum additional mitigation potential of all land stewardship options estimated at 23.8 $PgCO_2e$ y-1, the forest-related NCS can cover approximately two thirds of the total mitigation potential. There are six key forest stewardship options in the NCS: reforestation, avoided forest conversion, natural forest management, improved plantations, avoided fuelwood and fire

Among the advantages of Natural Climate Solutions are the benefits that human populations derive from the conservation of biodiversity. In the aerial photo, workers plant trees as part of the ecological project at the Qian'an City mine in China.

management. Reforestation is the most common forest-related NCS and requires the active planting of trees and long term care to prevent them from being destroyed or damaged by natural or man-made causes. Avoided forest conversion requires specific nature conservation policies and actions aimed at avoiding the replacement of natural forest with other land uses such as urban areas, croplands, grazing lands and tree plantations. Improving forest management practices such as extending harvest cycles, reduced-impact logging practices and active management of forest stand through cleaning and thinning will allow natural forests to increase their carbon storage while maintaining timber production for the long term. Improved plantations option consists of a lengthening of harvest cycles to increase carbon uptake in timber plantations that are usually managed on shortened harvest rotation lengths. Avoided fuelwood harvest is related to the improvement of cook stoves used in developing countries that burn more efficiently and conse- →



quently reduce the amount of wood taken from forests. Finally, fire management is based on fire control practices aimed at reducing forest and savanna fires and the resultant release of carbon into the atmosphere. All the above-mentioned NCS have as their main objective the increase of carbon storage in living biomass—above- and belowground biomass—and soil. At the same time, the forest related NCS have positive effects not only on carbon storage but also on a range of co-benefits such as conserving freshwater and maintaining species diversity, improving natural hazards protection, water filtration and flood control, increasing aesthetic landscape value and providing recreational opportunities. These co-benefits related to the NCS are commonly defined as "ecosystem services" by the international scientific literature (see the graphic above: "The positive impacts of NCS").

According to the Millennium Ecosystem Assessment Report (2005), ecosystem services are the benefits that human populations derive directly or indirectly from ecosystem functions such as raw materials provision, biodiversity conservation, watershed protection and human welfare. From a theoretical point of view the Millennium Ecosystem Assessment has classified ecosystem services into four main categories: provisioning services (e.g., food, energy, water, raw materials), regulating services (e.g., climate regulation, water cycle regulation, natural hazards protection), supporting services (e.g., photosynthesis, biodiversity, soil production) and cultural services (e.g., recreation, aesthetic, cultural and spiritual value). The Economics of Ecosystems and Biodiversity (2010) has replaced supporting services with habitat services, which adds lifecycle maintenance and gene pool protection. Finally, the Common International Classification of Ecosystem Services (2013) reclassified the ecosystem services into three categories to avoid double counts and overlaps: provisioning, regulation and maintenance and cultural ecosystem services. From the practical point of view, the description and classification of ecosystem services is an important starting point for biophysical assessment and socio-economic evaluation of ecosystem services provided by natural ecosystems. Biophysical assessment is the quantitative measurement and characterization of the ecosystem structure and functioning related to the provision of ecosystem services. It helps to understand the functioning of ecosystem and importance of different land uses in the supply of different ecosystem services. Socio-economic evaluation is aimed at estimating the direct benefits to society and thus can support decision-making on land use projects that have impact on different groups of the society. Socioeconomic evaluation provides monetary value to both market goods and services without a market price.

Ecosystem services: important to classify!

In the international literature, recent studies highlighted that approximately 30 percent of greenhouse gas (GHG) emissions could be offset by NCS including planting more trees, reforesting degraded forests, engaging in responsible forest management and improving cropland and peatland management. Those studies estimated that reforestation and avoided forest conversion are the two options with the greatest climate mitigation potential. In addition, it is important to emphasize that these two forest-related NCS are also those with the highest positive impact on a high number of provisioning and regulating ecosystem services (see the chart on page 27). Reforested areas compared to other land uses such as native grasslands, managed pastures and agricultural lands provide more wood for furniture and biomass for energy use such as timber and bioenergy production, fresh air regulation and carbon storage and protection against natural hazards such as landslides, avalanches, rockfalls and floods. At landscape scale, reforestation may improve relationships among existing remnant forest patches, increasing movement, gene flow and effective population sizes of native species. Reforested areas can also improve the agricultural landscape from an aesthetic point of view thanks to a greater variety of land uses, and create habitats and microhabitats for many species of birds and small mammals, thereby increasing biodiversity. At forest stand scale, reforested areas have the potential to reduce soil erosion and water contamination thanks to roots of trees that are natural nets spreading extensively into the ground to hold the soil in place. In addition, reforestation of agricultural land can improve biodiversity, which can result in increased primary production of chemical energy in organic compounds by living organisms, reduced susceptibility to biological invasion and increased ecological resistance to human pressures.

Conversely, reforestation activities can also have negative impacts on the environment and society related to the choice of tree species and harvest cycles. The use of non-native fast growing species can generate several negative impacts that include competition with multiple-use forestry of local communities, reduction of the level of biodiversity, negative hydrogeological impact in dry areas through soil erosion and run-off, trade-offs in water uses in the irrigation of plantations vs. subsistence agriculture, and increased soil pollution due to the use of herbicides and fertilizers. These negative impacts can be reduced by using native tree species chosen in collaboration with local communities.

Natural forests are best

Generally, natural forests have the capacity to provide more ecosystem

Reforested areas and natural forests

Compared to other uses of the soil (such as natural grasslands, managed pastures and farmland), reforested areas provide greater amounts of timber for furniture and biomass for energy purposes (wood and bioenergy production), air regulation and carbon storage, as well as protection against natural hazards (e.g., landslides, avalanches, rock falls and floods). Compared to planted or degraded forests, natural forests can provide a greater quantity and a better quality of ecosystem services. Some natural ecosystems have a high potential for mitigation and at the same time can provide different ecosystem services for the livelihoods of local communities.

Source: Data processed by the author

COMPARISON OF ECOSYSTEM SERVICES

Comparison of ecosystem services provided by reforested areas and areas with different land use

HIGHER (+)
LOWER (−)
EQUAL (=)

ECOSYSTEM SERVICES	NATIVE GRASSLANDS	MANAGED PASTURE	AGRICULTURE
PROVISIONING SERVICE			
Food production	−	=	−
Timber production	+	+	+
Bioenergy production	+	+	+
Medicines	−	+	+
Freshwater	+	−	+
REGULATING SERVICES			
Fresh air regulation	+	+	+
Carbon sequestration and storage	+	+	+
Groundwater recharge	−	−	+
Natural hazards protection	+	+	+
Water purification	−	+	+
Pollination	−	−	+
Soil erosion protection	−	=	+
SUPPORTING SERVICES			
Habitat for species	−	+	+
CULTURAL SERVICES			
Aesthetic values	−	−	+
Recreational opportunities	−	+	+

THE IMPACT OF NCS

Effects of improved natural climate solution (NCS) management on ecosystem services from a biophysical and socioeconomic point of view

VERY POSITIVE IMPACT (++)
POSITIVE IMPACTS (+)
NO IMPACTS (−)

ECOSYSTEM SERVICES	BIOPHYSICAL VALUE	SOCIO-ECONOMIC VALUE
PROVISIONING SERVICES		
Timber production	+	++
Bioenergy production	+	++
REGULATING SERVICES		
Carbon sequestration in living biomass	++	+
Carbon sequestration in soil	++	+
Natural hazards protection	+	−
SUPPORTING SERVICES		
Tree species diversity	++	−
Floristic diversity	+	−
Microbiological diversity	+	−
CULTURAL SERVICES		
Aesthetic values of landscapes	++	−

services both quantitatively and qualitatively than planted forests and degraded forests. Some natural ecosystems—such as tropical and sub-tropical forests and wetlands such as mangrove swamps—have a high mitigation potential and at the same time the capacity to provide several ecosystem services for the sustenance of local communities' livelihoods. In order to increase the biophysical and socio-economic value of ecosystem services provided by planted and degraded forests, improved forest management practices can positively affect the level of species biodiversity, water cycle components, recreational services, forest species composition, horizontal and vertical stand structure and stand density and age. Improved forest management practices, through the extension of harvest cycles, and active forest management, through the cleaning and thinning of planted and degraded forests, can positively influence the following ecosystem services (see the chart above): carbon sequestration in above and below-ground and soil; timber and bioenergy production that increases the quality of wood assortments; mechanical stand stability and the protection of forests against natural hazards; tree and floristic species richness; and recreational opportunities related to the aesthetic values of landscapes. These improved forest management practices have the capacity to increase the biophysical flows of all of the above-mentioned ecosystem services; however, only a few of them have a real market price, e.g., timber, wood biomass for energy, and climate change mitigation considering the global carbon market.

Some scientific studies have estimated that the positive impacts on other ecosystem services not recognized by the market, such as biodiversity conservation, landscape quality improvement and natural hazards protection, have a potential monetary value greater than 70 percent of the total economic value. Finally, it is important to emphasize that forest-related NCS can provide a key contribution for reducing the greenhouse gas (GHG) emissions in atmosphere in accordance with the need to limit global warming to 2 °C. Simultaneously, forest-related NCS can generate important co-benefits for human well-being and quality of life, although these benefits are only partially recognized by market prices.

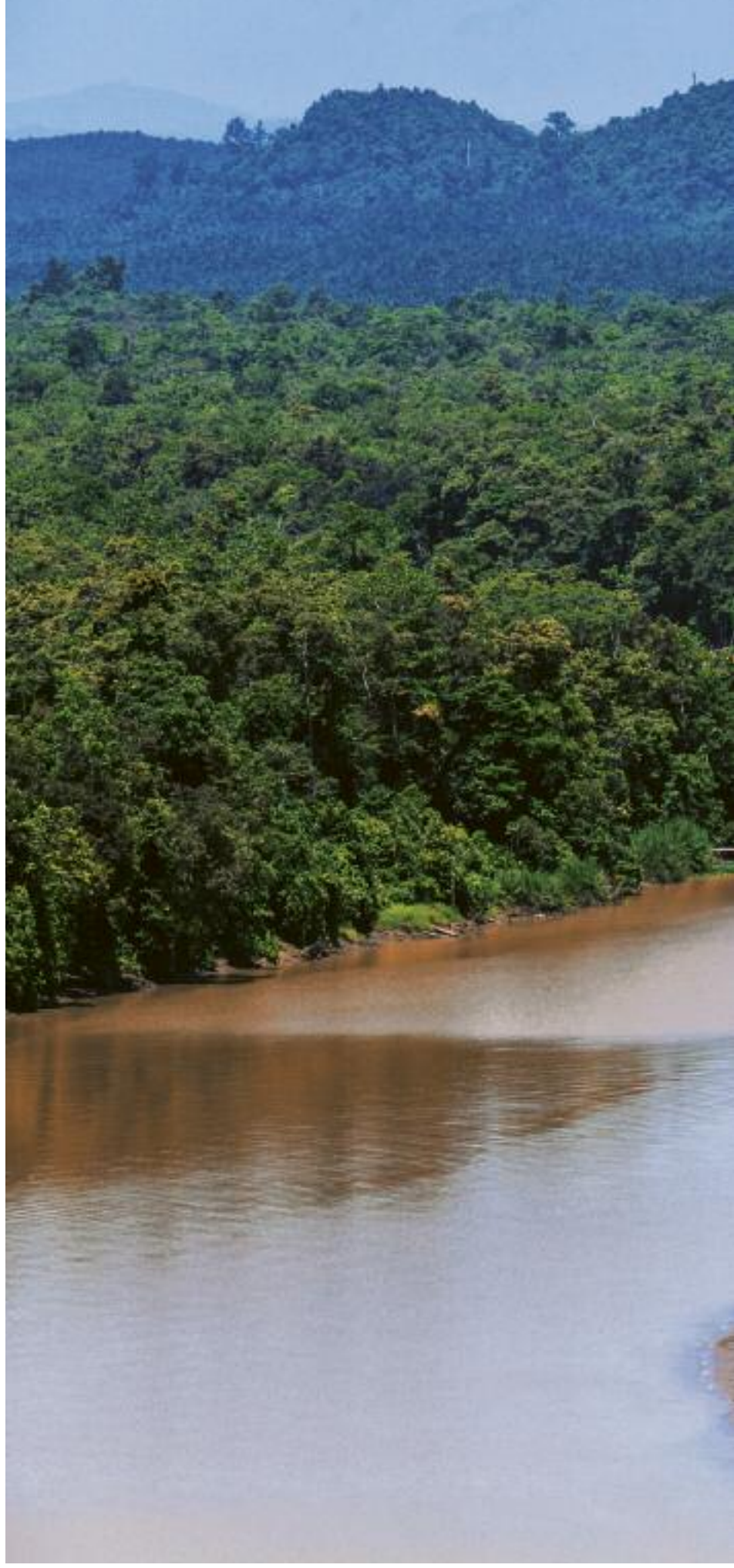
Analysis/Forests in international climate policies

A Radical Turnaround

Managing climate change will require a profound transition towards sustainable and low-emission economies. Therefore, we need a systemic approach to deforestation that can act directly on its causes in a lasting way

LUCIA PERUGINI

Researcher at the Euro-Mediterranean Center on Climate Change (CMCC Foundation) with a Doctorate in Forest Ecology, her work focuses on climate change, agriculture and forestry. Since 2003, she has been involved in the UN Climate negotiation, providing scientific support to the Italian delegation on matters relating to agriculture and forestry.



The peak in forest fires which plagued the Amazon and Siberian forests during the summer attracted public attention to the important role they play, especially in relation to climate change. In addition to providing the main basis for the survival of many populations—providing food, water, and many other fundamental ecosystem services—forest ecosystems are an important "sponge" (or sink) for atmospheric carbon, the main greenhouse gas. Forests, and vegetation in general, absorb 30 percent of man-made greenhouse gases from the atmosphere through the photosynthesis process, which transforms the CO_2 into plant tissues (stems, branches, leaves), using water and solar energy and releasing oxygen. This function is currently under more threat than ever. There are clear signs that forests can slow down their absorption capacity, reaching the so-called saturation point, particularly due to the impacts of climate change. Furthermore, global deforestation has started to increase again after years of reduction, seriously endangering the global climate system.

The precarious state of the earth system

The latest IPCC report on the interaction between territory and climate change published in August 2019, warns about the precarious state of the earth system, already in a clear state of over-exploitation, in a world undergoing continuous climate change and with a population in exponential growth. The impacts of climate change on natural terrestrial ecosystems, permafrost degradation, desertification, land degradation in many areas and food security have already been seen, and this situation is expected to worsen further and irreversibly if atmospheric emissions continue at the current rate. Currently deforestation activities, fires, forest degradation and agricultural activities (including fertilizers and enteric fermentation of ruminants) are responsible for approximately 23 percent of total greenhouse gas emissions. Almost half of this value comes from deforestation (about five billion tons of CO_2 per year). The UN Framework Convention on Climate Change (UNFCCC, 1992) recognizes the fundamental role of agro-forestry sector activities, including them among climate change mitigation tools, and offers industrialized countries that are signatories to the Kyoto Protocol the option to use the absorption derived from these activ-

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ities to achieve the reduction commitments undertaken in the context of the Protocol itself. However, it was clear from the outset that an incentive mechanism limited to industrialized countries would be insufficient to limit emissions from the forest sector, which are concentrated mainly in developing countries, due to the high rates of deforestation in these areas. With this in mind, since 2014, the UNFCCC has set up a reward mechanism for developing countries that demonstrate a reduction in deforestation through national policies, establishing robust monitoring systems and providing information on how the rights of local people and biodiversity are protected. This mechanism is known as REDD+ (Reducing Emissions from Deforestation and Forest Degradation, enhancement of forest carbon stocks and sustainable management of forests). The mechanism is predominantly national in scale (sub-national scales are accepted only if temporary) and its implementation is divided into three phases: an initial preparatory phase, which envisages the establishment of a national REDD+ and capacity building strategy; a second pilot phase, in which national strategies are implemented, including action plans and additional training activities and, finally, the third phase of payment by results or full implementation of the mechanism, which provides for incentives based on real and verified emission reductions.

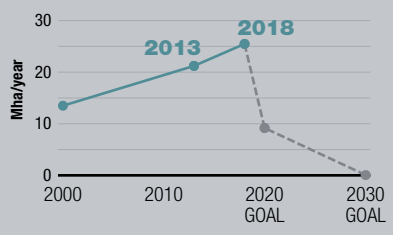
The decisive role of the forestry sector

In the Paris Agreement, the agro-forestry sector is part of the long-term mitigation objective (Article 4) which envisages the achievement, in the second part of the century, of a balance between emissions and absorptions (therefore through agro-forestry sinks). Furthermore, the sector occupies a prominent place in the agreement, being the only sector to have a dedicated article (Article 5), in which countries are invited to implement actions that preserve or increase the absorption and carbon stocks of terrestrial and marine ecosystems. In particular, nations are encouraged to implement actions to →

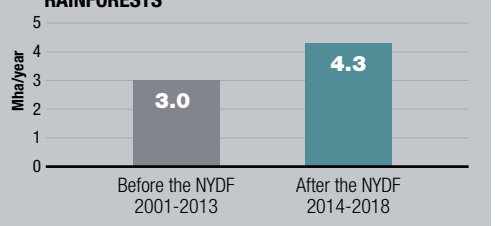
NYDF, where are we now?

The New York Declaration on Forestry (NYDF), which aimed to halve the increase in deforestation by 2020 and to halt the practice by 2030, was launched during the United Nations climate summit in 2014. Five years later, a report has been produced which shows that no progress has been made globally to end the loss of natural forests. The increasing rate of loss of irreplaceable primary forests is of particular concern.

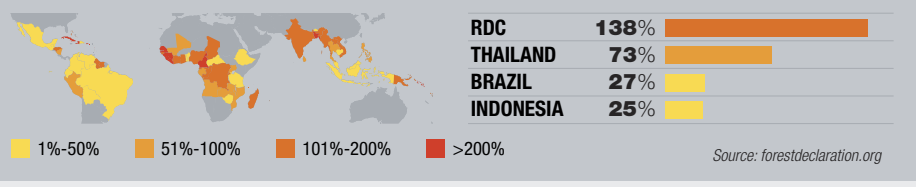
GROSS LOSS OF TREE COVER



AVERAGE ANNUAL LOSS OF PRIMARY TROPICAL RAINFORESTS



CHANGE IN AVERAGE ANNUAL EMISSIONS OF CO_2 – 2001-2013 vs 2014-2018



Source: forestdeclaration.org

THE TEN TARGETS

1 At least halve the rate of loss of natural forests globally by 2020 and strive to end natural forest loss by 2030.

2 Support and help meet the private-sector goal of eliminating deforestation from the production of agricultural commodities such as palm oil, soy, paper and beef products by no later than 2020, recognizing that many companies have even more ambitious targets.

3 Significantly reduce deforestation derived from other economic sectors by 2020.

4 Support alternatives to deforestation driven by basic needs (such as subsistence farming and reliance on fuel wood for energy) in ways that alleviate poverty and promote sustainable and equitable development.

5 Restore 150 million hectares of degraded landscapes and forestlands by 2020 and significantly increase the rate of global restoration thereafter, which would restore at least an additional 200 million hectares by 2030.

6 Include ambitious, quantitative forest conservation and restoration targets for 2030 in the post-2015 global development framework as part of new international sustainable development goals.

7 Agree in 2015 to reduce emissions from deforestation and forest degradation as part of a post-2020 global climate agreement, in accordance with internationally agreed rules and consistent with the goal of not exceeding 2° Celsius warming.

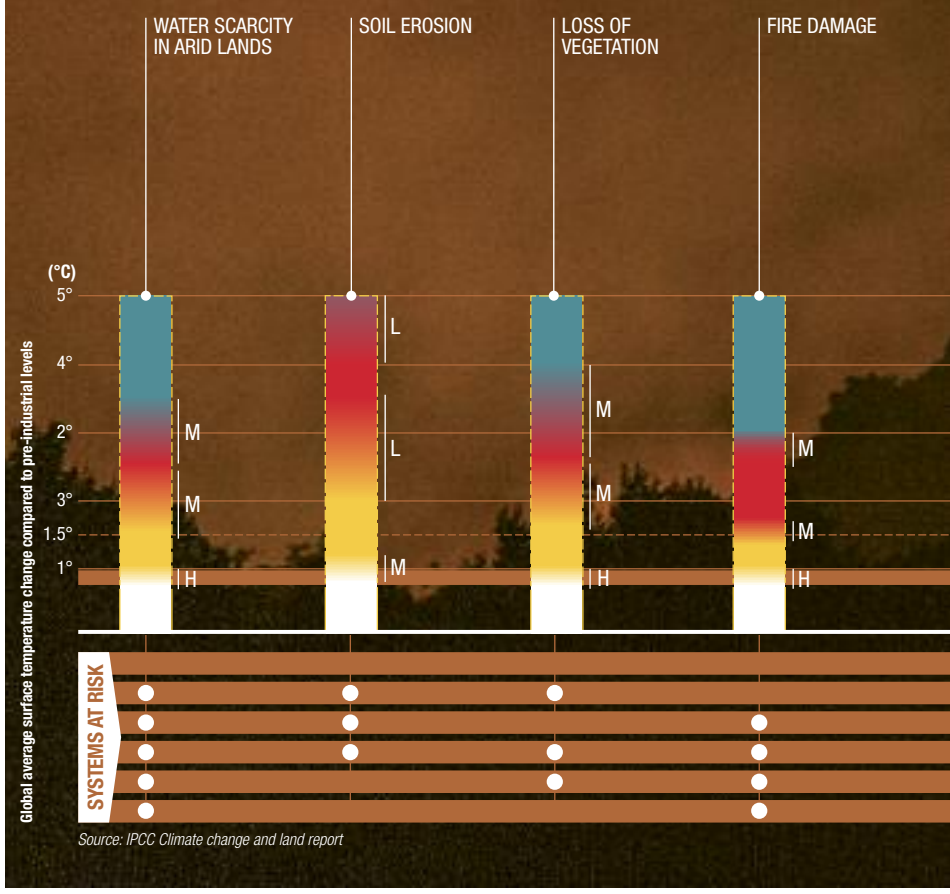
8 Provide support for the development and implementation of strategies to reduce forest emissions.

9 Reward countries and jurisdictions that, by taking action, reduce forest emissions, particularly through public policies to scale-up payments for verified emission reductions and private-sector sourcing of commodities.

10 Strengthen forest governance, transparency, and the rule of law, while also empowering communities and recognizing the rights of indigenous peoples, especially those pertaining to their lands and resources.

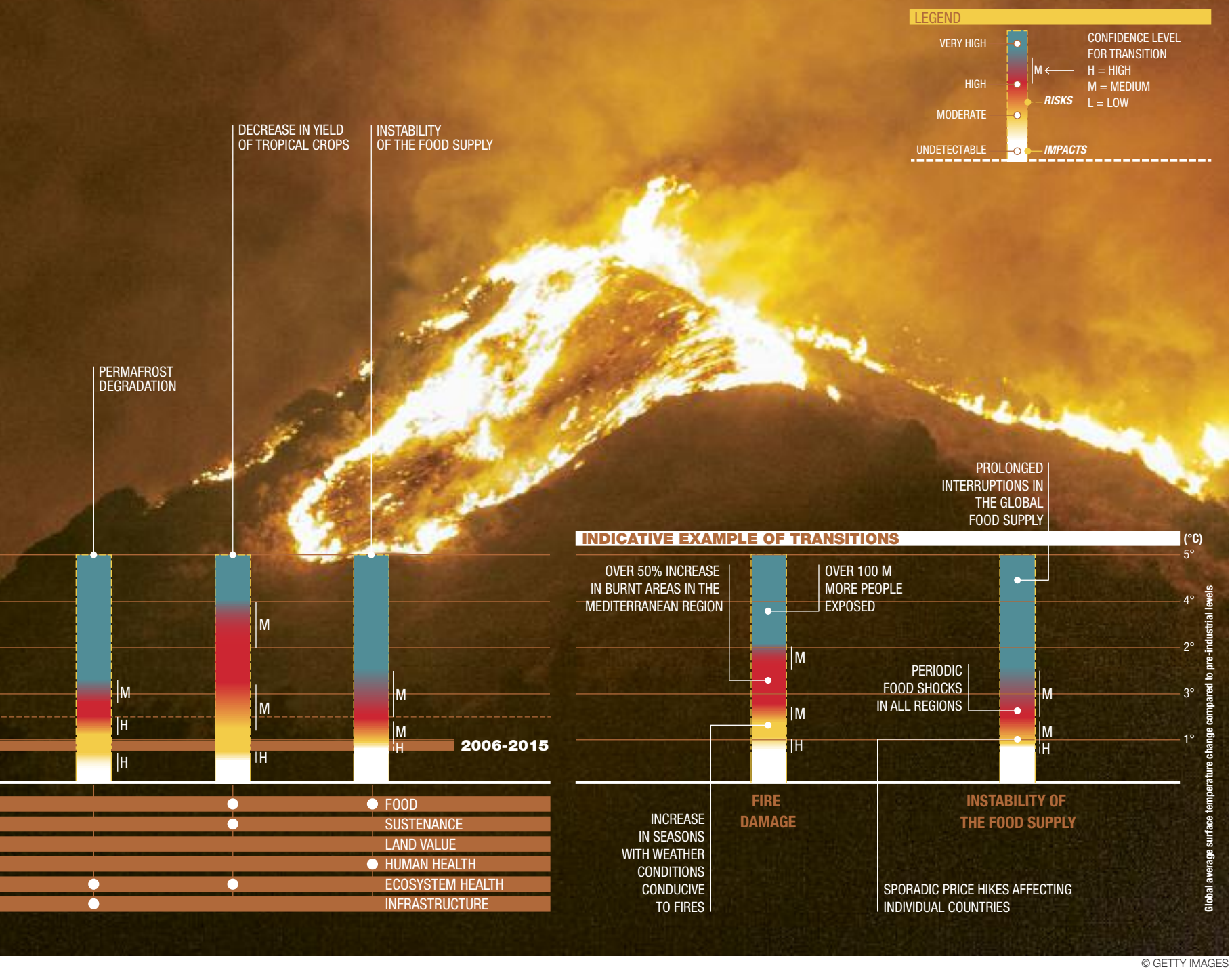
Rising temperatures, increasing risks

Increases in the average temperature of the earth's surface compared to pre-industrial levels are influencing the processes involved in desertification (water scarcity), soil degradation (erosion, loss of vegetation, fires, permafrost melting) and food safety (crop yield and instability of the food supply).
The changes taking place in these processes are endangering food systems, livelihoods, infrastructure, land value and the health of human and natural ecosystems. Even when they concern a single process (e.g., fire or water shortage), the changes can result in composite risks.
The risks vary depending on the region and the specific location.



Source: IPCC Climate change and land report

support REDD+, particularly the third phase of the mechanism.
Forestry and agricultural management are included in the calculation of emissions/absorptions for achieving the National Determined Contributions (NDC), which are the commitments identified by countries to achieve the objectives of the Paris Agreement.
Around 75 percent of the NDCs include agricultural and forest management and, based on an analysis of these objectives, it appears that 20-25 percent of reduction commitments are attributable to the forestry sector, especially for developing countries, where emissions from deforestation account for a major share of national emissions.
How and to what extent the sector can be included in the market mechanisms of the Paris Agreement remains to be determined as part of the negotiations on Article 6 (Voluntary cooperation approaches) which are expected to be completed, at best, by December 2019 in Madrid, at COP25.
In the meantime, the implementation of REDD+ is proceeding. At present, around forty countries have begun the formal process of accessing remuneration under the REDD+ mechanism and presented their reference levels of forest emissions to the UNFCCC for technical evaluation. Seven countries have communicated their REDD+ results to the UNFCCC for a total of 6 billion tonnes of CO_2 equivalent of emission cuts, primarily in Brazil. In its first phase, the Green Climate Fund has already made available $500 million for the payment of emission reduction results achieved through REDD+ actions. This figure is in addition to other initiatives such as, for example, those of



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the World Bank (FCPF) and the UN (e.g. UN-REDD), as well as individual donors (primarily Norway, Germany and the United Kingdom) which, in various forms, support countries in the REDD+ process.

The insufficient "I'll pay you not to cut" concept

While these initiatives have been essential to encourage countries to strengthen their forest governance and develop systems to control deforestation and forest monitoring, the concept of "I'll pay you not to cut" cannot be considered sufficient. A systemic approach needs to be adopted that can act directly on the causes of deforestation in a lasting way, including strategies to limit trade in agricultural and forestry products that are not "deforestation free." In this respect, at the international level, other initiatives have been promoted over time that promote an increase in forest cover and the conservation of existing forests, such as the New York Declaration on Forests (NYFD). The NYDF was launched at the UN Climate Summit in 2014 and is open to voluntary participation by countries and companies and other actors (NGOs, representatives of indigenous associations, etc.)—currently 200—united by the main objective of halving the rate of loss of natural forests globally by 2020 and trying to stop the loss of natural forests by 2030, in line with the 2 °C objective of the Paris agreement. The Declaration also aims to restore forests, identifying and addressing the causes of deforestation and increasing forest finance and governance. The results, however, are struggling to appear; unfortunately the trend towards deforestation since the adoption of the NYDF has far from decreased, with an increase in deforestation of 43 percent compared to the period prior to the Declaration (2001-2013), and average annual emissions from the signing of the NYDF 57 percent higher than the previous period (increasing from 3.0 to 4.7 Giga tons of CO_2 per year). There are on the other hand numerous private and public initiatives to combat deforestation, but they often lack ambition and risk remaining isolated experiences. Overall, actions to address the direct and indirect causes of deforestation and the available funds are inadequate to trigger systemic change.

A profound transformation towards sustainable economies

We are therefore in an emergency situation, in which the concentration of greenhouse gases in the atmosphere is such that only by implementing rapid and profound emission cuts in all sectors can the objective of limiting the increase in temperature to 2 °C (or better still 1.5 °C) compared to the pre-industrial era be reached. It is important to remember that these levels have been assessed as being the maximum global temperature increase that allows us to adapt to acceptable social, economic and environmental costs. Climate change is a reality, as is the hope of being able to manage it, but this requires a profound transition towards sustainable and low-emission economies. Without this radical turnaround, global environmental, economic and social balances will be seriously compromised, including the potential of environmental ecosystems to contribute to the absorption of human emissions.

REDD+/Supporting developing countries in their effort to protect forests

An Opportunity to be Seized

Forests are a crucial front in the battle to address climate change. Our efforts to preserve them will require commitment, investment and alignment between governments, the private sector and individuals

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DANAE MANIATIS

She is an independent international consultant and an environment and development specialist with 12 years of wide-ranging experience in tropical forestry, climate change, climate finance, biodiversity and partnership development. She has previously worked for the United Nations Development Programme and the Food and Agriculture Organization of the United Nations. Her skills include: REDD+, forestry, climate change, natural resource management, biodiversity, partnerships and financial mobilisation.

SUSTAINABILITY

Forests are a fundamental solution for avoiding the most serious impacts of climate change and are a key factor in climate action. They are essential for food, water, wood, energy, biodiversity, and health. In the photo, Indian women return to the village of Soroan after a day's work.

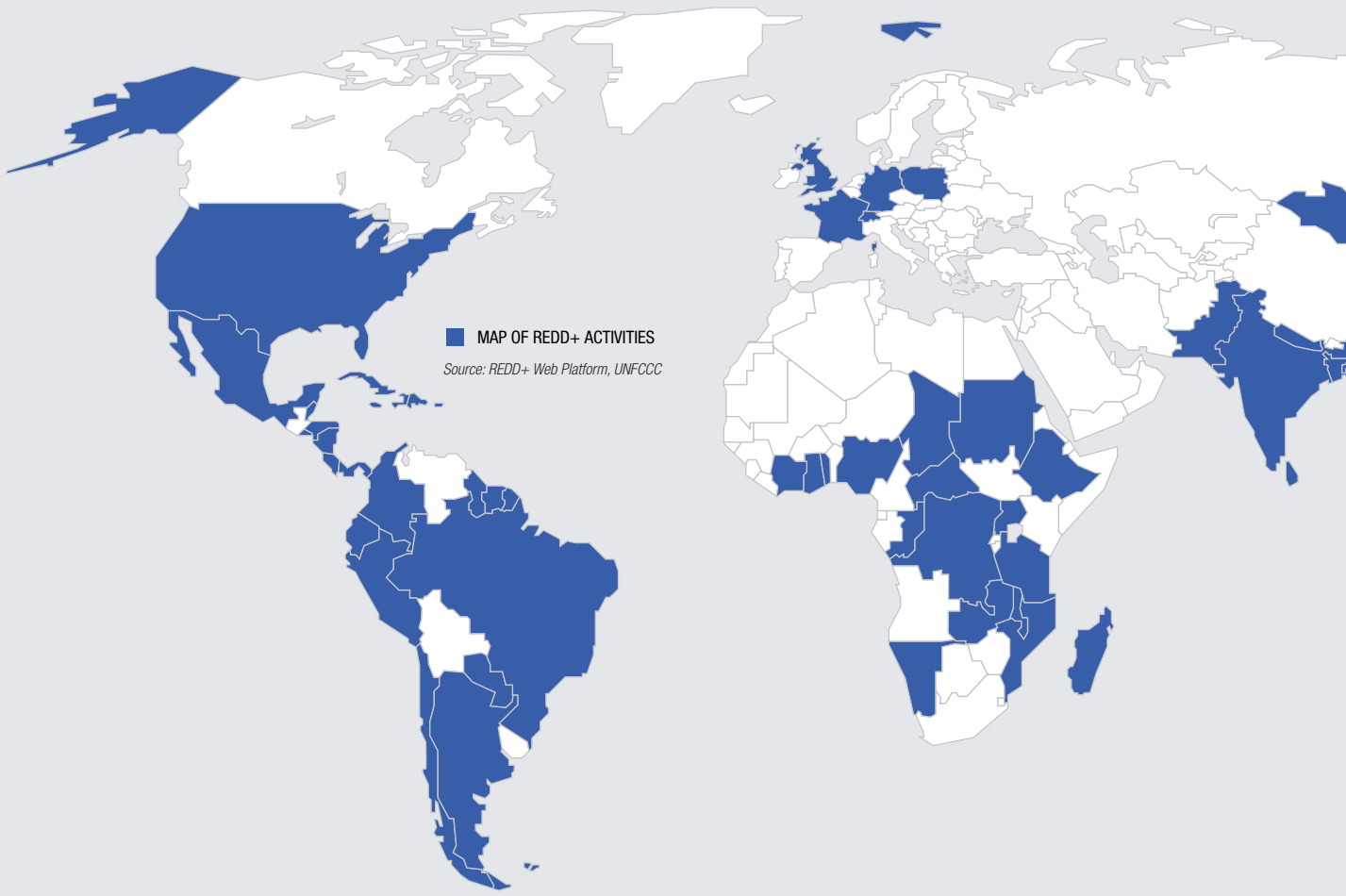
Forests offer a critical solution to the most severe impacts of climate change and provide a unique opportunity for climate action. They are crucial for food, water, wood, energy, biodiversity and health. The Sustainable Development Goals can only be achieved if forests are sustainably managed, deforestation is significantly reduced, if not stopped all together, and forest landscapes are restored. Forests currently remove around a quarter of the carbon dioxide emissions we add to the atmosphere each year. Stop reading for a moment and try to picture these first three sentences. With that picture in mind, now imagine that if we were to raze the world's forests, more than three trillion tons of carbon dioxide would be released, which is more carbon than in currently identified and exploitable reserves of oil, gas and coal deposits. It's not a nice picture to imagine, but it makes you think about the scale and impact deforestation can have on our climate and our lives.

Back to reality, which is less chilling than the one you just pictured, but one we need to actively work on. Currently, 11 percent of global carbon emissions stem from land-use change, primarily deforestation and forest degradation. Unfortunately, notwithstanding decades of forest protection and conservation at global, regional, national and local scales, deforestation is on the increase. Beyond carbon, forests are also home to approximately 1.6 billion people of our current world population of 7.7 billion. That is a big home, and it includes more than 2,000 indigenous cultures that depend on forests for their livelihoods. Recently, there has been much talk about Natural Climate Solutions (NCS), a term that is interchangeable with Nature-Based Solutions, the land sector, and the Agriculture, Forestry and Other Land-Use sector to the extent that they refer to the mitigation efforts associated with these sectors. NCS solutions also deliver strong results for adaptation and resilience and can provide more than a third of the cost-effective carbon dioxide emissions mitigation needed through 2030 for a > 66 percent chance of holding warming to below 2 °C. At the international level, the paramount role of forests is recognized in the Paris Agreement of the United Nations Convention on Climate Change (UNFCCC), as well as in the Nationally Determined Contributions (NDCs), countries' plans that outline their best efforts to reduce emissions. Approximately 25 percent of planned emissions reductions in current NDCs come from the land-use sector, primarily from actions related to forests. Although this is great, it is important to note that only about 31 percent of emission reduc- →

Costs, phases and actions

To carry out the REDD+ program and transform agriculture and land use by 2030, investments of up to 167 billion dollars a year are required, 96 percent (equivalent to approximately 161 billion dollars) of them from private sector participation. The remaining 6 billion will probably come from governments, donors or multilateral support.
To get an idea, the total investment is 60 percent of the value of current spending on renewable energy (270 billion a year).

Source: TFA 2020



tions in NDCs include quantifiable targets corresponding to the forest sector. As the global community is ramping up climate action, we must ensure that the entire mitigation potential of forests and wider NCS can be fully harnessed and implemented successfully. Reducing emissions from deforestation and forest degradation in developing countries, and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries, known as REDD+, provide us with such an opportunity—one that we must seize.

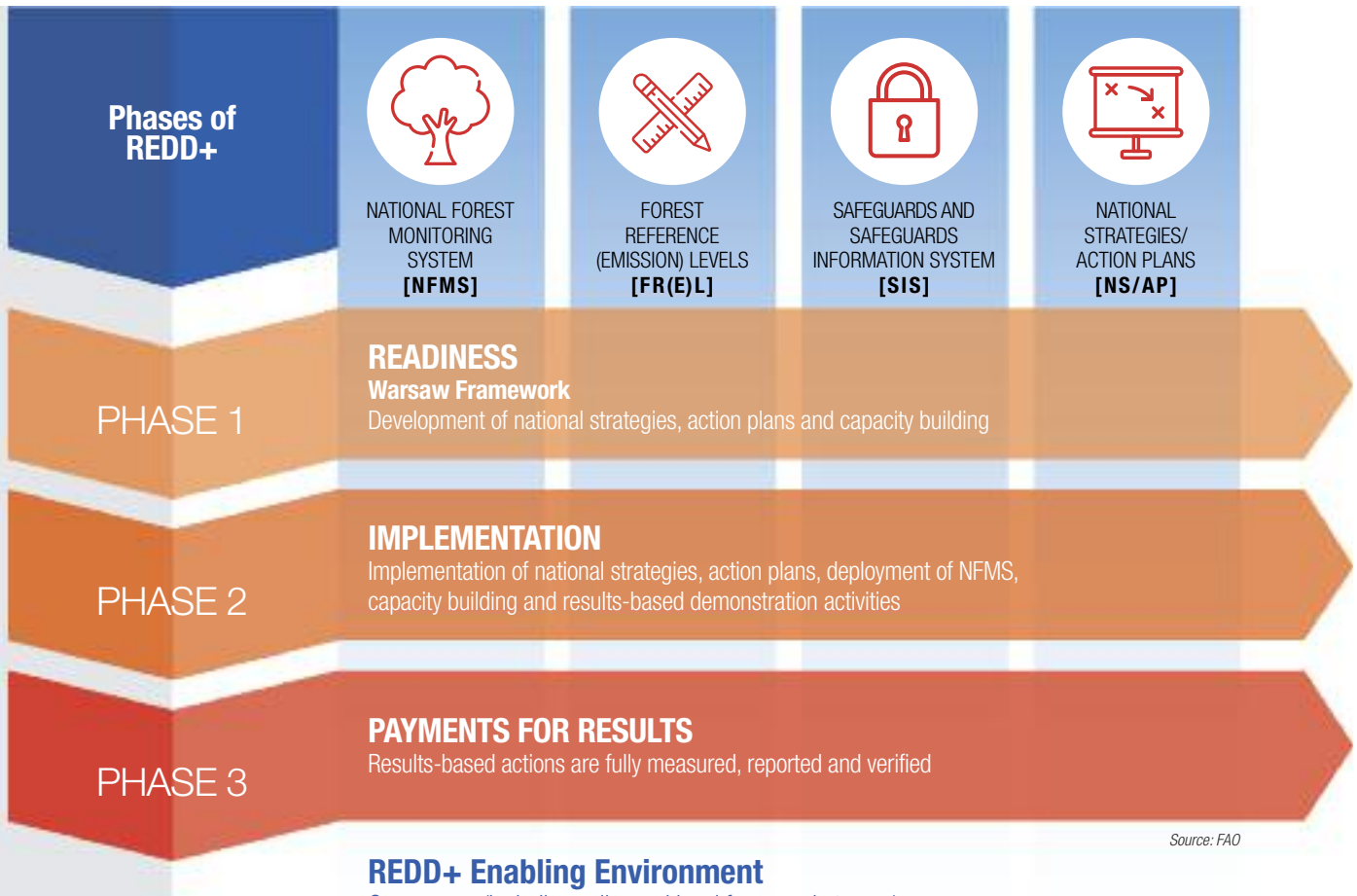
The REDD+ landscape

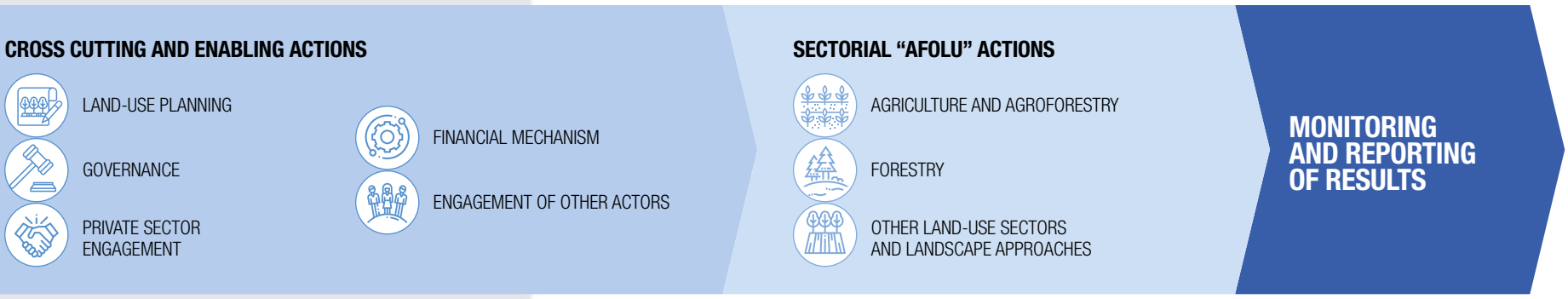
REDD+ emerged as a forest mitigation approach for developing countries under the UNFCCC, with rules for guiding its implementation formalized (the so-called "Warsaw Framework for REDD+") over several years and culminating in its inclusion in the Paris Agreement (Article 5). But what is REDD+? We will explore briefly what REDD+ is (the scope), where it can be implemented (the scale), the four required elements that underpin REDD+ implementation and a phased implementation approach.

The scope of REDD+ encompasses the so-called five "REDD+ activities":

1 | reducing emissions from deforestation;
2 | reducing emissions from forest degradation;
3 | conservation;
4 | sustainable management of forests;
5 | enhancement of forest carbon stocks.

What do these REDD+ activities look like in practice? The REDD+ activities have not been further defined in the UNFCCC decision texts, which allow for flexibility of implementation. It is useful, though, to have an idea what the different activities may relate to. Emissions from deforestation occur when forests are cleared for a variety of purposes, such as for agriculture or for building infrastructure such as roads. Reducing emissions from deforestation is an effort to mitigate greenhouse gas emissions resulting from the human-induced long-term or permanent conversion of land use from forest to other non-forest uses. Emissions from forest degradation occur when human disturbances, such as logging or fuelwood gathering, directly reduce the carbon stock of a forest without changing the land use (i.e., it remains a forest). "Enhancement" is generally understood to include afforestation, reforestation and forest rehabilitation / restoration. Conservation activities may be defined as the preservation of existing carbon stocks. REDD+ activities can be designed and implemented at various scales: national, subnational and local. To illustrate this, national level implementation can be characterised by the domestic achievement of an NDC, of which forests and/or REDD+ are a component (Refer to the UNFCCC website to see if REDD+ and/or forests are part of your home country's plan). The subnational level could involve a state or province that creates a baseline against which performance is measured and that seeks payment for results or generates carbon assets according to a pre-defined standard and sells them to buyers. At the local level, REDD+ could be implemented through carbon projects set baselines, measured performance and generated and sold carbon credits based on measured emission reductions and following third-party validated standards and methodologies. If you are confused, so are many of us. The key message is that REDD+ can be implemented at different scales, that each of these scales comes with its own set of characteristics that sometimes overlap. What these various scales of implementation have in common





though, is the notion of permanence. This notion requires emission reductions to be lasting. Therefore, it is essential that the implementation of REDD+ across scales is transformational, meaning that it should lead to changes that remove the underlying drivers of emissions or barriers to enhancement of carbon stocks. This can occur through the creation or improvement of carbon pools and their capacity to store carbon, such that emissions would not occur after the end of the activity's implementation period and enhancements would not be reversed. Therefore, if the emissions reductions and/or enhancements that were made should not be reversed, understanding why and where deforestation and forest degradation are happening is fundamental to designing effective REDD+ interventions. This leads us to the four required elements for REDD+ implementation, which build upon and reinforce each other:

a | a National Strategy or Action Plan;

b | a national (or interim subnational) Forest Reference Emission Level;

c | a robust and transparent National Forest Monitoring System for the monitoring and reporting of the five REDD+ activities, including for measurement, reporting and verification results;

d | a Safeguard Information System.

These required elements were developed in the context of the UNFCCC (therefore more of a national context) but are also included in some way or another in subnational and local REDD+ programs and projects. A national strategy or action plan usually seeks to address the drivers of deforestation and forest degradation, land tenure issues, forest governance issues, gender consideration and safeguards and usually presents a country's vision on how REDD+ will be implemented. A forest reference emission level is a benchmark for assessing a country's performance in implementing REDD+ activities and is expressed in tons of carbon dioxide equivalent per year. The primary function of a national forest monitoring system is the measurement, reporting and verification of REDD+ activities, while the monitoring system is primarily a domestic tool that allows countries to assess a broad range of forest information. National forest monitoring systems are often underpinned by forest inventories to measure forest carbon stocks and changes in those stocks and remote sensing analysis to measure land-use changes and changes of forest carbon stocks within the forest. When implementing REDD+, it is essential to promote and support seven safeguards, known as the Cancun safeguards. They aim to ensure that REDD+ implementation adequately address sensitive issues such as the preservation of natural forests →

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Public-private partnership is very important for the sustainable use and preservation of the world's forests because it allows synergies to be created between public policies and funding on the one hand, and the forestry-related sustainability commitments of companies on the other (e.g. sustainable palm oil). In the photo, a woman working for a cooperative that produces palm oil in Benin, Africa.

and biodiversity, the rights of indigenous peoples and traditional communities, social participation, the permanence of achieved REDD+ results, and the risk of displacement of the pressure from deforestation and forest degradation to other areas. Examples of how countries have approached these four required elements can be found on the UNFCCC REDD+ Web Platform, which centralizes information on countries' efforts on REDD+. All of this is pretty complex to do, so when REDD+ was designed, countries set out a three-phased approach to REDD+ implementation, reflecting countries' convergence around the need for a flexible, learning-by-doing approach. These phases begin with the development of national strategies, policies and measures and capacity-building (phase 1 or "readiness" phase), followed by the implementation of national policies and measures and national strategies that could involve further capacity-building, technology development and transfer and results-based demonstration activities (phase 2 or "implementation" phase), and evolving into results-based actions that should be fully measured, reported and verified (phase 3 or "results-based actions" phase). Once actions are measured, reported and verified, countries can, in principle, access results-based payments, i.e., payments by the international community for results achieved in terms of emissions reductions and removals.

Money makes the world, and REDD+, go round

The conceptualization and design of the architecture of REDD+ at the international level must go hand-in-hand with financing. The financing needs can be linked with the REDD+ phases as well as supporting governments to create or improve polices and measures and enforce them, for example, through land rights. The two main multilateral readiness initiatives that financed REDD+ in the early stages were the UN-REDD Programme and the Forest Carbon Partnership Facility of the World Bank. Many countries are now in phases 2 and 3 of REDD, for which finance is proving to be more challenging. Results-based payments for REDD+ should incentivize forest protection and improved land-use management, but developing countries struggle to meet program requirements and resources are limited. The governments of Norway and Germany have been piloting results-based payments with partner countries through bilateral agreements. To date, the Green Climate Fund that was established to limit or reduce greenhouse gas emissions in developing countries and to help vulnerable societies adapt to the unavoidable impacts of climate change has awarded REDD+ results-based payments to three countries: Brazil (USD 96.5 million), Ecuador (USD 18.6 million) and Paraguay (USD 50 million). The World Bank is also piloting results-based payments through the Forest Carbon Partnership Facility Carbon Fund. What is the lay of the land in REDD+ Finance? Let's start with the drivers of deforestation (for example, commercial agriculture): subsidies and investments amount to 40 times more than investments in protecting forests. How about international climate finance? Only two percent of international climate finance goes to forests. It's not enough. The current financial support for forests is insufficient to reach their mitigation potential and for REDD+ to play its full role in climate action. Reducing deforestation is also not cheap. A review of existing research estimated the costs of achieving REDD+ and transforming agriculture and land use by 2030 at $167 billion annually, of which 96 percent is amenable to private sector participation. So, what could the role of the private sector be in REDD+? Public-

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Private-Partnerships (PPPs) are one possible avenue to explore, among many others.

Public-Private-Partnerships: where two sectors meet

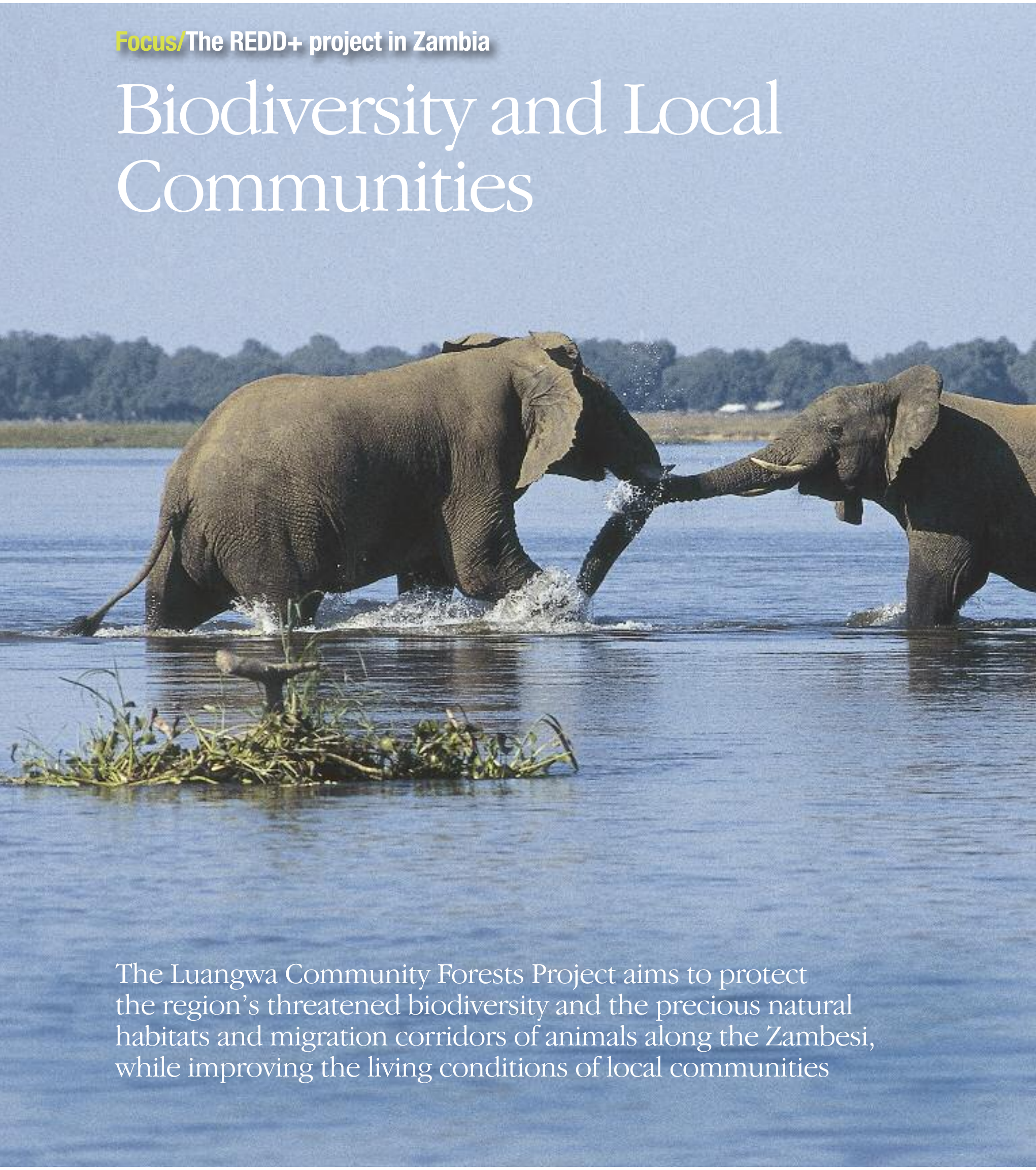
Massive targeted public and private investment into the conservation, sustainable use and conservation of the world's forests is needed. PPPs provide the space to create synergies between, on the one hand, public policy and public finance and, on the other hand, corporate sustainability commitments related to forests (for example, sustainable oil palm) as well as private sector investment in offsetting emissions through financing forests (done in a socially and environmentally responsible manner).

Let me try to illustrate through a delicious example. Do you like chocolate? I do. But did you know that cocoa production is a key driver of forest degradation and deforestation in the world's two largest cocoa producing countries, Ghana and Côte d'Ivoire? To tackle this issue, the governments of Ghana and Côte d'Ivoire, along with 34 leading cocoa and chocolate companies, have come together in the Cocoa and Forest Initiative (spearheaded by the World Cocoa Foundation) to restore forest areas and end deforestation. Across the ocean in Colombia, the largest cocoa and chocolate companies and the government signed the Cocoa, Forest & Peace Initiative in 2018 to eliminate cocoa-related deforestation. Time will tell if these PPPs in the cocoa sector will be successful, but I am on the look-out to find deforestation-free chocolate in shops and in my kitchen cupboard. There is a need, and there are opportunities like this for PPPs in all sectors related to forests. We need consumers and producers, policies and financial instruments and investments, public and private, to align. Otherwise, there is a risk that one will undo what the other tries to achieve. By aligning these elements, we also allow each party to commit and contribute to what they do best to protecting forests in a more efficient way. This is an opportunity we must seize!

Nature-Based Solutions (NBSs) are inspired and supported by nature, using or imitating natural processes, and allow excellent results to be achieved in terms of adaptation and resilience. In the photo, women harvesting tea leaves in the region of Darjeeling, India, where one of the best and most famous types of tea in the world is produced.

Focus/The REDD+ project in Zambia

Biodiversity and Local Communities



The Luangwa Community Forests Project aims to protect the region's threatened biodiversity and the precious natural habitats and migration corridors of animals along the Zambesi, while improving the living conditions of local communities

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HASSAN SACHEDINA

Founder and CEO of BioCarbon Partners, he is a career conservationist with 20 years plus experience. Prior to founding BCP, he was Vice President of Wildlife Works, and Partner in Conservation Capital, which catalyzed $210 million of conservation business investments globally. His scientific work has been published in Ecosystem Services, Oryx, Conservation Biology and Current Conservation.

PROTECTED HABITATS
BioCarbon Partners (BCP) forest projects, under the United Nations REDD+ program, generate carbon credits whose sale contributes to improving the living conditions of the local communities that protect the forests and valuable natural animal habitats. In the photo, two African elephants in the waters of the Zambezi river in Zambia.

Forests, through their rich biodiversity, provide benefits to communities whose livelihoods depend on them. The United Nations Sustainable Development Goals (SDG) and Aichi Biodiversity Targets accept that reducing emissions from deforestation and forest degradation (REDD+) provides a positive mitigation strategy for climate change. Additionally, conservation and the enhancement of forest carbon stocks create mechanisms for payments to developing countries.

Deforestation and forest degradation account for an estimated 15 percent of the world's CO_2 emissions and are a significant contributor to climate change. Zambia has the highest level of deforestation by landcover in Africa per year and loses just under 300,000 hectares of trees to unsustainable farming techniques and charcoal production annually. Deforestation in Zambia further exacerbates the loss of already threatened biodiversity and wildlife species. Recent UN reports highlight that one million species of wildlife and one third of tropical African plants face extinction, in large part due to deforestation and climate change.

Founded in 2012, BioCarbon Partners (BCP)'s mission is to make conservation of wildlife habitat valuable to people. Under the UN REDD+ framework, BCP develops forest carbon offset projects in areas of global biodiversity significance. The business model works with community and government partners to protect forests by investing in communities, forest management and carbon science. Projects are verified by international standards to produce carbon credits that can be sold to bring livelihood benefits to the local communities by protecting forests, valuable habitat and migration corridors.

Establishing the LCFP

In 2013, BCP started work on the Luangwa Community Forests Project (LCFP) in Zambia's iconic Lower Zambezi and Luangwa ecosystems. The LCFP was designed to support the Government of Republic of Zambia's (GRZ) REDD+ Strategy by establishing the largest program to date.

Fast forward almost seven years and the LCFP supports forest co-management across 950,000 hectares and deforestation mitigation activities that brings the total to one million hectares, management that benefits 13,000 households over an area of 20,000 sq. km.

By protecting close to one million hectares of forest, the 30-year LCFP has been verified as Africa's largest REDD+ project by hectarage. It also has been validated to CCB (Climate,

ON-SITE TRAINING
Each member of the forest monitoring team has been selected and hired from the local community and has been trained to scientifically measure and monitor the forest.

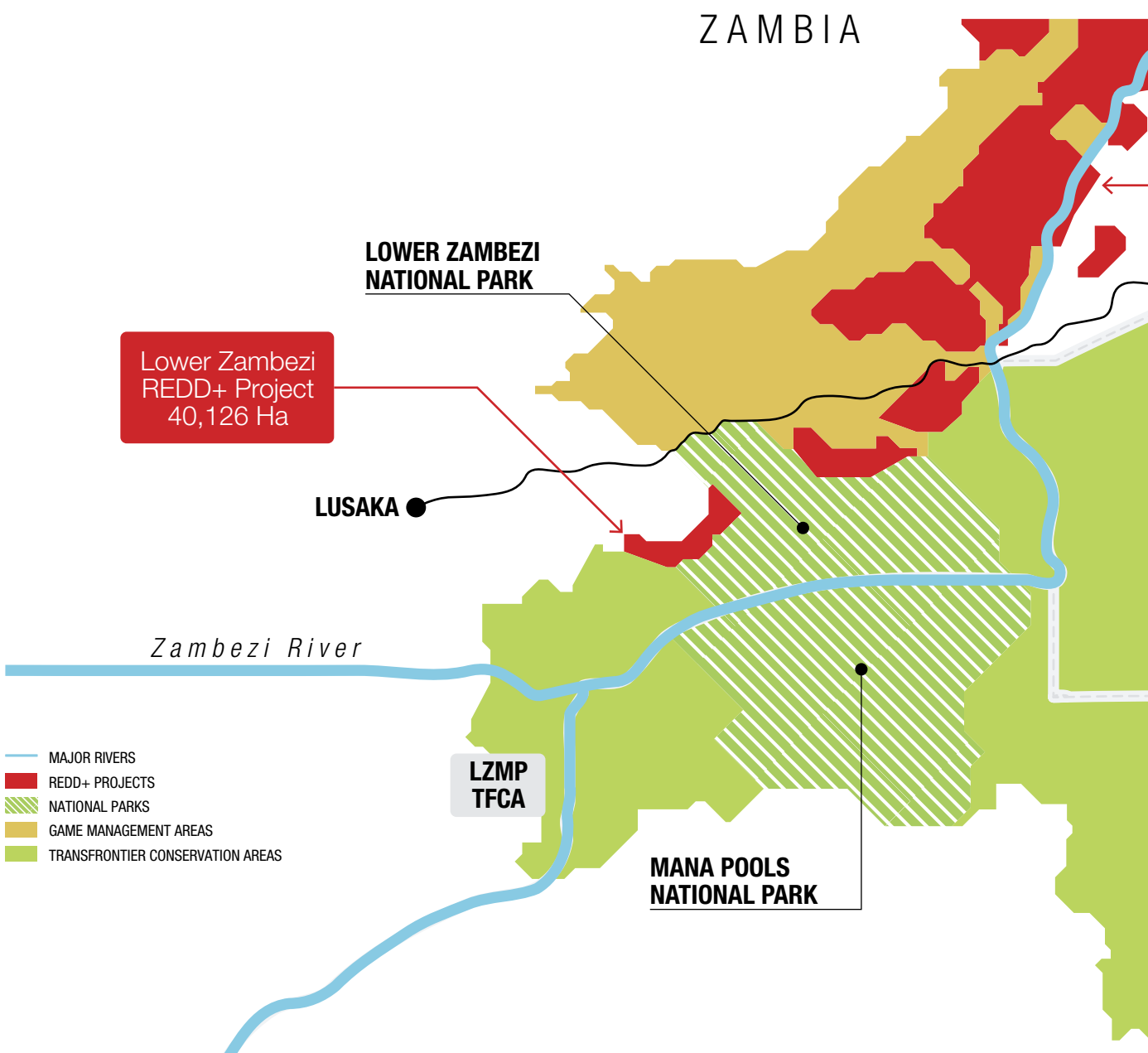
Community and Biodiversity Standards) "triple gold" for exceptional social impacts, illustrating that with scale, quality does not need to suffer. The LCFP works to address key drivers of deforestation through targeting the SDGs and poverty reduction, sustainable incomes, improving social services and encouraging conservation by protecting critical areas of the Luangwa Valley ecosystem. In total, 80,000 people benefit from the project activities. The LCFP is designed to yield transformational social and environmental returns in an area of global biodiversity value. Without the LCFP and carbon finance, this area would have limited economic prospects.

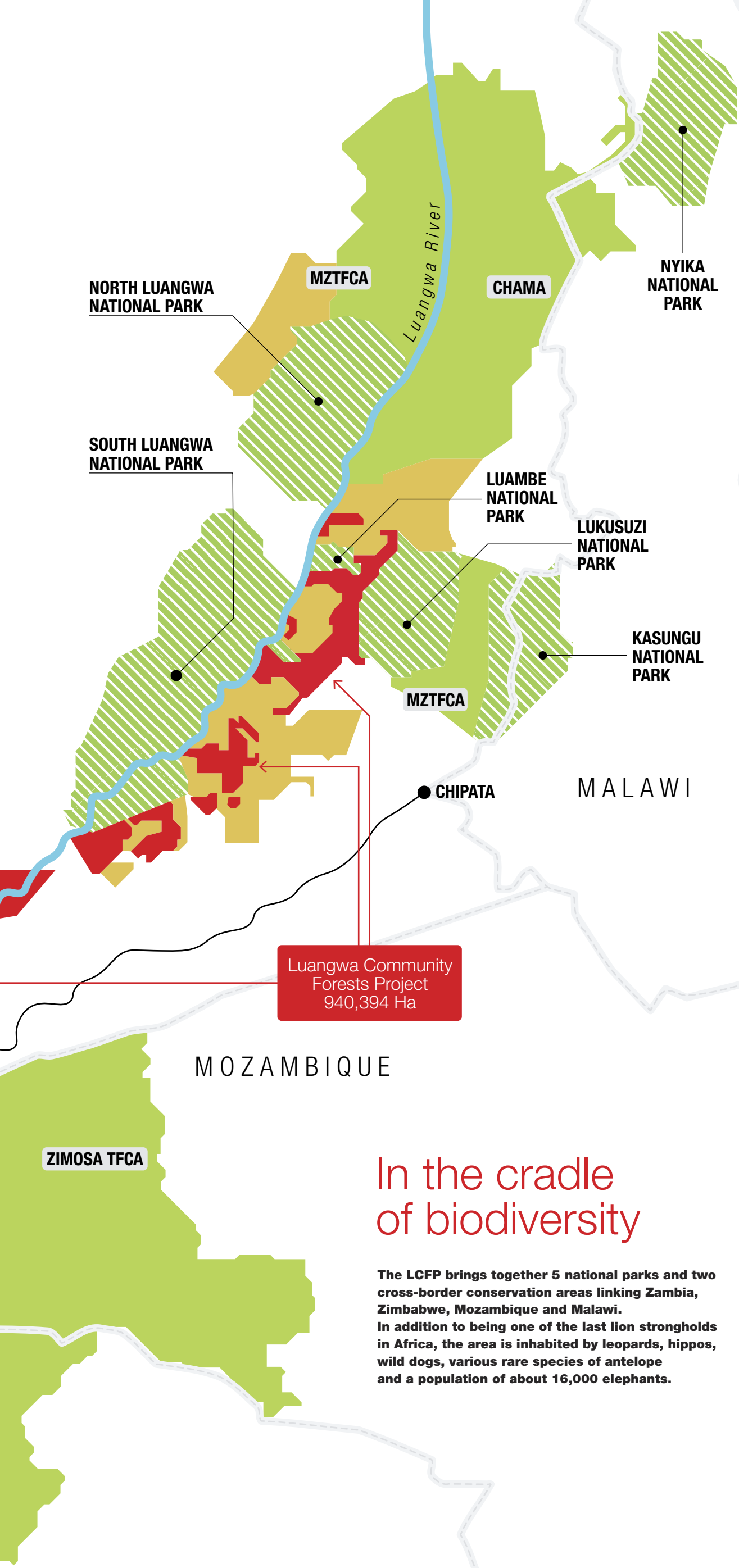
The Luangwa: One of the last biodiversity strongholds on earth

The LCFP links five national parks and two trans-frontier conservation areas linking Zambia, Zimbabwe Mozambique and Malawi. This area has significant importance for tourism revenue development as Zambia's most visited park is South Luangwa. However, the last forests in Eastern Zambia are under siege from a wave of deforestation approaching on both valley sides. The LCFP protects important buffers and wildlife dispersal areas around the parks in game management areas and is becoming one of the largest biodiversity corridors in Africa.

Community Partnership

The goal of the LCFP was to establish a community-based REDD+ project to improve natural resources management, particularly forests,





In the cradle of biodiversity

The LCFP brings together 5 national parks and two cross-border conservation areas linking Zambia, Zimbabwe, Mozambique and Malawi.
In addition to being one of the last lion strongholds in Africa, the area is inhabited by leopards, hippos, wild dogs, various rare species of antelope and a population of about 16,000 elephants.

through joint management, increased capacities, and improved livelihoods for forest dependent communities.

The development of large-scale community-based REDD+ projects involves many steps, from identifying potential REDD+ conservation areas with communities and government, designing Zambia-specific and effective Free Prior and Informed Consent (FPIC) processes that meet the local and international standards for community engagement, developing and negotiating 30-year community agreements that commit each party to their responsibilities and define benefit sharing, developing community organizational capacity to equitably and transparently manage carbon revenues and community development projects, developing community capacity to protect and conserve community forest assets, helping to develop and implement an enabling legal framework in a globally new sector to catalyze the first communities in Zambia to be transferred carbon rights, and finally, establishing audits and verifications by an independent auditor that will lead to the final approval and verification of carbon offsets for sale by VCS to sustain project activities.

The LCFP partners with 12 chiefdoms, through whom Free Prior and Informed Consent (FPIC) to establish REDD+ areas on their land required extensive engagement with communities and other stakeholders, is an ongoing process. Eastern Zambia has one of the highest prevalence of rural poverty in Zambia. In these food-insecure communities prone to various shocks that could further entrench and institutionalize poverty, the development of these co-management agreements with communities is a major milestone. To date, approximately USD 4 million has been invested in community empowerment projects and the social impact pillar of BCP's work is fundamental to its approach. For example, BCP became B Corp certified in 2017 and is the 5th highest scoring B Corp on earth for its social, environmental and staff benefit model.

The LCFP addresses 16 of 17 SDGs, and household incomes have been independently shown to increase 400 percent in communities where BCP has worked for 5 years. Key to forest carbon project development is verification. BCP verifies to the Verified Carbon Standard (verra.org), considered the globally leading and most rigorous standard for the validation and verification of voluntary carbon emission reductions. A yearly VCS verification of a REDD+ project certifies that it →

WITH THE LOCAL COMMUNITIES

Through conservation projects, like Luangwa Community Forests Project, that also contribute to the measurable achievement of most of the UN Sustainable Development Goals, Eni strongly supports the worldwide improvement of natural carbon sinks, contributes to maintaining biodiversity in forests and further supports the local communities by promoting the development of social and economic activities.

Eni joins the Luangwa Project

On November 21st, Eni signed an agreement with BioCarbon Partners to become an active member of the governance of the Luangwa Community Forests Project. As part of the initiative, Eni is also committed for 20 years, until 2038, to purchase certified carbon credits according to the Verified Carbon Standards and the Climate, Community and Biodiversity Standard. The operation will contribute to the success of this REDD+ project in the long term and will help to achieve most of the United Nations Sustainable Development Goals (SDGs). Eni's entry into the LCFP project is part of the decarbonization process undertaken by the company. Indeed, this year Eni strongly re-launched its traditional commitment in this area, setting itself the goal of zero upstream net emissions by 2030, a goal that can be achieved through improving efficiency by significantly reducing direct emissions, thanks to the offsetting role of primary and secondary forest conservation projects.

meets certain international standards in terms of ensuring quantifiable carbon emissions reductions and tangible community and biodiversity benefits. BCP's first project, the Lower Zambezi REDD+ Project, was the first REDD+ project in the world to pass six successful VCS verifications and was the first project in Africa to achieve CCB triple gold validation. LCFP, while much larger in size, is also establishing a base for exceptional climate, community and biodiversity benefits and the ability to deliver transformational land and community benefits alongside offset generation. The sustainability of these projects is dependent on the price of carbon and the sale of VCUs on the voluntary carbon market—which in turn is dependent on how the world approaches the issue of climate change over the pivotal next ten years.

Innovation

LCFP has evolved into Africa's largest REDD+ project and operates in areas with limited road networks and major river barriers. "Flying FPIC" activities, a BCP innovation, allows representatives from the 12 chiefdoms and local communities to fly over their forest resources to confirm boundaries and prevent conflicts. Flying facilitated an effective land use planning approach for a project of this scale.

As deforestation is a leading contributor to the disappearance of valuable wildlife habitat, in partnership with Oxford University affiliated NGO Lion Landscapes, LCFP is piloting a community-based biodiversity monitoring system.

The area is one of Africa's ten last lion strongholds and also is home to leopards, hippos, wild dogs, various rare species of antelope and a population of around 16,000 elephants.

The results of these surveys show that a significant wildlife recovery is underway in some areas since BCP's work began, with an up to 300 percent increase in high conservation value species within 5 years and the re-establishment of important carnivore species.

Lessons Learned

Seven years of implementation of the LCFP has led to multiple lessons. The project was technically challenging in that REDD+ is a new sector and approach to conservation finance in a country that has had little experience with climate change mitigation. Complicating this was the scale: close to one million hectares of forest, in a total footprint of two million hectares including community project zones.

Local capacity needed direct support to develop different management / support models to find one that can ensure conservation, livelihoods and governance impacts at a local level. The CFP had to invest directly in community capacity development and provide direct mentoring to help manage conservation fees. Supporting communities to use conservation fees to implement community development projects was key. When budgets are announced, communities become focused on spending the entire budget. Balancing transparency on financial amounts available against the desire to avoid distractions based on the amount of funding available and the need to focus on the delivery of critical community development needs, are essential for community-led decision-making and delivery of community projects.

J.B. Russell is a Paris-based documentary photographer, filmmaker and educator. He has more than 25 years of experience working extensively throughout Europe, Africa, the Middle East, Asia and Latin America focusing on current events, the human consequences of conflict, human rights, environmental and development issues. He works regularly for major print and on-line publications, international NGOs, and his work has been recognized by numerous awards.

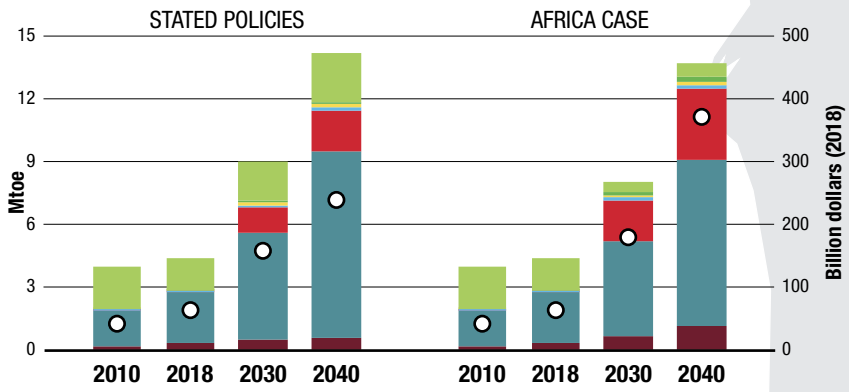
Senegal/Interview with the Minister of Energy

Forest Conservation? One of our Priorities

Mouhamadou Makhtar Cisse

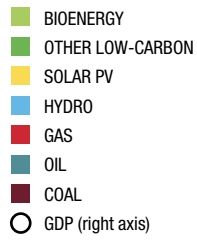
Minister of Petroleum and Energy of Senegal since 2019. Previously Budget Minister. Former CEO of Senelec, the national electricity company of Senegal.

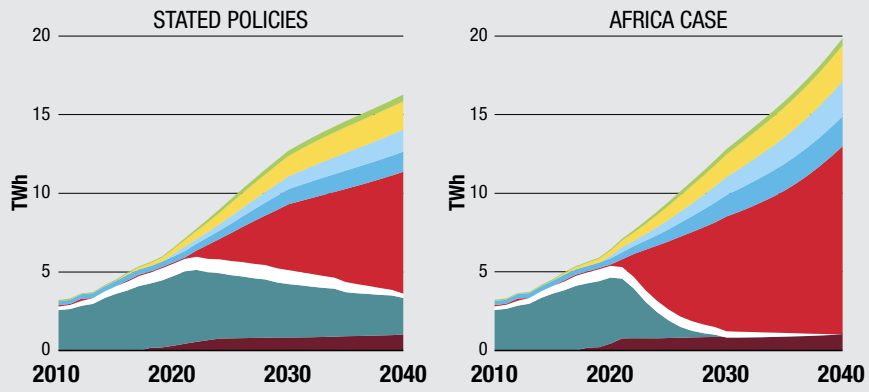
Countering the use of coal and wood as energy sources is central to our efforts. We are therefore working at a macro level to improve network coverage and have developed programs to support clean energy for cooking and lighting with biogas



PRIMARY ENERGY DEMAND AND GDP

Senegal's economy could grow six times larger in the AC while limiting growth in energy demand to three times its current level by utilising new gas resources and boosting the use of renewables in power. In the AC, gas meets a growing share of energy demand while traditional use of biomass starts to decline in rural areas.





ELECTRICITY GENERATION BY TECHNOLOGY

Electricity demand increases sharply in both scenarios, while the power mix changes, with gas playing an increasingly important role and investments in wind and other renewables bringing more diversification. Plans to phase out heavy fuel oil in the AC hinge on successful implementation of new gas-to-power plans.

FIELDS

Source: Africa Energy Outlook 2019, IEA

A journalist, she works in External Communications at Eni and on WE magazine. She previously worked at the AGI press agency, and before that in print media (*Corriere della Sera*, *Il manifesto*, *El País*).

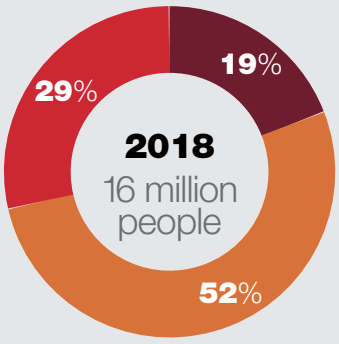
Senegal is a country in a hurry, eager to conquer the challenges it faces in diversifying its energy sources and making energy accessible to its entire population. It is among the few African countries to have discovered gas deposits. Mozambique, Tanzania, Egypt, Mauritania and South Africa and Senegal account for 40 percent of global deposits discovered between 2011 and 2018. Despite having huge reserves of oil and gas, Dakar also aims to make renewables a significant part of its energy mix, with the goal of reaching 30 percent by 2030. Thanks to successful policy initiatives, Senegal has also managed to guarantee access to energy to 70 percent of its population, with the aim of achieving 100 percent coverage by 2025. Forests, one of the country's fundamental resources, are also among its priorities. The country's Minister of Petroleum and Energy, Mouhamadou Makhtar Cissé, is firm in giving this assurance: "We are deeply committed to protecting our forest resources and all our natural resources in general."

Senegal plans to make all its offshore projects operational between 2022 and 2026. What can we expect in the coming years?

First of all, we will continue to carry out exploration activities. Only a week ago [November 5, 2019, ed.] in Cape Town, we launched an international competitive tender procedure to assign licenses for twelve new blocks. What happens over the coming years will depend largely on the new discoveries we hope to make as a result of this assignment process. What is certain is that gas production is scheduled to start in 2022, while for other fields, we will have to wait for 2023, 2024, 2025, and 2026, as you rightly pointed out. It is a long-term process over a period of 25 to 30 years, so we have to act intelligently. We will be able to make forecasts about resources and improve the results of ongoing projects as well.

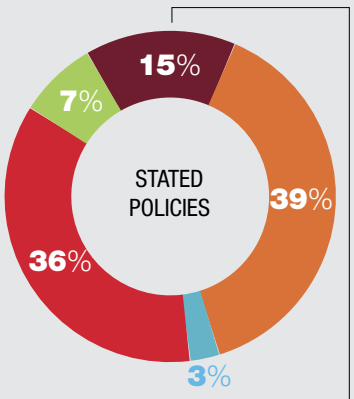
According to the IMF, Senegal is estimated to have reserves of over 1 billion barrels of oil and 40,000 billion cubic feet of gas. These are very significant reserves...

Yes, we have huge reserves, but this should not divert our attention from the issue of resource depletion. We cannot continue to live in a world of exponential development. Climate change means that renewable energy is the right way forward. Even though Africa has to think primarily about its economic development, this issue affects everyone, and Senegal wants to be a leader in the field of renewables and increase their share of the energy mix. Therefore, despite →

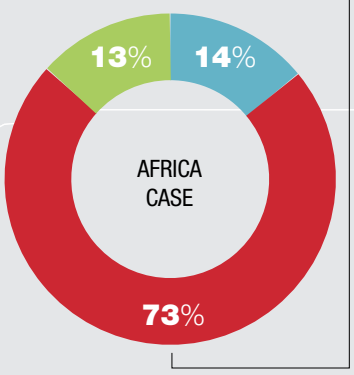


FUELS AND TECHNOLOGIES USED FOR COOKING

LPG is used for cooking by almost 30% of the population today, one of the highest shares in sub-Saharan Africa. It is expected to remain the main clean cooking fuel in 2030. In the AC, LPG is the least-cost option in both rural and urban areas for more than 70% of the population currently still lacking access.



2030
22 million people



- CHARCOAL
- OTHER SOLID BIOMASS
- IMPROVED COOKSTOVES
- LPG
- OTHER CLEAN

The **Stated Policies Scenario** reflects our measured assessment of today's policy frameworks and plans, taking into account the regulatory, institutional, infrastructure and financial circumstances that shape the prospects for their implementation.

The **Africa Case** is built on the premise of Agenda 2063, the continent's inclusive and sustainable vision for accelerated economic and industrial development. Faster economic expansion is accompanied by the full achievement of key Sustainable Development Goals by 2030.

Pictured on page 43, palm trees in the forest near the village of Diagho, in the southern province of Casamance, Senegal. Casamance is famous for its palm oil and other agricultural activities. The production of palm oil in Casamance is a traditional and sustainable activity and has resisted the industrial-scale plantations needed to meet the growing demand for palm oil from the food industry.

**The inhabitants of the village of Diagho (pictured above) collect palm nuts to produce soaps, wine and palm oil.
During the dry season, men gather the sap of palm trees and women turn nuts into local products.**

A woman (in the center) carries salt-rich crusts collected in the former rice fields at the edge of the Soungrougrou River. The cultivation of rice here is an ancient practice, but today, it has had to adapt to environmental changes.

**Men preparing a wood pile for the authorized and controlled production of charcoal in the Kalounayes managed forest (bottom).
The local population rely on the forest for their livelihoods.**

A man observes the inhabitants of the village of Diagho, in southern Senegal, collecting palm nuts in the forest. Senegal is the world's fifteenth biggest palm oil producer (the first three are Indonesia, Malaysia and Thailand).

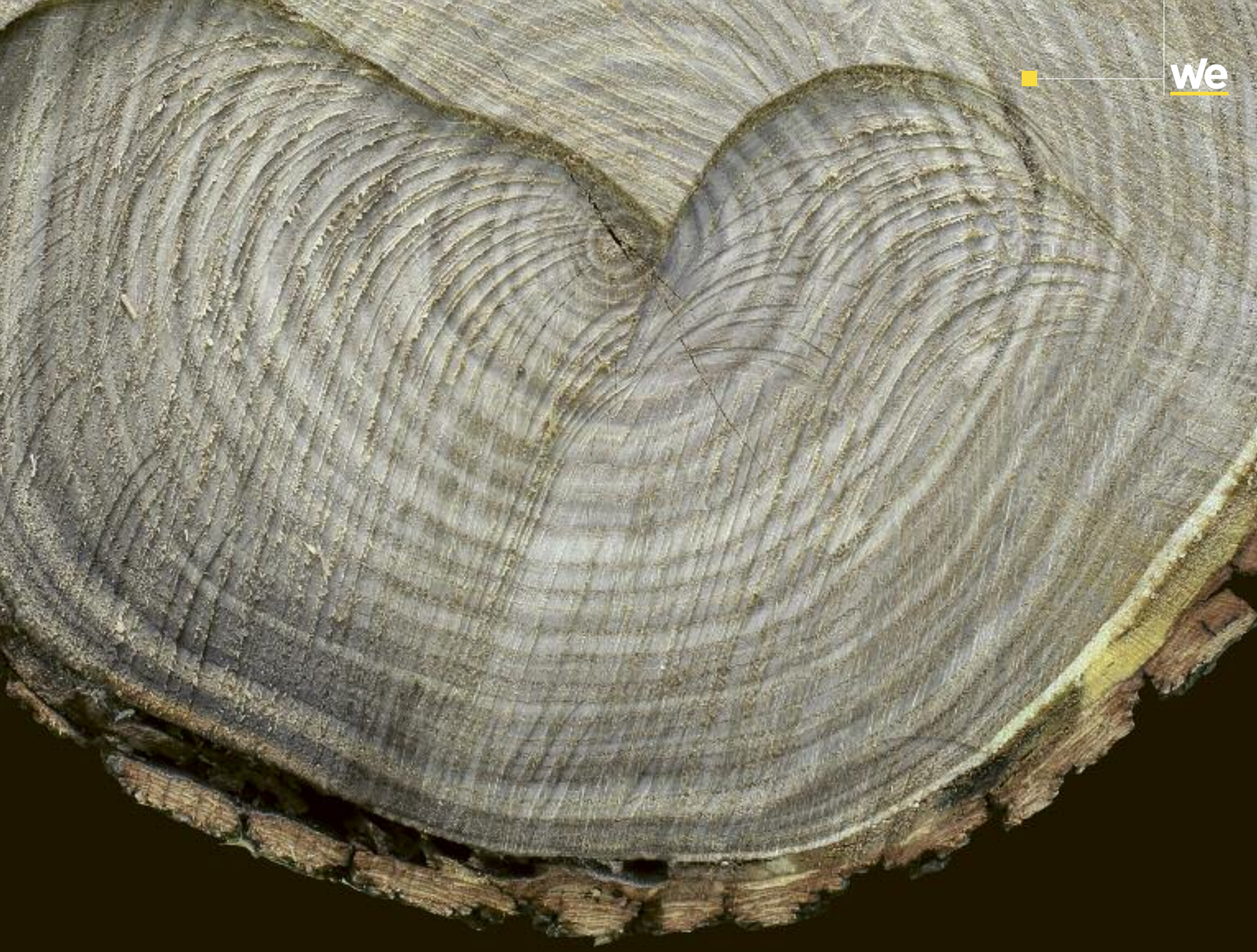
the country's huge gas and oil reserves and the new discoveries, we are continuing to expand our policy of diversifying energy production. Our goal is to reach 30 percent of renewables in the energy mix by 2030. We are at 20 percent today.

Apart from renewable energies, are there other objectives or measures you have adopted to ensure greater sustainability in the energy sector?

I believe we need to continue investing in new technologies and to monitor the system. The introduction of renewable energy allows users to save money, and recourse to new technologies is therefore fundamental. We have therefore launched technological innovations in Senegal that will allow us to guarantee universal access to electricity. We will do this by exploiting all the technologies—grid, off-grid, mini-grid—but also via the photovoltaic kits distributed in rural areas, where the greatest efforts must be made to achieve universal electrification by 2025.

The share of biomass in Senegal's energy mix for the supply of primary energy is very high, and we know that the use of biomass has heavy repercussions for forests. Has the Ministry of Energy introduced measures to protect forests? How are you trying to solve the problem?

We are deeply committed to protecting our forest resources and all our natural resources in general. Just six months since his re-election, the President of Senegal has launched an ambitious initiative, one of the most important ever seen, to create a "green Senegal." For this purpose, the head of state has established an agency for reforestation. Countering the use of coal and wood as energy sources is central to our efforts. For this purpose, we are not only working on a macro level, to improve the coverage of our country's electricity grid using various technologies mentioned (grid, off-grid, mini-grid and photovoltaic kits distributed in rural areas), but have also developed programs to install and disseminate biodigestors as part of the Programme National de Biogaz (PNB). These plants allow the development of organic fertilizers to fertilize the soil starting from basic resources, increasing the agricultural performance of rural populations and at the same time providing them with clean energy for cooking and lighting with biogas. These are extremely important programs. Safeguarding forests is a priority for the Senegalese government.



THE LANGUAGE OF FORESTS

BY ENI - REDD+ AND FORESTRY INITIATIVES
CARLOTTA CIOCCI • FABIO PASTORELLA • SIMONETTA SANDRI • LUIGI SCOPPOLA

Forests are of fundamental importance to the planet and to living beings. In addition to providing livelihoods for the people who live there, they provide clean air and water and preserve biodiversity. Furthermore, by regulating the natural carbon cycle and mitigating the effects of anthropogenic greenhouse gas (GHG) emissions, they are essential in the fight against global warming. There follows a coherent set of the most significant terms to do with forests and the climate.

A

ADAPTATION - to climate change
The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.

AFFORESTATION
Establishment of a forest trough planting, seeding and/or the human-induced promotion of natural seed sources, in an unstocked forest area which has been deforested for more than fifty years. It implies a land use change.

AFOLU (Agriculture, Forestry and Other Land Use)
The AFOLU category combines two previously distinct sectors LULUCF (Land Use, Land Use Change and Forestry) and Agriculture.
AFOLU plays a central role for food security and sustainable development. The main mitigation options within AFOLU involve one or more of three strategies: prevention of emissions to the atmosphere by conserving existing carbon pools in soils or vegetation or by reducing emissions of methane (CH_4) and nitrous oxide (N_2O); sequestration—increasing the size of existing carbon pools and thereby extracting carbon dioxide (CO_2) from the atmosphere; and substitution—substituting biological products for fossil fuels or energy-intensive products, thereby reducing CO_2 emissions. Demand-side measures (e.g., reducing losses and wastes of food, changes in human diet, or changes in wood consumption) may also play a role.

AGROFORESTRY
It is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components. Agroforestry can also be defined as a dynamic, ecologically based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels. In particular, agroforestry is crucial to smallholder farmers and other rural people because it can enhance their food sup-

EUROPE & CENTRAL ASIA
+235,000

MIDDLE EAST
& NORTH AFRICA
+33,000

EAST ASIA
& PACIFIC
+133,000

SOUTH
ASIA
+45,000

SUB-SAHARIAN
AFRICA
-830,000

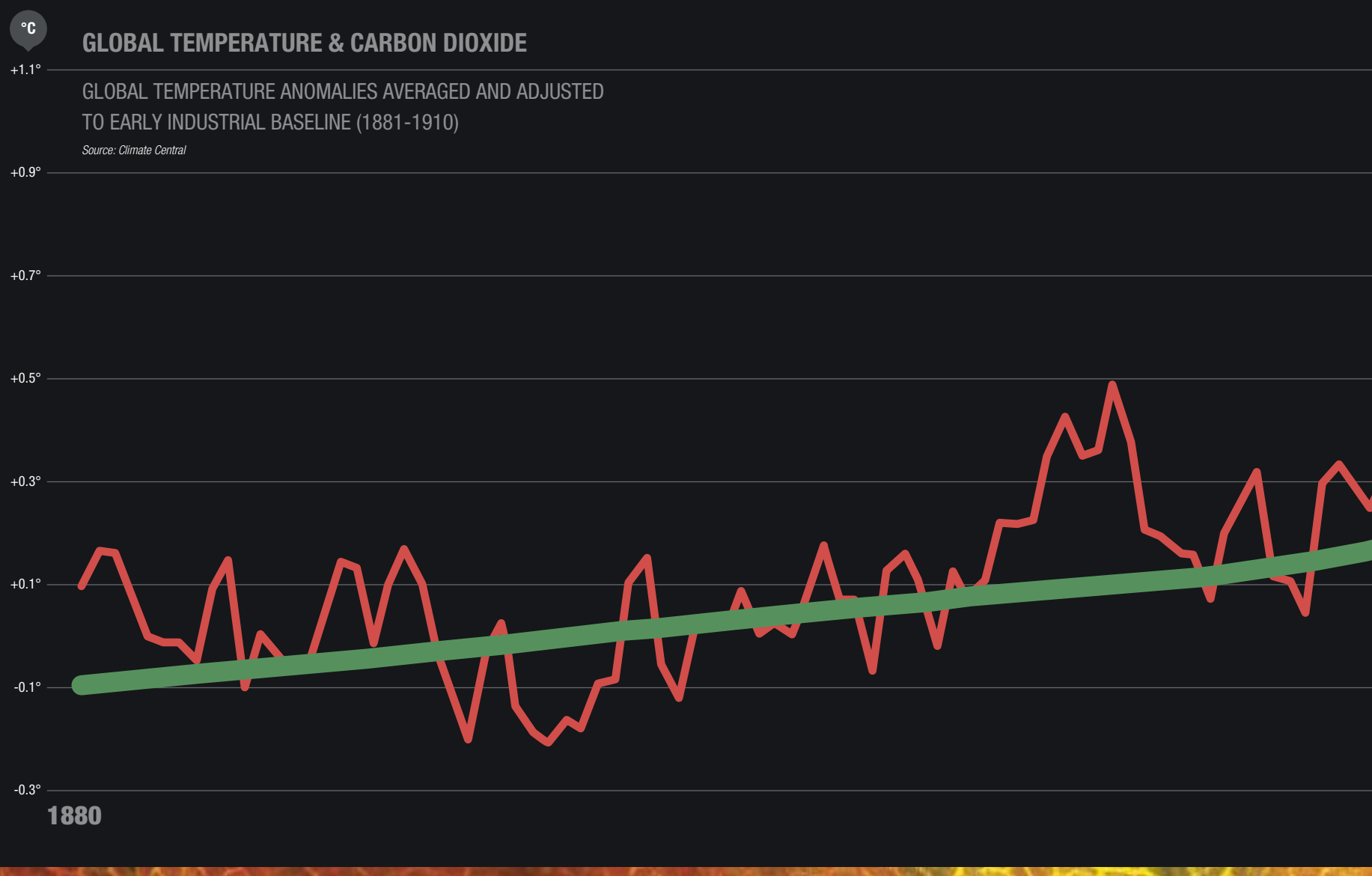
CHANGE IN FOREST AREA
(IN SQUARE KILOMETERS) **FROM 1990 TO 2015**

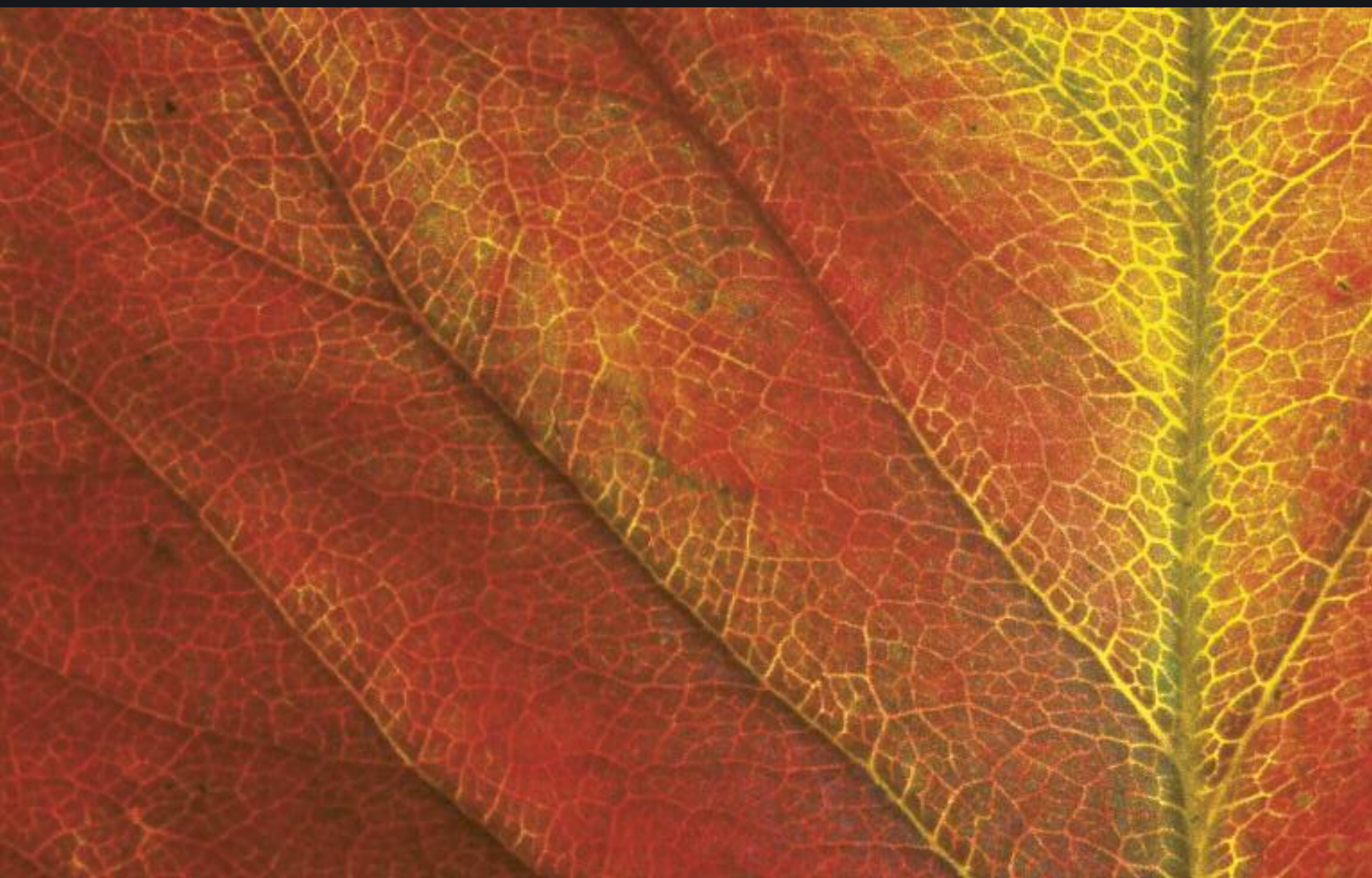
FORESTATION
DEFORESTATION

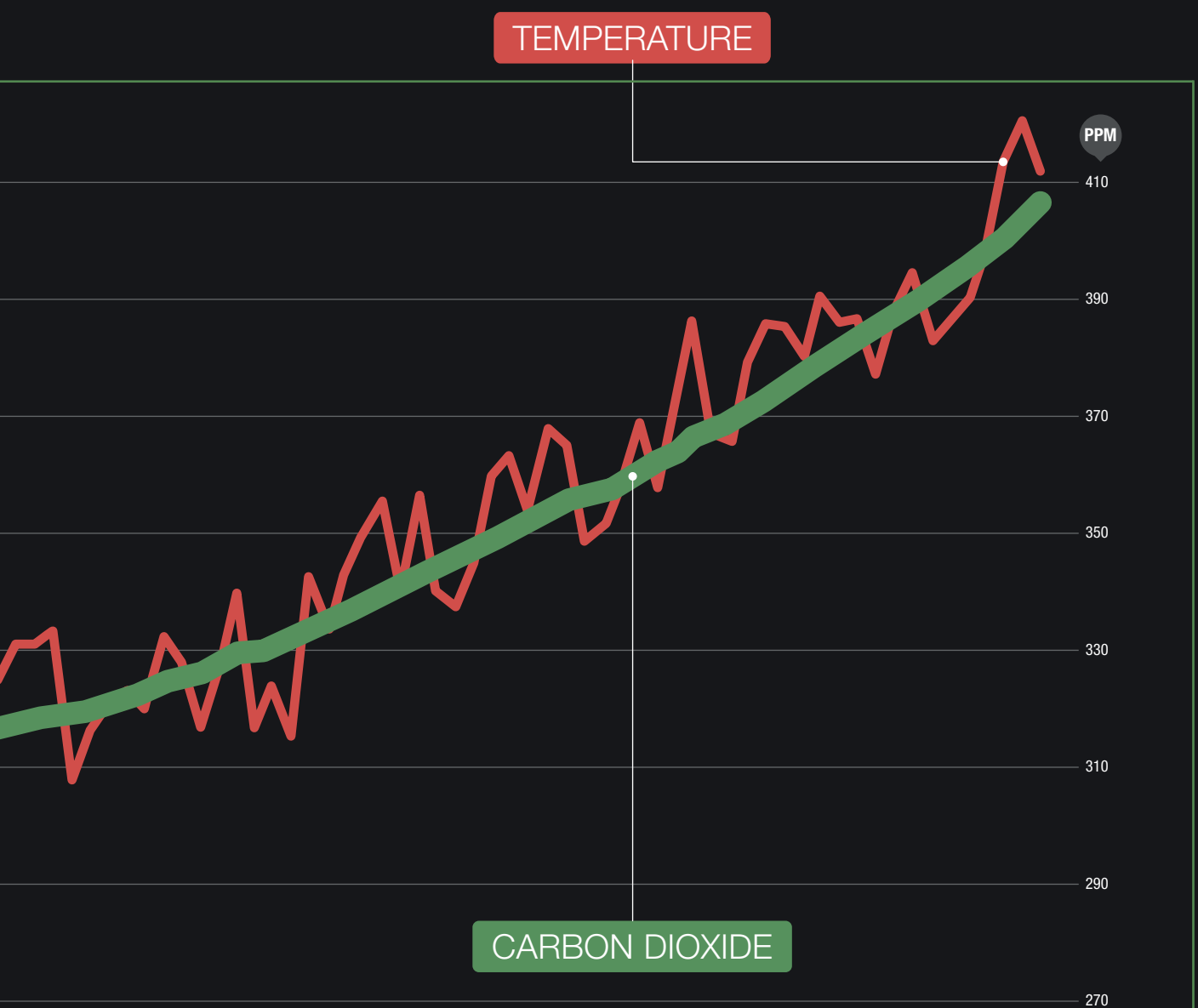
Source: World Bank

AFOLU: forestation and deforestation, how land use is changing

CO_2: emissions and global warming







ply, income and health. Agroforestry systems are multifunctional systems that can provide a wide range of economic, socio-cultural, and environmental benefits.
There are three main types of agroforestry systems:

- Agrisilvicultural systems are a combination of crops and trees, such as alley cropping or homegardens;
- Silvopastoral systems combine forestry and grazing of domesticated animals on pastures, rangelands or on-farm;
- The three elements, namely trees, animals and crops, can be integrated in what are called agrosylvopastoral systems and are illustrated by homegardens involving animals as well as scattered trees on croplands used for grazing after harvests.

B

BIODIVERSITY
The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species (i.e. at genetic level), between species and of ecosystems.

C

CANOPY COVER
The percentage of the ground covered by a vertical projection of the outermost perimeter of the natural spread of the foliage of plants.

CARBON CREDIT
Credits awarded to projects, organizations or governments that have reduced their greenhouse gas emissions below their emission quota, or 'cap'. One carbon credit is equivalent to an emission reduction of one metric ton of CO_2e.

CARBON DIOXIDE (CO_2)
A naturally occurring gas, CO_2 is also a by-product of burning fossil fuels and biomass, as well as land-use changes and other industrial processes. It is the principal anthropogenic greenhouse gas (GHG) that affects the earth's temperature. It is the reference gas against which other GHGs are measured and therefore has a "Global Warming Potential" (GWP) of 1.

CARBON FLUX
Transfer of carbon from one carbon pool to another in units of measurement of mass per unit area and time (e.g., t C $ha^{-1}a^{-1}$).

INFRASTRUCTURE EXTENSION
- Transport (roads, railroads, etc)
- Markets (public & private, e.g. sawmills)
- Settlements (rural and urban)
- Public service (water lines, electrical grids, sanitation)
- Private company (hydropower, mining, oil exploitation)

AGRICULTURAL EXPANSION
- Permanent cultivation (large-scale vs smallholder, subsistence vs commercial)
- Shifting cultivation (slash & burn vs traditional swidden)
- Cattle ranching (large-scale vs smallholder)
- Colonization (incl. transmigration & resettlement projects)

WOOD EXTRACTION
- Commercial (State-run, private, growth-coalition)
- Fuelwood (mainly domestic usage)
- Polewood (mainly domestic usage)
- Charcoal production (domestic & industrial uses)

OTHER FACTORS
- Pre-disposing environmental factors (land characteristics, e.g. soil quality, topography, forest fragmentation)
- Biophysical drivers (triggers, e.g. fires, droughts, floods, pests)
- Social trigger events (e.g. war, revolution, social disorder, abrupt displacements, economic shocks, abrupt policy shifts)

DEMOGRAPHIC FACTORS
- Natural increment (fertility, mortality)
- Migration (in/out migration)
- Population density
- Population distribution
- Life cycle features

ECONOMIC FACTORS
- Market growth & commercialization
- Economic structures
- Urbanization & industrialization
- Special variables (e.g. price increases, comparative cost advantages)

TECHNOLOGICAL FACTORS
- Agro-technical change (e.g. in/extensification)
- Applications in the wood sector (e.g. mainly wastage)
- Agricoltural production factors

POLICY & INSTITUTIONAL FACTORS
- Formal policies (e.g. on economic development, credits)
- Policy climate (e.g. corruption, mismanagement)
- Property rigths (e.g. land races, titling)

CULTURAL FACTORS
- Public attitudes, values & beliefs (e.g. unconcern about forests, frontier mentality)
- Individual & household behavior (e.g. unconcern about forests, rent-seeking, imitation)

DIRECT CAUSES
INDIRECT CAUSES

Source: CIFOR

DEFORESTATION: the direct and indirect causes

CARBON OFFSET
A reduction in emissions of carbon dioxide or greenhouse gases made in order to compensate for, or to 'offset', an emission made elsewhere. Once certified by the regulatory body, a carbon offset can be sold as a carbon credit and linked with official emission trading schemes, such as the European Union Emission Trading System (EU ETS). One offset is equivalent to an emission reduction of one metric ton of CO_2e.

CARBON POOL
A system that has the capacity to store or release carbon. The Marrakesh Accords recognize five main carbon pools or reservoirs in forests: above-ground biomass, below-ground biomass, dead wood, litter and soil organic matter.

CARBON SINK
Any process or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere. A given pool can be a sink for atmospheric carbon if, during a given time interval, more carbon is flowing into it than is flowing out.

CARBON STOCK
The absolute quantity of carbon held within a pool at a specified time. The units of measurement are mass.

CER (Certified Emissions Reduction)
A unit of greenhouse gas reduction that has been generated through interventions in Developing Countries and then certified under the Clean Development Mechanism (CDM) regulations. CDM is one of the three flexibility mechanisms under the Kyoto Protocol within the United Nations Framework Convention on Climate Change (UNFCCC). The certified unit can be traded on the voluntary carbon market and used by Annex I parties (UNFCCC, list of Parties), the so called Industrialized and Transition Economies Countries, to meet emissions reduction commitments. This unit is equal to one metric ton of carbon dioxide equivalent (CO_2e).

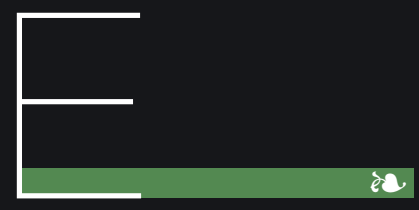
CO_2 – EQUIVALENT EMISSION (CO_2e)
The IPCC defines it as the amount of carbon dioxide (CO_2) emission that would cause the same integrated radiative forcing, over a given time horizon, as an emitted amount of a greenhouse gas (GHG) or a mixture of GHGs. The CO_2-equivalent emission is obtained by multiplying the emission of a GHG by its Global Warming Potential (GWP) for the given time horizon. The unit is used to compare emissions from various greenhouse gases based on their global warming potential over 100 years. In this sense, the global warming potential (GWP) for methane (CH_4) is 28 while Nitrous oxide (N_2O) is 265. This means, for example, that emissions of one million metric tons of methane is equivalent to emissions of 21 million metric tons of carbon dioxide. IPCC provides and update the GWP values.

COMMUNITY FORESTRY
A forest management model which involves the participation and collaboration of local communities in the decision making surrounding forest resource extraction and production activities and the subsequent sharing of benefits derived from these activities.

DECARBONIZATION
The process by which countries or other entities aim to achieve a low-carbon economy, or by which individuals aim to reduce their consumption of carbon.

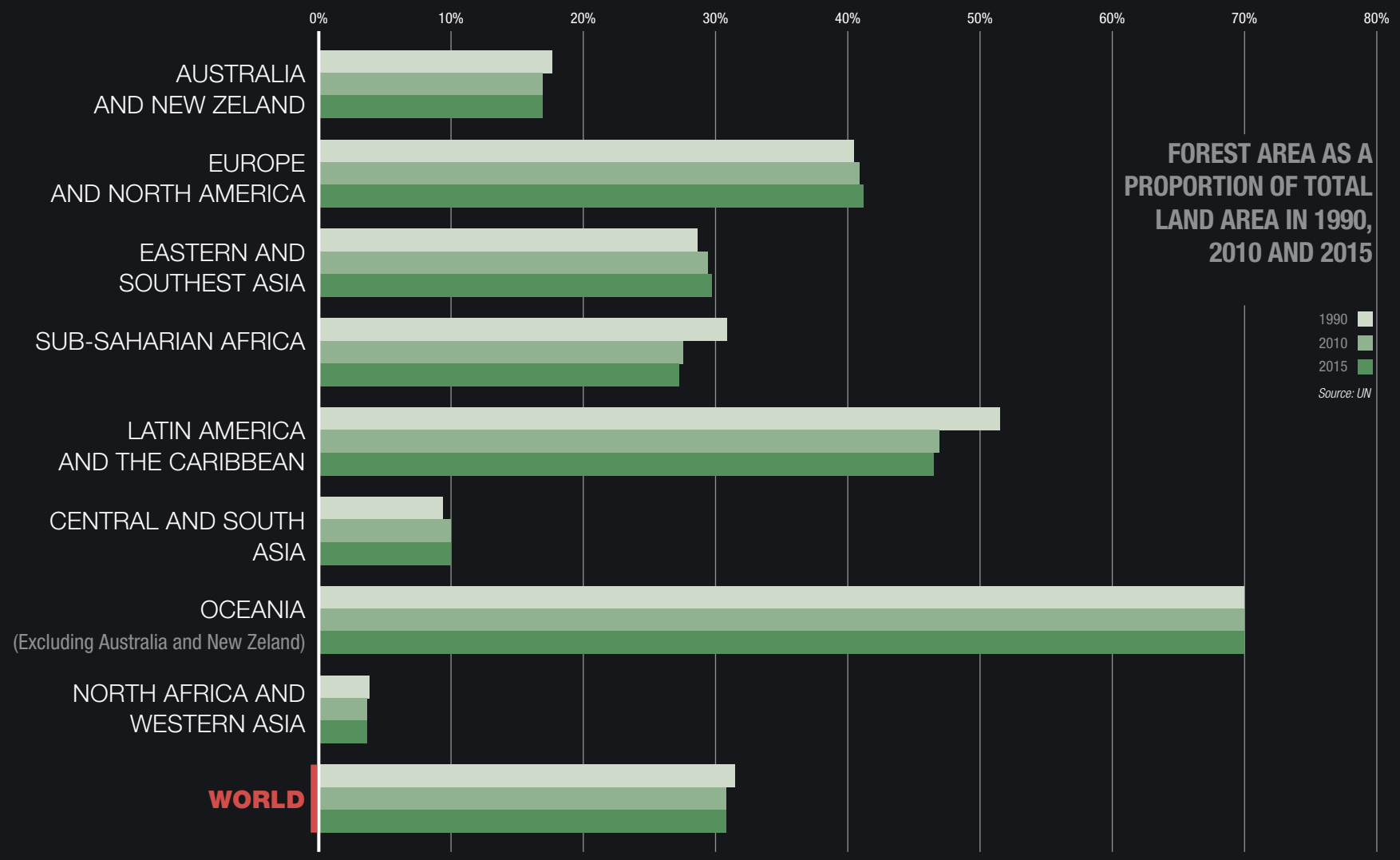
DEFORESTATION
The conversion of forest to other land use independently whether human-induced or not. It includes permanent reduction of the tree canopy cover below the minimum 10 percent threshold. It includes areas of forest converted to agriculture, pasture, water reservoirs, mining and urban areas.
The term specifically excludes areas where the trees have been removed as a result of harvesting or logging, and where the forest is expected to regenerate naturally or with the aid of silvicultural measures. The term also includes areas where, for example, the impact of disturbance, over-utilization or changing environmental conditions affects the forest to an extent that it cannot sustain a canopy cover above the 10 percent threshold.

DEFORESTATION DRIVERS
A distinction is commonly made between direct and indirect causes of deforestation and forest degradation.
Direct causes are human activities or immediate actions that directly impact forest cover and loss of carbon. These causes can be grouped into categories such as agriculture expansion (both commercial and subsistence), infrastructure extension and wood extraction.
Indirect causes are complex interactions of fundamental social, economic, political, cultural and technological processes that are often distant from their area of impact.



ECOSYSTEM
A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.

FORESTS: the surface area in relation to the territory



ECOSYSTEM MANAGEMENT

Ecosystem management is the application of ecological science to resource management to promote long-term sustainability of ecosystems and the delivery of essential ecosystem goods and services to society.

ECOSYSTEM SERVICES

The benefits gained by humans from ecosystems (Millennium Ecosystem Assessment, 2005), linking the natural environment with economic development and social wellbeing.

Classify Ecosystem Services is difficult. Several conceptual frameworks have been developed to classify and explain the links and relationships between ecosystems and human wellbeing. Among them, the Millennium Ecosystem Assessment (MEA) was the first attempt to define and classify ecosystem services:

- The MEA (2005) groups the ESs into four categories: Provisioning Services (the products obtained from ecosystem, e.g. food, fresh water, fiber, ornamental resources); Regulating Services (the benefits obtained from the regulation of ecosystem processes, e.g. air quality regulation, erosion regulation, pollination); Cultural Services (the nonmaterial benefits, e.g. educational values, aesthetic values, inspiration) and Supporting Services (those services that are necessary for the provision of all the other services, e.g. soil formation, nutrient and water cycling).
- TEEB (2010) adopts the MEA classification but with the omission of the Supporting Services (which are seen as subset of ecological processes) and defines Habitat Services highlighting the importance of ecosystems to provide habitat for migratory species (e.g. as nurseries) and gene-pool "protectors".

Subsequent work in the context of the TEEB (The Economics of Ecosystems and Biodiversity) study (TEEB, 2010), the Mapping and Assessing Ecosystems and their Services initiative (Maes, et al., 2014), the Inter-governmental Platform on Biodiversity and Ecosystem Services (IPBES) have further developed the concept of ecosystem services, and provided further evidence of the potential of the ecosystem services approach in understanding the relationship between humans and the environment. There are both differences and similarities between the various existing classification systems.

The UN endorsed a System of Environmental-Economic Accounting – Experimental Ecosystem Accounting (SEEA EEA) in 2013. Currently, SEEA is working on a classification revision based on CICES (Common Classification of Ecosystem Services) classification developed by the European Environment Agency and drawing from a range of existing classifications, including IPBES, MAES, FEGSCS, NESCS, TEEB, and the Millennium Ecosystem Assessment. The new common approach focuses on a classification based on three categories: Provisioning, Regulating and Cultural.

ENHANCEMENT OF FOREST CARBON STOCKS

One of the activities under the Cancun agreements (COP16, 2010). It refers to the creation (i.e. afforestation) or improvement (through forest management) of carbon pools and reservoirs and their ability to sequester and capacity to store carbon. It includes forest management activities such as restoring existing but degraded forests and increasing forest cover through environmentally appropriate afforestation and reforestation.

FOREST

There are more than 800 definition of forest). The main ones used are those of FAO, UNFCC and Global Forest Watch (GFW).

FAO: Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use (FAO, 2018).

UNFCC: "Forest" is a minimum area of land of 0.05-1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10-30 percent with trees with the potential to reach a minimum height of 2-5 meters at maturity in situ. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10-30 per cent or tree height of 2-5 meters are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest (UNFCCC, 2001).

Global Forest Watch: defines the "tree cover" instead of "forest". In this sense "tree cover" refers to the biophysical presence of trees, which may be part of natural forests or tree plantations. The terms "tree cover" and "forest" should not be used interchangeably.

FOREST CONSERVATION

The practice of planting and maintaining forested areas for the benefit and sustainability of future generations. In this sense, refers to a range of activities, tools and approaches to achieve forest health and biodiversity objectives, including in managed forests where harvesting occurs.

FOREST OWNERSHIP: the distribution

FOREST DEGRADATION

Changes within a forest which negatively affect the structure or function of the forest area, and thereby lower the natural capacity of the forest to supply products or services.

FOREST MANAGEMENT

The process of planning and implementing practices for the stewardship and use of forests and other wooded land to meet specific environmental, economic, social and cultural objectives. It deals with the overall administrative, economic, legal, social, technical and scientific aspects related to natural and planted forests. It may involve varying degrees of deliberate human intervention, ranging from actions aimed at safeguarding and maintaining forest ecosystems and their functions, to those favoring specific socially or economically valuable species or groups of species for the improved production of forest goods and services.

FOREST OWNERSHIP

Generally, refers to the legal right to freely and exclusively use, control, transfer, or otherwise benefit from a forest. Ownership can be acquired through transfers such as sales, donations, and inheritance.

- PRIVATE OWNERSHIP: Forest owned by individuals, families, communities, private co-operatives, corporations and other business entities, religious and private educational institutions, pension or investment funds, NGOs, nature conservation associations and other private institutions;
- PUBLIC OWNERSHIP: Forest owned by the State; or administrative units of the Public Administration; or by institutions or corporations owned by the Public Administration.

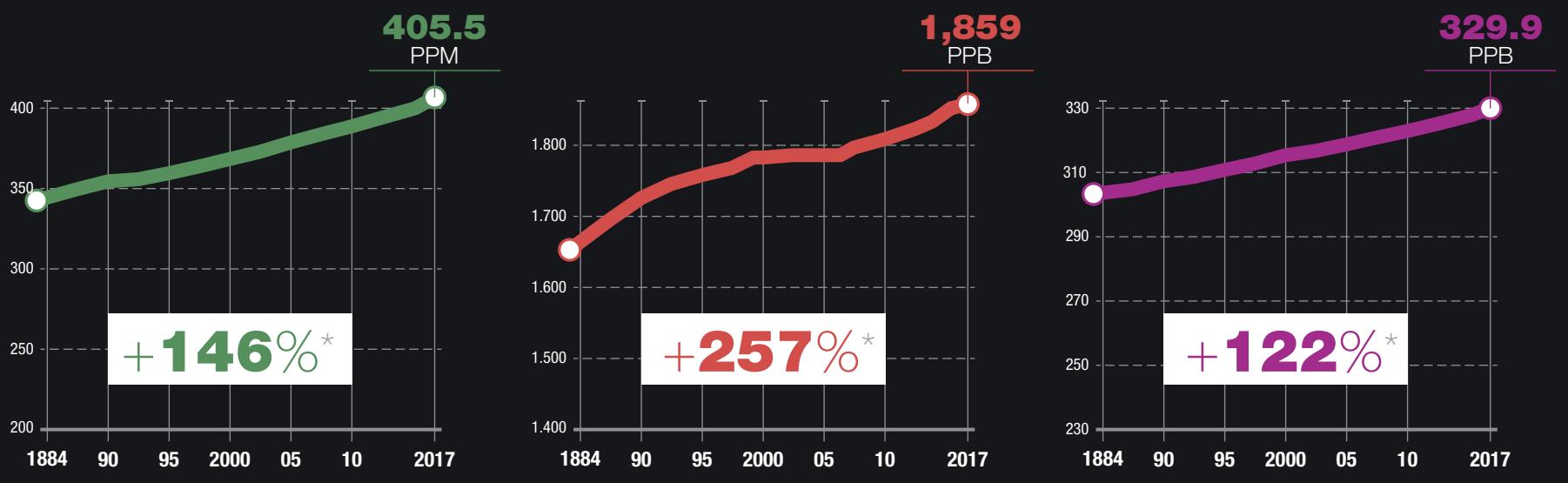
FOREST POLICY

A set of orientations and principles of actions adopted by public authorities in harmony with national socio-economic and environmental policies in a given country to guide future decisions in relation to the management, use and conservation of forest for the benefit of society.

FRA (Global Forest Resource Assessment FAO)

Since 1948, FAO Global Forest Resources Assessment (FRA) provides essential information for understanding the extent of forest resources, their condition, management and uses.
The FRA data is collected through a global network of officially nominated National Correspondents. Combining this knowledge with data from remote sensing and other sources allows FAO to provide information which can be used to draw recommendations for governments, civil society and the private sector. FRA is also central part in monitoring progress towards the Sustainable Development Goal 15 - Life on Land - as it collects information and reports for indicators of targets 15.1 and 15.2.
FRA covers all countries and territories and contains a wealth of information structured according to seven thematic elements of Sustainable Forest Management (SFM). With the grand and detailed data

RECORD LEVELS OF GREENHOUSE GASES IN 2017 - AVERAGE CONCENTRATION IN THE ATMOSPHERE



CO_2 - CARBON DIOXIDE (parts per million)
CH_4 - METHANE (parts per billion)
N_2O - NITROUS OXIDE (parts per billion)

PPM: parts per million
PPB: parts per billion

*Rise in % compared to pre-industrial levels (before 1750)

Source: WMO

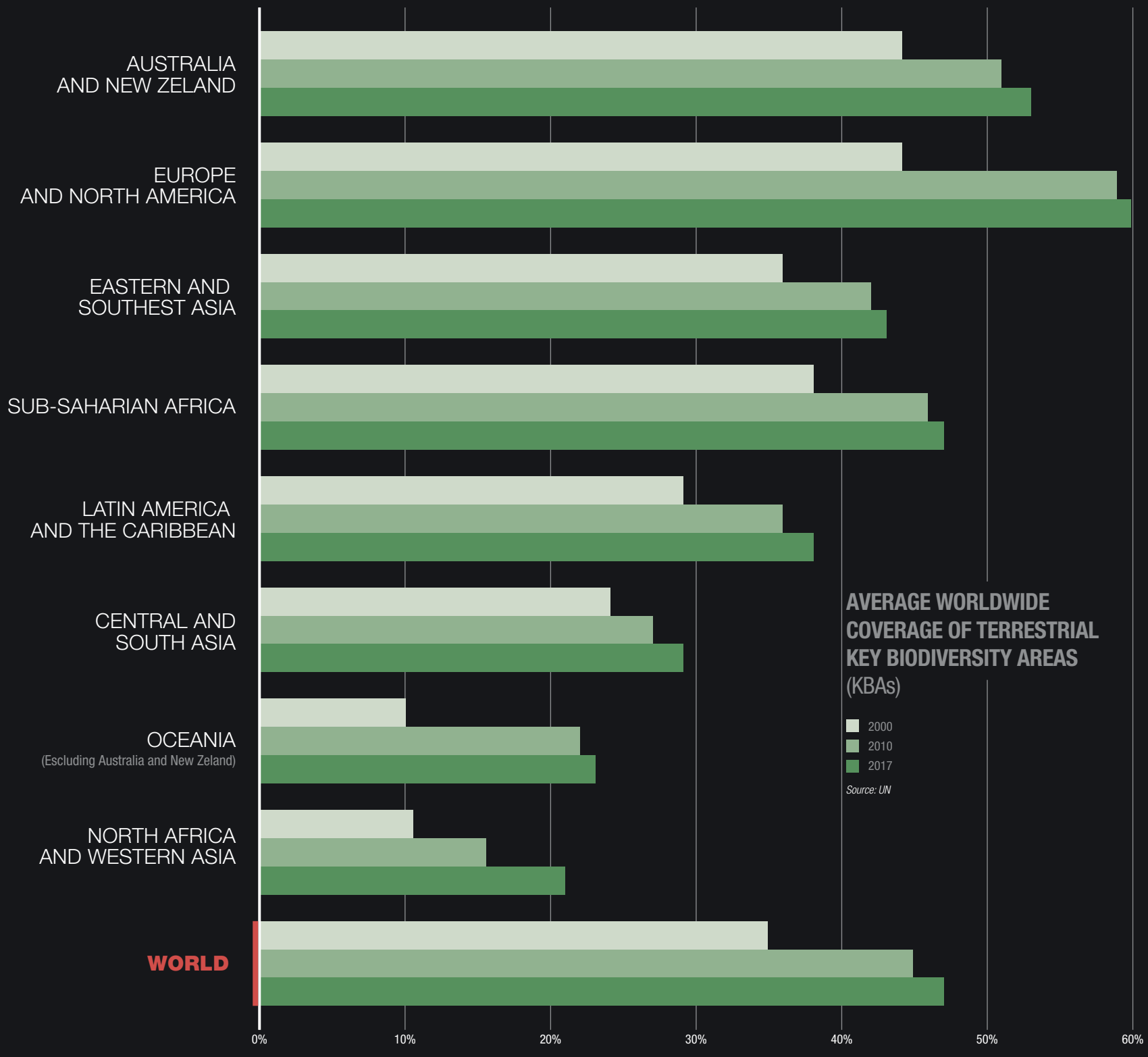
SHARE OF GLOBAL WARMING ATTRIBUTABLE TO GREENHOUSE GASES

GHG: greenhouse gas levels and global warming

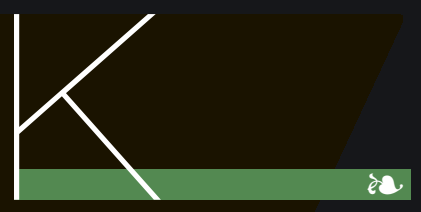
collected and made available by the countries and analyzed by FRA, the instrument allows to know the world's forests resources and how they are changing.

GHG (Greenhouse Gases)
Gases in the earth's atmosphere that absorb and re-emit infrared radiation. These gases occur through both natural and human-influenced processes. The major GHG is water vapor. Other GHGs include CO_2, N_2O, CH_4, O_3, and CFCs.

IPCC (Intergovernmental Panel on Climate Change)
The IPCC is an organization that was created in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP). The objective of the IPCC is to provide governments at all levels with scientific information that they can use to develop climate policies. It provides regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation. IPCC currently counts 195 members, but thousands of scientists from all over the world contribute voluntarily to the work and assessment reports.



BIODIVERSITY: key areas increasing



KBAs (Key Biodiversity Areas)
Key Biodiversity Areas (KBAs) are sites contributing significantly to the global persistence of biodiversity, in terrestrial, freshwater and marine ecosystems. According to the International Union for Conservation of Nature (IUCN), sites qualify as global KBAs if they meet one or more of 11 criteria, clustered into five categories: threatened biodiversity; geographically restricted biodiversity; ecological integrity; biological processes; and, irreplaceability.

L

LAND USE
Land use refers to the total of arrangements, activities and inputs undertaken in a certain land cover type (a set of human actions).
The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction, conservation and city dwelling). In national greenhouse gas inventories, land use is classified according to the IPCC land use categories of forest land, cropland, grassland, wetland, settlements, other.

LAND USE - Direct Change of
The conversion of one ecosystem to another for economic activities or other human purposes.

LULUCF (Land Use, Land-Use Change and Forestry)
In the context of national greenhouse gas (GHG) inventories under the UNFCCC, LULUCF is a GHG inventory sector that covers anthropogenic emissions and removals of GHG from carbon pools in managed lands, excluding non-CO_2 agricultural emissions. Following the 2006 IPCC Guidelines for National GHG Inventories, "anthropogenic" land-related GHG fluxes are defined as all those occurring on "managed land," i.e., "where human interventions and practices have been applied to perform production, ecological or social functions."

M

MITIGATION - of climate change
A human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs).

IF TROPICAL DEROSTATION WERE A COUNTRY, IT WOULD RANK THIRD IN CO_2e EMISSIONS

NBSs (Nature-Based Solutions)
Nature-based Solutions (NBSs) are defined by IUCN (The International Union for Conservation of Nature) as "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits".

NCSs (Natural Climate Solutions)
Natural climate solutions are conservation, restoration and improved land management actions that increase carbon storage or avoid greenhouse gas emissions in landscapes and wetlands across the globe. Combined with innovations in clean energy and other efforts to decarbonize the world's economies, natural climate solutions offer some of our best options in the response to climate change.

NDCs (Nationally Determined Contributions)
A term used under the United Nations Framework Convention on Climate Change (UNFCCC) whereby a country that has joined the Paris Agreement outlines its plans for reducing its emissions. Some countries' NDCs also address how they will adapt to climate change impacts, and what support they need from, or will provide to, other countries to adopt low-carbon pathways and to build climate resilience. According to Article 4 paragraph 2 of the Paris Agreement, each Party shall prepare, communicate and maintain successive NDCs that it intends to achieve. In the lead up to 21st Conference of the Parties in Paris in 2015, countries submitted Intended Nationally Determined Contributions (INDCs). As countries join the Paris Agreement, unless they decide otherwise, this INDC becomes their first Nationally Determined Contribution (NDC). NDC submission is a five-years cycle and the Paris conference specifically requested that countries come forward with new or updated NDCs by the end of 2020.

REDD+: emissions from deforestation

REDD+ (Reducing Emissions from Deforestation and forest Degradation)
Reducing Emissions from Deforestation and forest Degradation, plus the sustainable management of forests, and the conservation and enhancement of forest carbon stocks (REDD+), is an essential part of the global efforts to mitigate climate change. Forests have a fundamental role they play in climate change mitigation, by removing CO_2 from the atmosphere (sink) and storing it in biomass and soils (stock). This also means that when forests are cleared or degraded, they can become a source of greenhouse gas (GHG) emissions by releasing that stored carbon. It is estimated that globally, deforestation and forest degradation account for around 11 percent of CO_2 emissions. Halting deforestation is a cost-effective action that has a clear impact in reducing global GHG emissions. REDD+ provides a unique opportunity to achieve large-scale emissions reductions at comparatively low abatement costs. By economically valuing the role forest ecosystems play in carbon capture and storage, it allows intact forests to compete with historically more lucrative, alternate land uses resulting in their destruction. Therefore, REDD+ now includes:

a) reducing emissions from deforestation;
b) reducing emissions from forest degradation;
c) conservation of forest carbon stocks;
d) sustainable management of forests;
e) enhancement of forest carbon stocks.

REFORESTATION
Re-establishment of a forest trough planting, seeding and/or the human-induced promotion of natural seed sources, in an unstocked forest area which has been deforested for less than half a century. It does not imply a land use change only if the area has been a non-forest land for less than twenty years.


we

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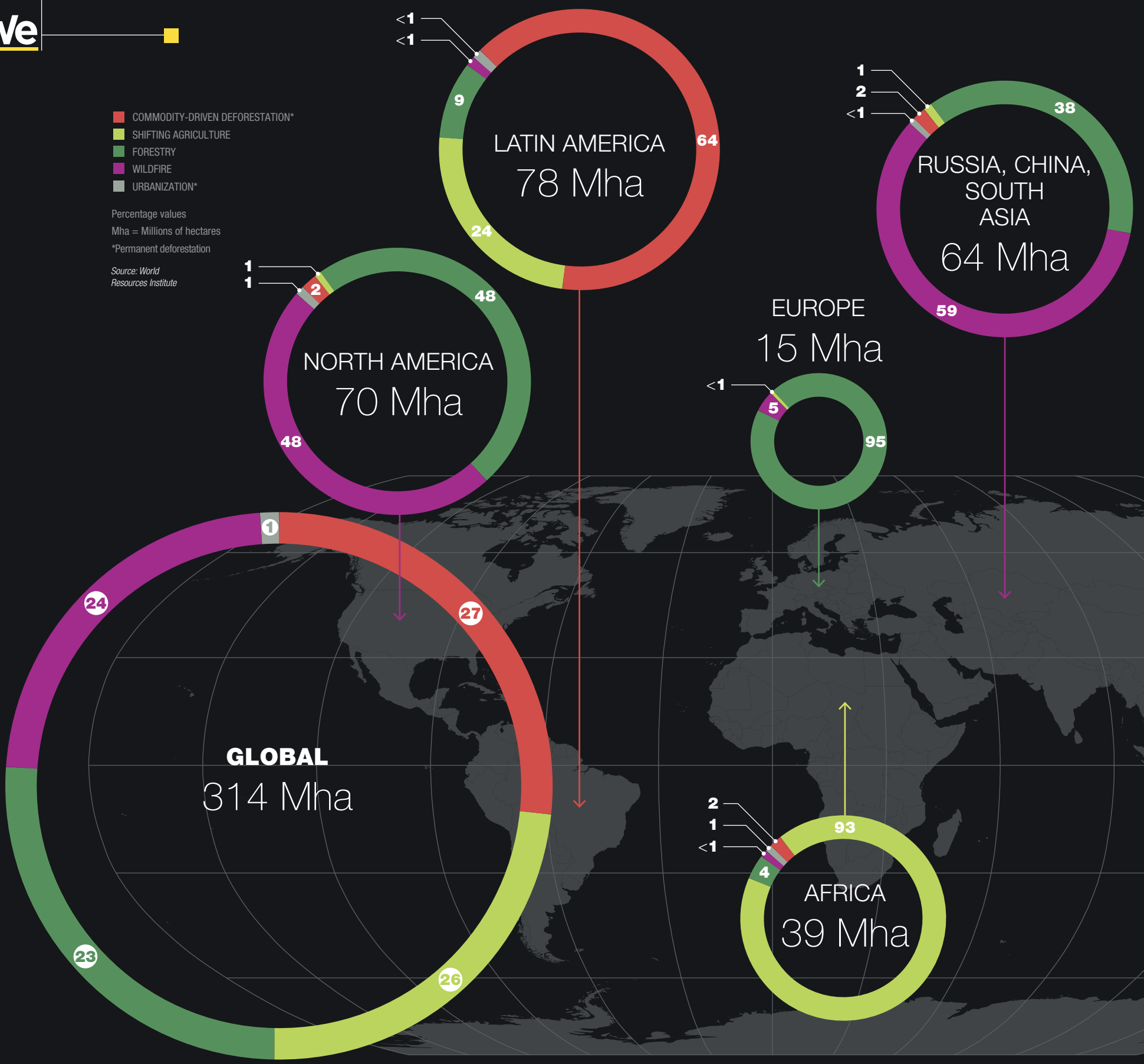
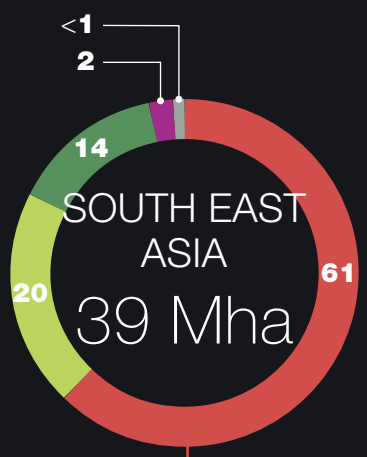
COMMODITY-DRIVEN DEFORESTATION*
SHIFTING AGRICULTURE
FORESTRY
WILDFIRE
URBANIZATION*

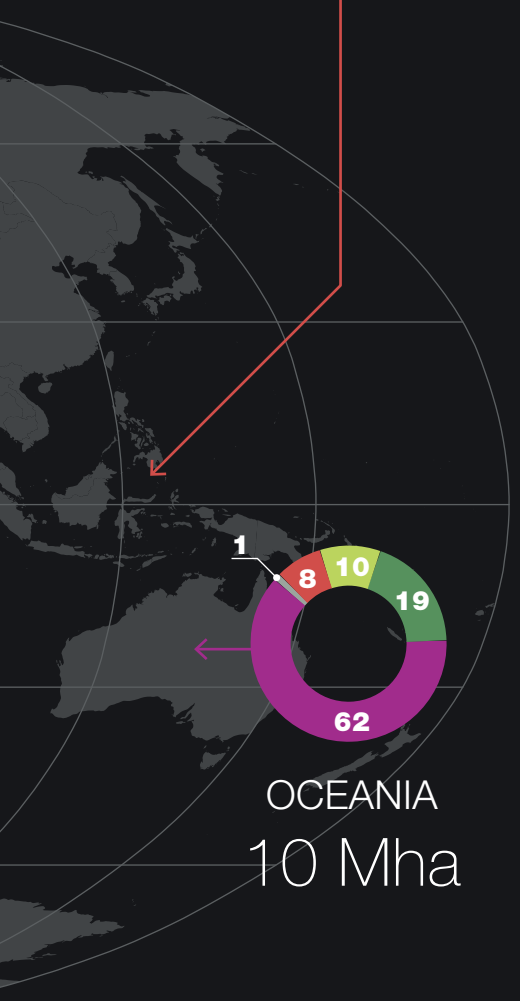
Percentage values
Mha = Millions of hectares
*Permanent deforestation

Source: World Resources Institute



TREE COVER LOSS: the causes of the loss of trees by region between 2001 and 2015





REVEGETATION
A direct human-induced activity to increase carbon stocks of woody biomass on sites through the establishment of vegetation that covers a minimum area of 0.05 hectares and does not meet the definitions of afforestation and reforestation.

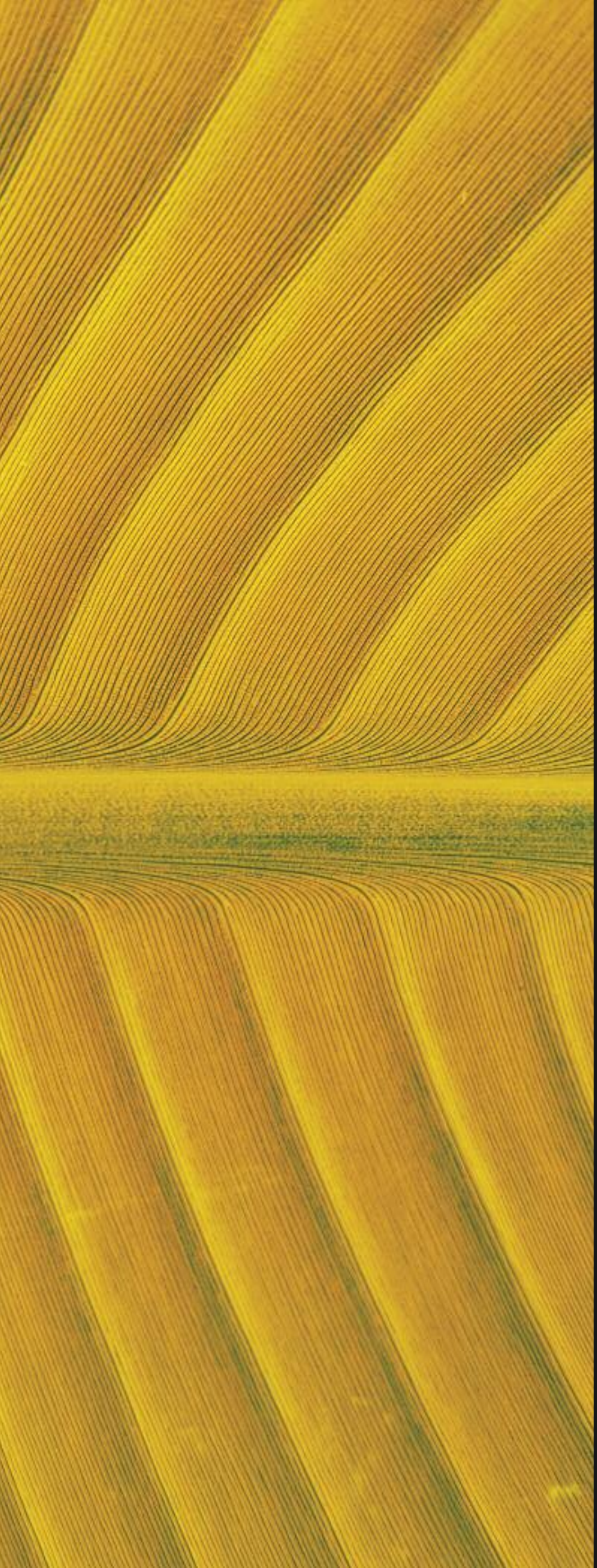
SUSTAINABILITY
A dynamic process that guarantees the persistence of natural and human systems in an equitable manner.

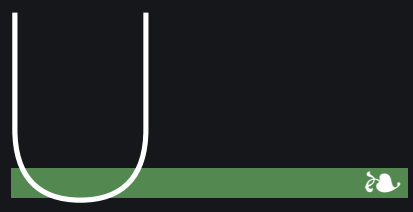
SD - (Sustainable Development)
Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987).

SDGs - (Sustainable Development Goals)
The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future.
At its heart are the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries - developed and developing - in a global partnership.
They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth - all while tackling climate change and working to preserve our oceans and forests.
SUSTAINABLE DEVELOPMENT GOALS
- 1. end poverty in all its forms everywhere;
- 2. end hunger, achieve food security and improved nutrition and promote sustainable agriculture;
- 3. ensure healthy lives and promote well-being for all at all ages;
- 4. ensure inclusive and equitable quality education and promote lifelong learning opportunities for all;
- 5. achieve gender equality and empower all women and girls;
- 6. ensure availability and sustainable management of water and sanitation for all;
- 7. ensure access to affordable, reliable, sustainable and modern energy for all;
- 8. promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all;
- 9. build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation;
- 10. reduce inequality within and among countries;
- 11. make cities and human settlements inclusive, safe, resilient and sustainable;
- 12. ensure sustainable consumption and production patterns;
- 13. take urgent action to combat climate change and its impacts;
- 14. conserve and sustainably use the oceans, seas and marine resources for sustainable development;
- 15. protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss;
- 16. promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels;
- 17. strengthen the means of implementation and revitalize the global partnership for sustainable development.

SFM - (Sustainable Forest Management)
A globally agreed definition of Sustainable Forest Management (SFM) is impractical beyond a very general level because of the huge diversity of forest types, conditions and socioeconomic contexts worldwide.
In general, however, SFM can be viewed as the sustainable use and conservation of forests with the aim of maintaining and enhancing multiple forest values through human interventions.

TREE COVER LOSS
Tree cover loss refers to the removal of trees, which may be within natural forests or tree plantations. Accordingly, tree cover loss does not necessarily equate to “deforestation” and can result from a variety of factors, including mechanical harvesting, fire, disease, or storm damage.





UNFCCC (United Nations Framework Convention on Climate Change)

The UNFCCC entered into force on 21 March 1994. Today, it has near-universal membership. The 197 countries that have ratified the Convention are called Parties to the Convention.
The UNFCCC is a "Rio Convention", one of three adopted at the "Rio Earth Summit" in 1992. Its sister Rio Conventions are the UN Convention on Biological Diversity and the Convention to Combat Desertification. The three are intrinsically linked. It is in this context that the Joint Liaison Group was set up to boost cooperation among the three Conventions, with the ultimate aim of developing synergies in their activities on issues of mutual concern. It now also incorporates the Ramsar Convention on Wetlands.
Preventing "dangerous" human interference with the climate system is the ultimate aim of the UNFCCC.

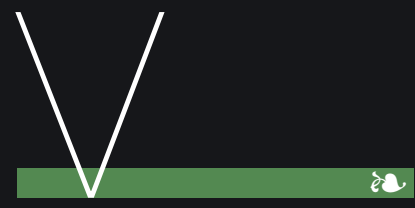
UN-REDD

An initiative launched in 2008 that combines the expertise of the Food and Agriculture Organization, the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP) to support nationally-led REDD+ projects and promote national and international REDD+ implementation.

URBAN AND PERI-URBAN FORESTRY

Urban forests can be defined as networks or systems comprising all woodlands, groups of trees, and individual trees located in urban and peri-urban areas; they include, therefore, forests, street trees, trees in parks and gardens, and trees in derelict corners. Urban forests are the backbone of the green infrastructure, bridging rural and urban areas and ameliorating a city's environmental footprint. There are many ways to classify urban forests, but FAO adopt five simplified reference types:

1. PERI-URBAN FORESTS AND WOODLANDS. Forests and woodlands surrounding towns and cities that can provide goods and services such as wood, fibre, fruit, other non-wood forest products, clean water, recreation and tourism.
2. CITY PARKS AND URBAN FORESTS (>0.5 ha). Large urban or district parks with a variety of land cover and at least partly equipped with facilities for leisure and recreation.
3. POCKET PARKS AND GARDENS WITH TREES (<0.5 ha). Small district parks equipped with facilities for recreation/leisure, and private gardens and green spaces.
4. TREES ON STREETS OR IN PUBLIC SQUARES. Linear tree populations, small groups of trees, and individual trees in squares and parking lots and on streets, etc.
5. OTHER GREEN SPACES WITH TREES. For example, urban agricultural plots, sports grounds, vacant lands, lawns, river banks, open fields, cemeteries and botanical gardens.



VERs (Voluntary Emissions Reductions)

It refers to carbon offset units traded at a voluntary base. Reductions that are not mandated by any law or regulation, but originate from an organization's commitment to take active part in climate change mitigation efforts.
The Voluntary Carbon Credit cannot be used by entities to meet their obligations under the compliance scheme of the Kyoto Protocol. However, a compliance carbon credit (i.e. certified emission reduction, CER) can be accepted by entities wanting to voluntarily compensate their emissions.

SOURCES

The glossary entries are based on the following sources: Convention on Biological Diversity, DNVGL, Fabis Consulting, Fail Climate Fund, FAO, Global Forest Watch, Greenhouse Gas Protocol, IPCC, IUCN - International Union for Conservation of Nature, Millennium Ecosystem Assessment, ONU, Our World in Data, Principles of Terrestrial Ecosystem Ecology (F. S. Chapin III, P. A. Matson, H. A. Mooney), Science Direct, The Economics of Ecosystems and Biodiversity, The Nature Conservancy, The REDD desk, UNFCCC.

The Key Role of the Market

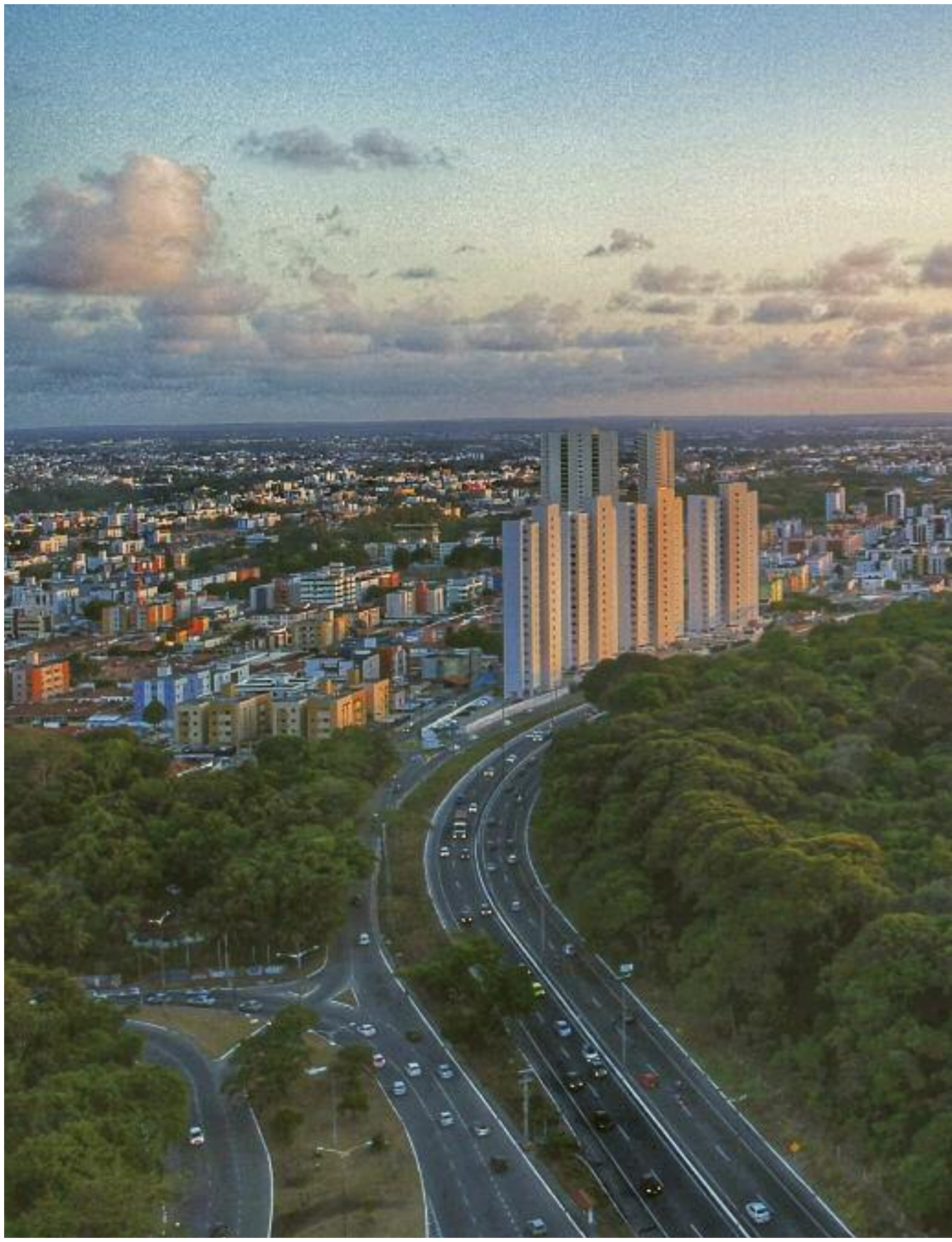
Current levels of public funding are insufficient to curb the threat of deforestation and land degradation. Carbon offsets can play a key role in securing sufficient funding for effective avoided deforestation projects and can supplement state action on forest conservation

JOCHEN GASSNER

He is CEO of First Climate Markets AG. The company is a developer of international emissions reduction projects and a provider of carbon management, green energy and water services. Gassner has been a member of the Executive Committee at the International Carbon Reduction and Offset Alliance (ICROA) since 2008.

Forests, along with other kinds of biomass and soils, act as carbon sinks, which both regulate the naturally occurring carbon cycle and mitigate the effects of human-induced greenhouse gas (GHG) emissions. Protecting and enhancing the vital sink functions of forests are critical components in the fight against climate change, particularly as human activities have reduced these capacities over time. Carbon finance can play a key role in securing sufficient funding for effective avoided deforestation projects and can supplement state action on forest conservation. Deforestation and other land use changes are among the main drivers of climate change. The most recent Special Report "Climate Change and Land," published by the Intergovernmental Panel on Climate Change (IPCC) earlier this year, estimates that agriculture, forestry and other land use account for 23 percent of net anthropogenic emissions of GHG, →

Mata do Buraquinho is a botanical garden that slices through the city of João Pessoa, the state capital of Paraíba, Brazil. Created by the state government in 2000, the garden is one of the largest reserves in the Brazilian Atlantic Forest, covering an area of 520 hectares.



rising to 37 percent if pre- and post-production from the global food systems are included. The IPCC anticipates that GHG mitigation through the enhancement of sinks must increase to up to 10 gigatons per year by 2050 to limit increases in global temperatures to 1.5 °C. This, according to the IPCC report, would require investments of USD 500 per hectare on average to maintain such levels of carbon sequestration in a sustainable manner. Achieving the goals of the Paris Agreement will not be economically possible without curbing the problem of deforestation and land degradation.

Funding forest conservation

Current levels of public funding are insufficient to curb the threat of deforestation and to effectively protect the world's forests. At the planet's current state, there is no doubt that private finance is required as a second pillar to complement public spending on forest conservation measures. The voluntary carbon market can play a key role in this context. It offers a standardized and institutionalized framework that enables private companies, organizations and individuals to purchase Verified Emission Reductions from certified climate protection projects around the world. Carbon offsets are a widely used market instrument that allows for direct investments in climate protection projects that, without additional financial support, would not be feasible and would consequently not be implemented. The carbon markets provide an effective tool to address the above-mentioned financing gap.

The evolution of an idea—emission reductions from avoided deforestation

Monitoring large stocks of forests to ensure that offsets are real, permanent and do not lead to deforestation outside the project boundaries comes with many complexities. Consequently, avoided deforestation as a project type, and landscape inter-

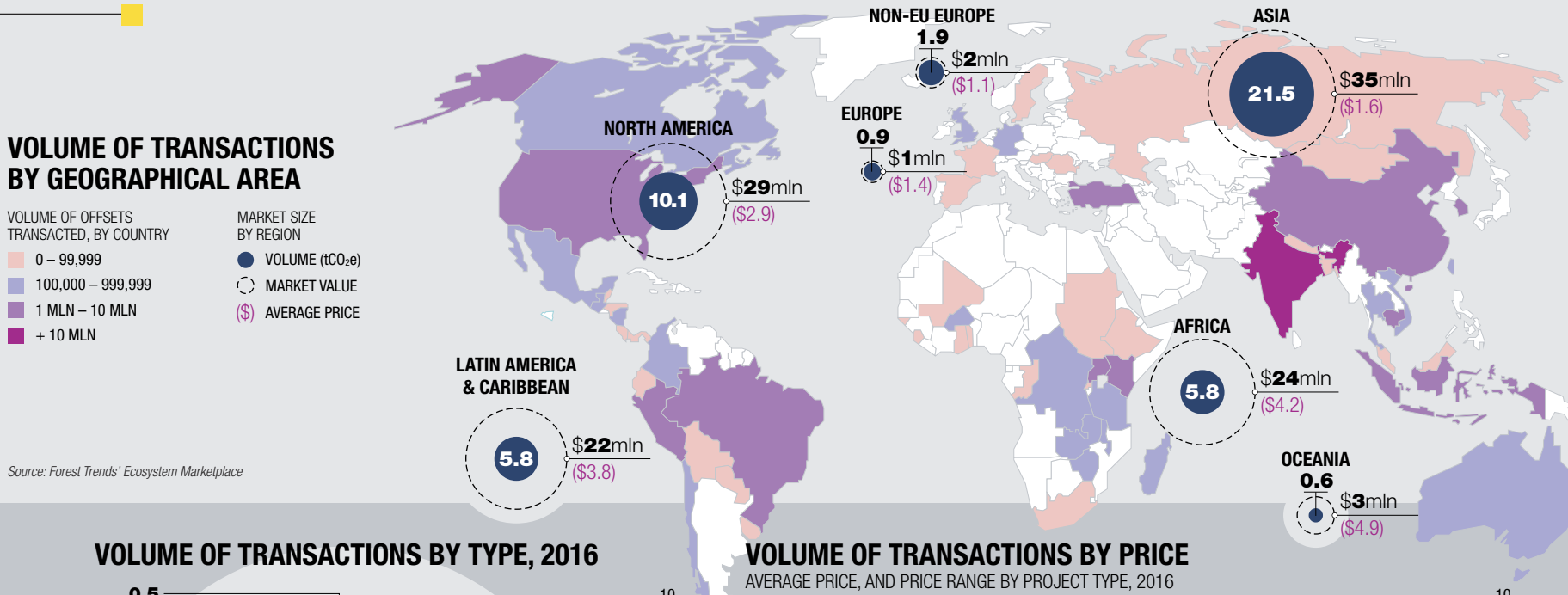
ventions more generally, have continued to be the subject of intense political debate and disagreements across various countries. This was particularly so in the early years of the carbon market, when technical solutions to address such concerns were not readily available. While many countries that suffer from forest degradation saw avoided deforestation as an important local tool in desperate need of financial assistance, others were skeptical that such benefits could be adequately verified. As a result, forest intervention methodologies within many compliance offset markets, such as CDM and EU-ETS, were never approved, leaving the voluntary offset market and its actors room to experiment and find consensus on these challenging issues.

It took until 2013 for this consensus to happen and for avoided deforestation projects to become recognized as part of the 'Reduced Emissions from Deforestation and Forest Degradation' (REDD+) framework. The idea behind this is to give economic value to standing trees, thereby incentivizing responsible forest management and woodland conservation. The REDD+ framework was a breakthrough. Since then, forestry-based emission reduction projects have become important tools for corporations around the world to manage unavoidable carbon emissions resulting from their business activities. This framework helped spur the development of other land-based methodologies in the voluntary carbon market, which are referred to as nature-based solutions. These land-based emission reduction project types include interventions such as sustainable agricultural management, improved forest management, avoided peatland conversion, grassland management, wetland management and interventions that enhance the sequestration potential of soil carbon.

REDD+ and the carbon markets

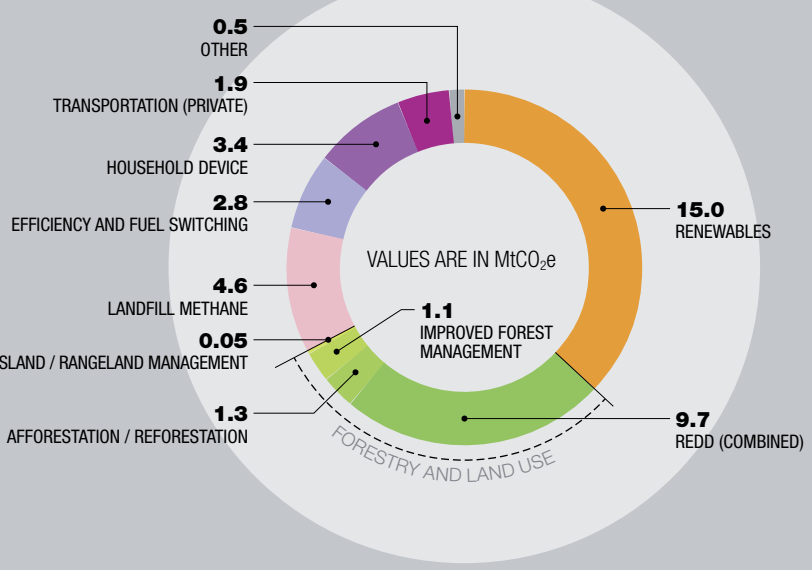
REDD+ and forestry-based projects →

VOLUME OF TRANSACTIONS BY GEOGRAPHICAL AREA



Source: Forest Trends' Ecosystem Marketplace

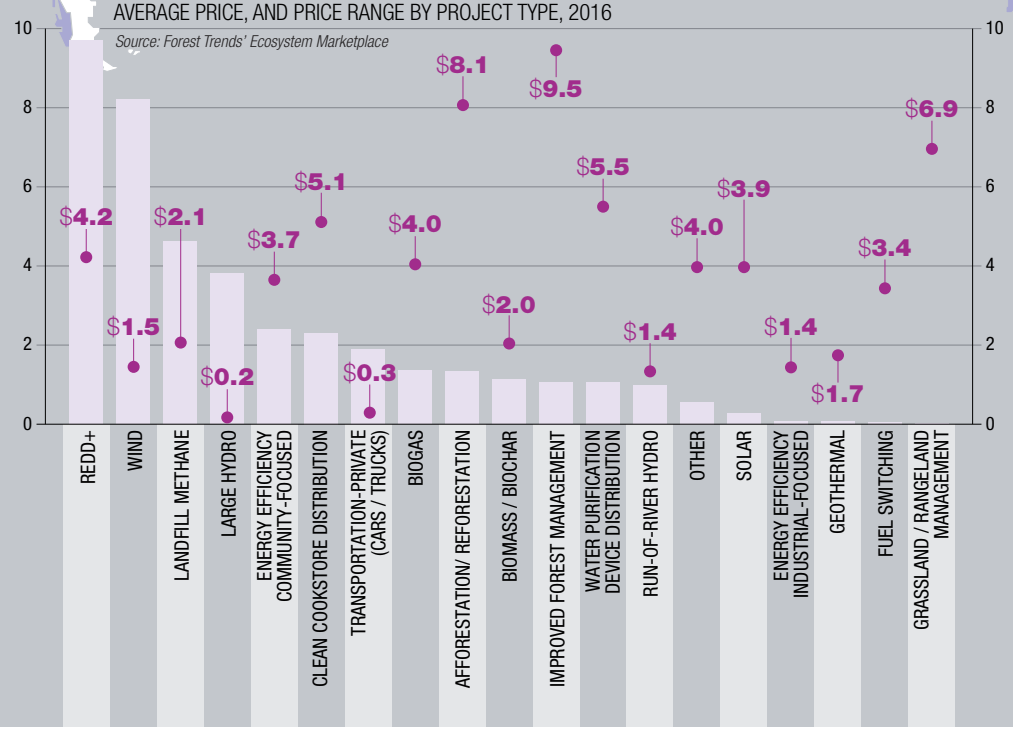
VOLUME OF TRANSACTIONS BY TYPE, 2016



VOLUME OF TRANSACTIONS BY PRICE

AVERAGE PRICE, AND PRICE RANGE BY PROJECT TYPE, 2016

Source: Forest Trends' Ecosystem Marketplace



In 2016, renewables and forestry and land use were the two most traded offset categories by volume, with 15 and 12.15 $MtCO_2e$ traded, respectively.

are comparable to all other climate protection projects in the carbon offset market in so far as they reduce the amount of greenhouse gases in the atmosphere or avoid the release of such gases in the first place. In addition to this, they must undergo the same rigorous certification and auditing processes to be eligible for registration and purchase. Just like other community-based projects, forest conservation is not only about the conservation of global carbon stocks. Meaningful forestry-based emission reduction projects are also built on social factors and are established to work with indigenous and forest-dependent communities in order to conserve biodiversity, prevent soil erosion and maintain water cycles in a healthy state to sustain livelihoods.

The REDD+ model gives a greater value to standing forests by raising funds and enabling payments for ecosystem services, including forest conservation. Forestry-based emission reduction projects provide forest communities with a new model for economic development – one where both people and the planet can benefit. Supporting a REDD+ project not only provides vital project finance, it also enables one of the most effective and direct climate change mitigation actions possible. With these assets, REDD-based emission reduction projects today represent the single largest intervention class for the generation of emission reductions in the voluntary carbon market in terms of transacted volumes, representing approximately 16 percent of the total. It can be expected that this development will continue and that this project type will play an increasingly important role in satisfying future demand for high quality carbon offsets.

Risk management in forestry-based emission reduction projects

While REDD+ is usually associated with a broad range of co-benefits and projects capable of decisively contributing to the UN Sustainable Development Goals, the question of how the permanence of these projects can be ensured in the long-term has previously been a cause for concern. Forestry-based emission reduction projects are developed to last—even more so than other project types. These projects must be guaranteed to sequester carbon or prevent emissions from deforestation for decades.

What happens if the socio-economic conditions among local communities change? How can we guarantee that avoided deforestation is permanent over long periods of time in light of known human activities and natural disasters? What if deforestation pressures simply shift elsewhere beyond the project boundary? Developing long-term forestry projects in close collaboration with land users raises a number of questions, all of which must be addressed by project developers and the certification standards that support them.

One of the biggest achievements from the introduction of the REDD+ project model is the development of effective risk management tools that have enabled forestry-based projects to become a prominent class in the voluntary carbon market. The main objective of all REDD+ related risk management tools is to fulfill, under all circumstances, the permanence criterion implied in these projects. For risk management, project-specific risks must be distinguished from general risks. To manage project-specific risks, projects are required to undergo a strict forest-related risk assessment for verification, which takes into consideration regional or location-specific risk factors—for example political risks, the risk of natural disasters like wild fires, storms or floods and the risk of loss of biomass due to increasing economic pressure. All these risks need to be assessed by the auditor and the verification standard.

Buffering risk by pooling credits

General risks that are beyond the control of project developers or project owners have to be managed differently. To cover these risks, all forest protection projects across the globe that are registered under the same standard are required to contribute some (upwards of 30 percent in some cases) of their credits to a non-permanence risk-buffer pool. The volume of credits that each project must contribute can be higher or lower depending on the risk profile of each individual project. Essentially, this is a reserve account of

In 2016, Asia sold the most carbon offsets on the voluntary market (21.5 metric tons of carbon dioxide equivalent), most of which came from India (10.0 $MtCO_2e$), Korea (3.4 $MtCO_2e$) and China (3.3 $MtCO_2e$). There are fewer voluntary projects based in Europe, as the European Union's Emissions Trading Scheme (EU ETS) already regulates many sectors that produce carbon projects.

In 2016, REDD+ was the most transacted carbon offset project type, with 9.7 $MtCO_2e$. Wind ranked second, with 8.2 $MtCO_2e$. Less-traded project types were fuel switching, urban forestry, grassland/rangeland management, and wetland management.

VOLUME tCO_2e (left axis)
AVERAGE PRICE $/$tCO_2e$ (right axis)
Notes: Based on 769 transactions representing 46.5 $MtCO_2e$ in 2016.

credits that cannot be traded and will only be unlocked in case of reversals, i.e., the loss of forest stocks for which carbon credits have been issued before. Buffer credits are maintained and retired only for compensating for the unforeseeable and unplanned loss of trees.

If a certain project cannot fulfill the permanence criterion and an already issued credit suffers from a reversal, other credits will be drawn from the risk buffer from projects elsewhere to ensure that the buyer's offset claim remains valid. The risk buffer acts as an insurance mechanism to account for geographically concentrated risks. In most cases, however, only part of a project will be affected by a disaster, so it is usually enough to use a project's own buffer credits to compensate for lost areas.

What is important from a climate perspective is not what happens to any one tree or hectare of land, but ensuring that the stock of forested land remains the same or increases overall.

Similarly, the risk of pushing deforestation beyond the boundaries of the project, also known as leakage, is a consistent pressure faced by project developers and community members. While strong community relations with adjacent settlements can help ease this pressure, certification bodies have dealt with this issue through strong monitoring requirements of nearby forested land. The use of satellite images and remote sensing not only allow for ease of monitoring, but also for conservative project-by-project emission biomass stock monitoring or leakage rates based on the social and political realities faced by individual projects. These technological and conservative accounting methods ensure that no single project can overclaim its mitigation potential.

Market developments and new challenges

The emergence of these mechanisms designed to deal with REDD+ project risks and their growing acceptance among private actors, as represented by developers, certifiers and funders, provided the basis that enabled volumes of carbon offsets transacted from forestry-based projects to grow.

While these projects represented less than 1 percent of the total market in 2006, this figure has increased to over 20 percent today, with REDD+ alone accounting for over 15 percent of the total.

Concretely, the growth of this voluntary market has contributed USD 381 million in payments to support REDD+ activities between 2009-2014. One spillover effect of such growing voluntary market activity has been the revival of the debate regarding the role of REDD+ under compliance programs, which has become a feature of climate discussions among public actors. International donors, such as the World Bank through its Forest Carbon Partnership Facility or country donors such as Norway, sought to secure the legitimacy of REDD+ and integrate projects into national programs. To date, USD 2.9 billion in funding has been pledged to support REDD+ activities from such sources, although only USD 218 million has actually been disbursed. At the same time, some national and sub-national compliance offset schemes, such as California's Climate Action Reserve, recognized and increasingly relied upon REDD+ offset volumes to meet their emission reduction obligations.

Since the ratification of the Paris Agreement, the renewed focus on REDD+ as a climate change mitigation tool has re-emerged at a national jurisdictional level, as countries with large and threatened forest stocks seek to integrate efforts to combat deforestation into their nationally determined contributions (NDCs). Such recognition will likely expand the scope of REDD+ activities globally and open up significantly more avenues for financing. At the same time, new mechanisms will be needed to integrate project-level management from private sector actors with nationally based strategies and carbon accounting in what has been referred to as the nested-REDD or jurisdictional-REDD approach.

Regardless, the development of the REDD+ concept has not lost its momentum, and it will be interesting to observe how mixed public-private management and financing approaches will develop across multiple market segments.

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THE BIGGEST PROJECT

The Rimba Raya biodiversity reserve, with its 64,000 hectares of marshy forest, protects one of the most threatened ecosystems on the planet. Rimba Raya is the largest REDD+ project in the world in terms of the volume of emissions avoided.

Policies/In the absence of strong and globalized leadership

Governance Wanted

Effective and inclusive governance of the forestry sector and greater visibility on these issues in international debate, is increasingly becoming a key factor in confronting the immense challenges posed by climate change

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NICOLÒ SARTORI

He is Senior Fellow and Head of the Energy Program of the IAI (Institute for International Affairs), where he coordinates projects on the issues of energy security, with a focus on the external dimension of Italian and European energy policy.

Should we extend forested areas to save the planet from the fast-approaching disasters of climate change? This is certainly an important option to reduce the increase in CO_2 emissions, coupled with "traditional" mitigation policies and adaptation to the effects of global warming, and potentially—at the end of a decades-long process—begin to reduce greenhouse gas levels in the atmosphere. Although the Land Use Change and Forestry (LULUCF) sector has received attention and is the subject of initiatives on a global and regional scale—particularly within the United Nations and the European Union—its potential is often underestimated, relegating forestry issues to fringe and niche discussions. Effective and inclusive governance of the sector, and greater visibility into these issues in international debate, is increasingly becoming a key factor in confronting the immense challenges posed by climate change.

Massive potential

Mismanagement of forest areas—about 11 percent of greenhouse gas emissions are caused by the destruction of tropical forests—is only one of the major causes of climate change. Currently, LULUCF is also (and most of all) one of the sectors with the most potential for CO_2 capture from the atmosphere. Based on UNFCC data, global forest vegetation ensures the storage of large amounts of carbon: 260 billion tons in biomass, 37 billion in dry timber and 189 billion in soil surface and humus. It is estimated that the total amount of carbon stored in global forest ecosystems amounted to around 485 billion tons in 2015, a quantity well beyond the 412 billion tons of CO_2 currently in the atmosphere. This is, however, a substantial reduction from the 685 billion tons in 2005, mainly due to human activity in forest environments. Human action has a significant impact in reducing the ability of these ecosystems to reduce and store greenhouse gas emissions on a global scale. Deforestation, intensive use of forest resources, and environmental degradation not only limit the potential for CO_2 capture and storage in these areas, but also contribute to "freeing"—increasing the concentration levels of—climate-altering substances in the atmosphere. In particular, although deforestation rates have slowed compared to the past—from 7.3 million hectares in 2000 to 3.3 million in 2015—the gradual conversion of forested areas into agricultural land to meet the demands of continued population growth and food constitute a serious challenge to the balance of the ecosystem. In this context, traditional climate change mitigation policies—focused mainly on the penetration of renewable en-

The road map of climate change, the last 40 years

1979 — The first World Climate Conference was held in Geneva. Governments around the world were urged to prevent potential anthropogenic climate change that could have a negative impact on the well-being of humanity.

1980 · 1981 · 1982 · 1983

2001 — The United States, presided over by George Bush, exited the Kyoto Protocol.

2005 — The Kyoto Protocol became operational.

2006 · 2004 · 2003 · 2002 · 2000

2007 — COP13 was held in Bali, Indonesia. During the conference, an action plan was set up to reach a comprehensive agreement by 2009. Its purpose included an increase in the CO_2 reduction obligations of rich countries and the inclusion of emerging economies (such as China, India and Brazil).

2008

2009 — Great expectations but very few results at COP15 in Copenhagen, ending with a political agreement without any concrete constraint or objective.

2010

2011 — At COP17 in Durban, South Africa, the agreement of the 194 countries gathered was once again devoid of concrete promises and binding action. 2015 would already be a decisive year.

2012 · 2013 · 2014

2015 — The Paris climate conference in France created a truly historic global agreement to combat climate change, signed by the 196 countries present, almost the entire international community.

ergy and energy efficiency—cannot fail to be supported and complemented by increasing effort on forested areas worldwide. From the sustainable and responsible management of these areas, to policies of repopulation and better management and protection of ecosystems considered at risk, to the fight against degradation and more careful management of agricultural processes, there are many options for ambitious action on the ground that could potentially have an immense impact on the concentration levels of greenhouse gases in the atmosphere.

Absence from global forums

Despite its great relevance and considerable potential, this topic often remains marginal when addressing the issues of decarbonization and climate change on a global scale. There are a number of institutions, especially within the UN (in addition to recent EU initiatives), which have traditionally been involved in defining a comprehensive policy approach on the issues of forestry/deforestation, and which still play a key role in shaping the agenda and action of the international community. But the focus on the subject is often limited to technical aspects and non-binding statements and objectives. The United Nations Forest Forum (UNFF), an intergovernmental process created in 2000 with the specific aim of promoting forest management, conservation and sustainable development, is certainly the main institutional forum where governments can advance multilateral dialog on forest policy, facilitated by the Intergovernmental Panel on Forests (IPF) and the Intergovernmental Forum on Forests (IFF). With the approval of the General Assembly in 2007, the UNFF also established the United Nations Forest Instrument, a non-binding tool designed to bolster political action and cooperation in order to improve forest management and the ability of the international community to achieve global forestry goals, including those related to sustainable development. In addition to the UNFF's activities and initiatives, there is also the action of the United Nations Food and Agriculture Organization (FAO) which, in light of the contribution of agricultural activities to deforestation processes (about 80 percent), has developed a portfolio and significant internal expertise in forestry. The Department working on these issues—in addition to constant monitoring of the status of forests through publications and outreach work—focuses mainly on building capacity in developing countries. The FAO also actively contributes to the Reducing Emissions from Deforestation and Forest Degradation Plus (REDD) initiative, developed by the United Nations Convention on Climate Change (UNFCCC) to support developing countries in reducing greenhouse gas emissions due to deforestation. Via the Collaborative Partnership on Forests (CPF), the FAO and 14 other international forestry organizations have established an innovative horizontal partnership that will enable them to pool and align their expertise and tools with the goals of promoting sustainable development of forested areas and of strengthening long-term political commitments to these matters. The absence of a strong political vision is evidenced by the fact that the European Union, a global leader in environmental protection and the fight against climate change, has to date taken a downward approach to sustainable and virtuous management of forested areas. Until 2020, the EU's carbonization target—a 20 percent reduction in CO_2 on 2005 figures—does not even take into account the LULUCF sector, either in terms of emissions counts or the potential for CO_2 absorption by forested areas. Only in discussions of the European Energy and Climate Framework for 2030 has the issue been addressed in a structured way, with the creation within the Union of a mechanism which provides for the compensation of greenhouse gas emissions from the LULUCF sector for 2021-2030, through an equivalent level of CO_2 absorption from the atmosphere. This mechanism provides Member States with a framework for encouraging more climate-friendly land use without imposing new restrictions or bureaucratic burdens on individual operators.

Seeking visibility and international governance

The still-highly technical and non-binding approach developed within

The World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) set up the Intergovernmental Panel on Climate Change (IPCC).

First IPCC evaluation report, serving as a scientific basis for the Rio de Janeiro Climate Convention in 1992.

1984 1985 1986 1987 **1988** 1989 **1990** 1991

At COP3 in Japan, the Kyoto Protocol, an international environmental treaty on global warming, was drawn up by more than 180 countries.

Second World Climate Conference. The call for negotiations to develop a climate protection convention was very enthusiastic: 137 states and the European Union approved a final declaration.

1992

1999 1998 **1997** 1996 **1995** 1994 1993

According to the IPCC's evaluation report prepared by some 2000 scientists and specialists from around the world, the conclusion was of humans' obvious influence on the global climate.

The first Conference of the Parties of the UN Climate Change Conference (UNFCCC), the first international environmental treaty to deal with global warming, was held.

Rio de Janeiro summit, where the "United Nations Framework Convention on Climate Change" was signed. The Convention entered into force on March 21, 1994 and was ratified by 50 Member States. Ten years later, 189 countries had ratified it.

The United States officially informed the United Nations of its exit from the Paris climate agreement, a decision made by Donald Trump in 2017.

2016 2017 2018 **2019**

the organizations of the United Nations system, the only recent action of the European Union on this issue, and the lack of significant debate among the major global emitters, demonstrate the necessity of bringing the importance of the LULUCF sector to the attention of the international community. The preparatory work at COP21 in Paris, with the definition by the participating states of their Intended Nationally Determined Contributions (INDCs), represented—with all respective limitations— an important first step toward the beginning of collective consciousness of the sector's contribution to combating climate change. In setting their decarbonization targets, governments were free to decide whether and how to include the LULUCF sector in their counts and, apart from a few exceptions (Egypt, South Korea, Belarus), almost all of them included parameters related to land and forest use in their national indexes. Although the level of detail provided by different countries (especially in terms of accounting) often makes it difficult to objectively assess the impact of the effort made in the LULUCF sector on combating climate change, their inclusion in the governance mechanisms envisaged by the Paris Agreement certainly offers hope for greater focus on the issue in the future. This attention has been entirely missing in the two main global political forums, the G7, and especially the G20. The debate on forestry/deforestation issues and the sustainable management of forested areas within the two groups was virtually absent until the beginning of 2019, which is quite unjustified, especially for the G20. Among the "great" twenty international powers are countries such as Brazil, Indonesia, Russia and Mexico, which are also some of the countries most affected by practices of widespread deforestation and the unsustainable use of forested areas. In light of these data, and the global size and impact of deforestation processes, it would therefore be appropriate and legitimate to expect greater attention and a more proactive role from the group on these issues. Only in the face of the ongoing catastrophe in the Amazon rainforest and the media wave it has created in international public opinion, the G7 (and less so, the G20) have taken their first major steps—at least in terms of statements—on the management and exploitation of forested areas as a globally relevant matter. The statement adopted by the G7 Environment Ministers' Meeting in Metz on the need to "stop deforestation, also via a chain of sustainable value for food commodities" and the attention at the Biarritz summit in August 2019 on the state of the Amazon forest, during which the G7 countries allocated an aid package (bizarrely rejected by Brazilian President Jair Bolsonaro) to deal with the devastating fires in the area, are probably the first steps toward a more structured discussion on these issues within the international community.

A lack of strong global leadership

However, many steps still remain to be taken, and significant obstacles to be faced. The lack of serious internal debate by the two major global powers (the United States and China), conflicting interests among international players such as Russia and Brazil, and the European Union's too-solitary (and still too timid) action, on which topics they have often given up, are currently reining in an unequivocal response and a firm approach to the issue. In the hope that the G7 and G20 will get going with conviction and ambition, the lack of strong leadership on a global scale requires us to try to overcome these obstacles via international governance based on variable geometries and the interaction of different stakeholders, interests and powers. A governance that builds on the initiatives started within the "United Nations system" and leverages the action of the European Union, and knows how to put the priorities and specificities of multiple stakeholders, including the private sector, cities and local communities. This is certainly not an easy process, but the magnitude of the climate threat and the potential contribution of the LULUCF sector to combating the changes taking place require efforts thus far unprecedented in this direction.

AI is Set to Revolutionize the Credits Market

The use of technological tools including AI and big data to measure and monitor forests allows a new market to be created for forest carbon that fulfills two essential criteria: immediate storage of large amounts of carbon and cost containment

MAX NOVA

He is the co-founder of SilviaTerra. He helps design, build, and deploy precision forestry tools for some of the largest landowners in the US. Born and raised in Louisville, KY, Max has a degree in computer science from Yale University.

There exists an incredible machine that sucks carbon out of the atmosphere and turns it into a wide variety of useful materials that we use in our everyday lives. This machine runs on solar power and can be deployed on roughly one-third of the Earth's landmass. In addition to removing carbon from the atmosphere, this machine also purifies water and creates wildlife habitat. Too good to be true? In fact, you're already very familiar with this machine. You probably call it a tree.

Given the potential of trees to sequester carbon and slow climate change, many scientists and policymakers are enthusiastic about planting lots of new trees. However, saplings take decades to grow to maturity. The first year after a young tree is planted, it sequesters very little carbon. Its growth rate is very high, but because it starts so small, the overall effect is tiny. That's a problem because the November 2019 UN Emissions Gap Report says that we don't have the option of waiting decades to start putting a dent in global carbon flows. By the time trees planted today reach maturity, will it be too late? Will Venice be completely underwater?

Timescales and prices for an effective strategy

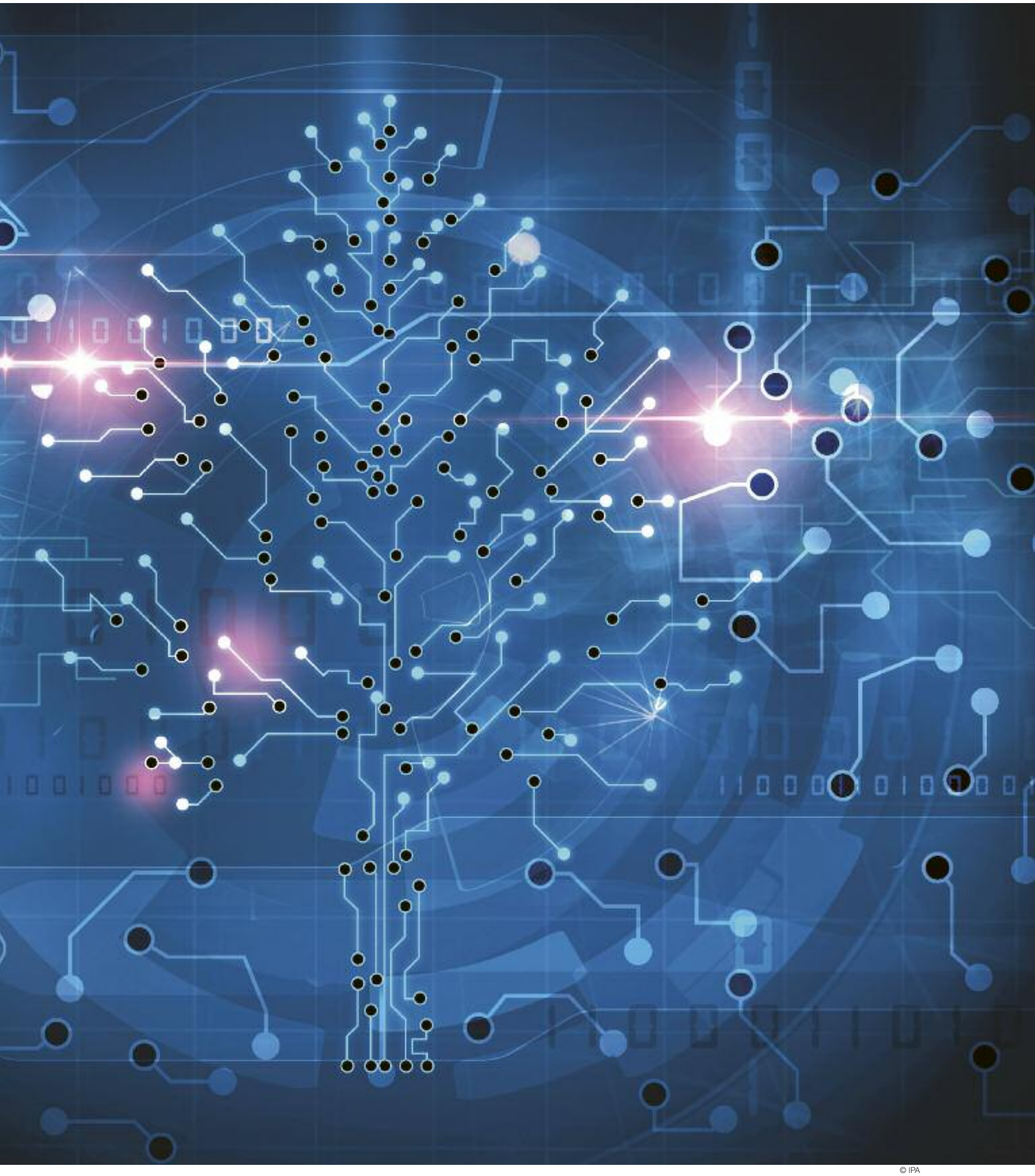
An effective forest carbon strategy should have two main features:

1 | PULL AS MUCH CARBON OUT OF THE ATMOSPHERE IN 2020 AS POSSIBLE. Climate experts often say that the most important carbon to sequester is carbon today. Each year, we should try to store as much carbon in forests as we possibly can. This sounds obvious, but this simple idea is often missed. For example, planting trees fails this test because each newly planted tree only sequesters a tiny amount of carbon in the first year.

2 | SEQUESTER CARBON FOR AS FEW DOLLARS PER TON AS POSSIBLE. Cheap carbon means greater potential scale of impact. Again, this seems like it should be obvious. Yet existing forest carbon schemes often fail this test as well.

Focusing on the other end of the tree lifecycle turns out to be a more immediate and scalable solution. Avoiding deforestation (or harvesting trees) is a clear way to keep carbon on the landscape and out of the atmosphere. Maturing forests are often still growing aggressively and pull lots of additional carbon out of the atmosphere every year they are kept standing. This is the key idea behind the popular REDD (reduced emissions from deforestation and forest degradation) program discussed at the 2005 United Nations Framework Convention on Climate Change.

Yet forest carbon markets have →



Digitized forests

The Sierra Nevada mountains viewed from the satellite (below) and processed by Basemap, a forest inventory that allows the different species of trees that populate the forest (right) to be mapped and identified.

OAKS
SILVER BIRCHES
CEDARS

Source: SilviaTerra

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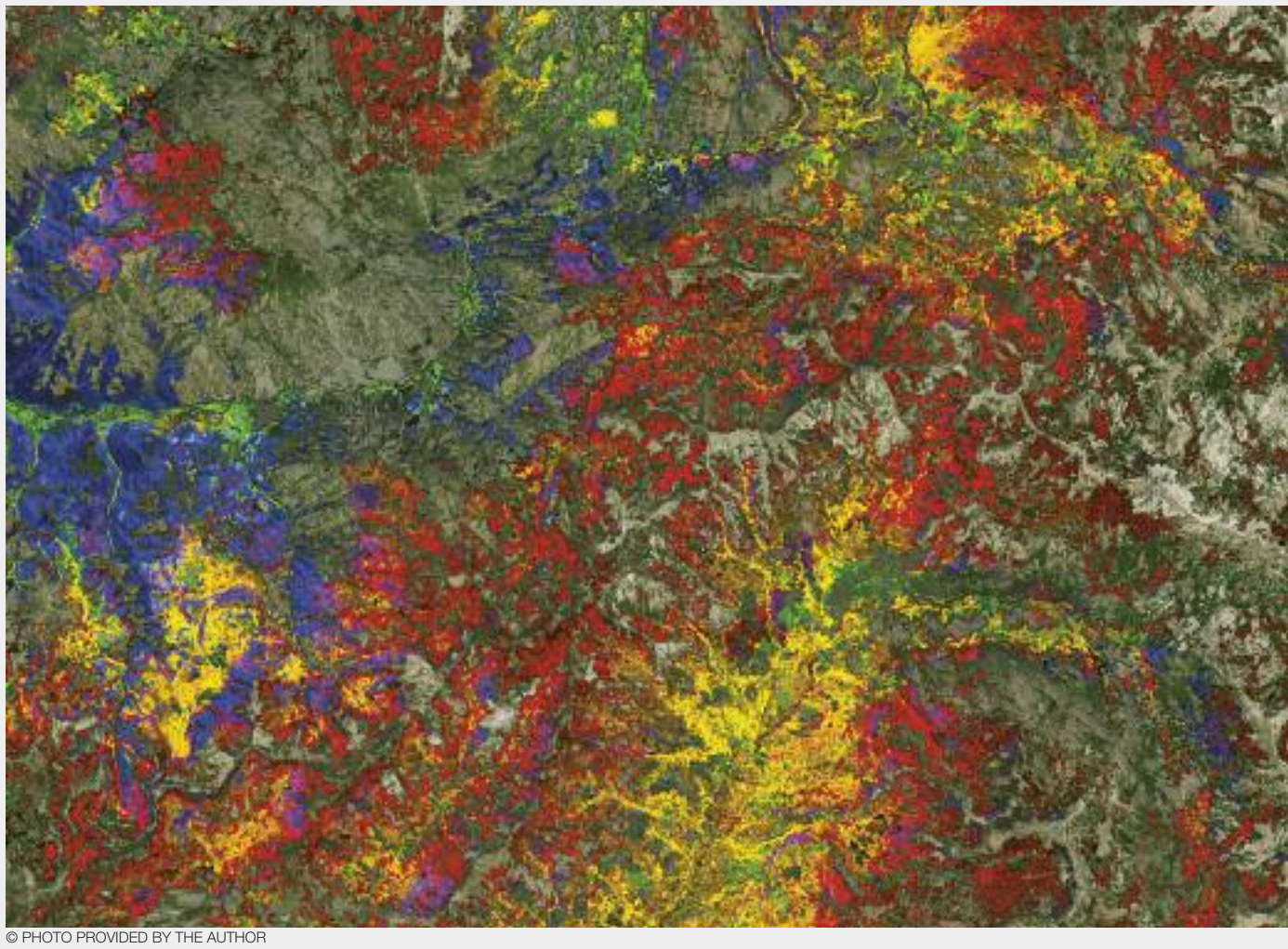

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struggled to gain widespread adoption. Hundred year time commitments and the high costs of forest monitoring have made it difficult for forest carbon projects to get off the ground. But recent advances in artificial intelligence are now enabling new approaches for forest carbon markets. With a vast wealth of information from satellite imagery, it's now possible to use data to assess every individual forested acre every year. By targeting a narrow band of high-impact years in the biological lives of trees, this "big data" approach makes it possible to direct payments to where they will sequester the most carbon for the least amount of money.

This data-driven shift away from a hundred-year term for forest carbon projects to an annual "rental" style market has the potential to store several additional gigatons of carbon in our forests for less than a dollar per ton per year. The key driver of this efficiency is a practice called extended rotation age (ERA). For the billions of acres of managed forests in the world, letting trees stand for a few more years has the potential to keep a lot of carbon out of the atmosphere for less than a dollar per ton per year. For example, in the US South, a pine forest is usually harvested and replanted every 26 years. Extending the rotation age to 27 or 28 years keeps a lot of carbon on the landscape, pulls more carbon out of the atmosphere and doesn't cost the owner much. This is one of the cheapest, most immediate, and most scalable levers we have for keeping carbon out of the atmosphere.

There is a catch though. When you buy forest carbon, you're buying something that's literally out in the woods, often in a remote location that you'll never physically visit. How do you know how much carbon you're getting for your money? This has historically been one of the major stumbling blocks for forest carbon projects. While foresters have been scientifically measuring forests for centuries, the actual process of measurement still involves sending foresters out into the woods where they literally count trees with paper and pencil. This is an expensive and time-consuming process, and it means that only the largest forest carbon projects can make enough revenue to outweigh the burdensome overhead of measurement and monitoring.

AI and big data to measure forests

In collaboration with Microsoft's AI for Earth program, an American startup company called SilviaTerra is beginning to change that. Analyzing terabytes of satellite imagery with AI and machine learning on Microsoft's Azure cloud, SilviaTerra created Basemap, the first high-resolution forest inventory of the continental United States.

This unprecedented dataset contains information about the sizes and species of trees on every acre across the country. From this foundation, it's possible to compute not only the value of the timber on every acre, but also the tonnage of carbon contained within the trees. By using modern technology to dramatically reduce the cost of measuring and monitoring forests, it's possible to create a market for forest carbon that achieves the two key criteria of storing lots of carbon in 2020 and doing it cheaply.

This isn't just a theory. In 2019, Microsoft and SilviaTerra partnered to use the forest Basemap data to buy carbon offsets from a wide range of landowners in Pennsylvania. SilviaTerra assessed both the carbon stocking and the harvest risk on every property. Landowners were offered payment to defer timber harvests on their properties for a single year. SilviaTerra's updated 2020 Basemap data will be used to verify that landowners did indeed defer harvest. If the landowners desire, they can cut down their trees after the one-year term or they can participate in the next year's carbon rental market.

This annual rental market for forest stands in stark contrast to existing regulatory forest carbon markets that were designed back before the age of AI and big data. The two key differences are in the term-length of the contracts and the size of the properties that can participate. In conventional forest carbon markets, landowners have to commit to 100-year terms rather than one-year terms. Further, given the regulatory and measurement overhead of participating in these markets, only landowners with more than 5,000 acres can participate profitably.

Data-driven annual forest rental markets outperform the conventional forest carbon markets in four key areas: immediacy, scale, non-leakage and additionality.

Immediacy

If you take a flight that emits a ton of carbon into the atmosphere, how long do you need to lock up a ton of carbon in trees to offset it? The California forest carbon market says it's a century, so the project term for a California carbon project is 100 years. But recall that one of our key market design criteria is to maximize the amount of carbon we sequester in 2020. Every dollar spent to lock up carbon decades into the future is a dollar not being spent to sequester carbon today. If our society is serious about taking immediate action on climate change, allo-

cating current funds to buying carbon 90 years in the future is not a wise allocation of resources.

A more effective way to maximize present-day carbon sequestration is through an annual rental-style market. Buyers renting carbon for one year rather than purchasing 100 years upfront enables a 100x increase in present-day impact for the same amount of present-day dollars. Each year, buyers can choose to rent carbon for another year, and the dollars will flow to the cheapest carbon on the landscape.

An annual rental market also avoids locking our society into long-term commitments. Given the rapid advance of technology and an uncertain future, the flexibility afforded by an annual rental market leaves room to shift to other strategies as new decarbonizing technologies come online.

Scale

A short-term rental market for forest carbon also unlocks hundreds of millions of tons of very cheap carbon. As discussed earlier in this article, commercial forest owners don't lose much timber value when they extend a plantation pine rotation from 26 to 27 years. However, at that stage in the tree's lifecycle, it's still adding lots of biomass and sequestering lots of carbon from the atmosphere. This one-year period right after optimal timber harvest age is the sweet spot for buying forest carbon—there's a lot of carbon being sequestered and the cost of doing so is very low.

You may be surprised to learn that commercial forest plantations represent one of our most effective tools for combating climate change. By extending rotation ages by just a year or two, forest plantations have the potential to sequester gigatons of carbon for very low prices per ton. These tons are clearly additional because they require managers to extend rotation ages beyond the optimal age for commercial timber. This is a change that can start happening right away.

Leakage

There's only one atmosphere. Any forest carbon scheme has to account for the landscape as a whole—it's not enough to just change the behavior on a single property. If timber harvests are simply displaced from one property onto another, the amount of carbon on the landscape hasn't actually increased. This displacement of harvests is called leakage, and it occurs when not all acres are exposed to carbon markets. Harvests leak from acres exposed to the market to acres not exposed.

Under the conventional forest carbon markets, harvests typically leak from large ownerships to the surrounding small landowners. This occurs because landowners typically need 5,000+ acres to make carbon market participation economically viable. This ends up excluding small landowners, and so harvests are displaced onto their properties. In America, small landowners own over 200 million acres of forest, so there is a lot of potential for leakage. By dramatically lowering the overhead costs of measuring and monitoring forest carbon, SilviaTerra's technology massively expands participation in carbon markets. Properties as small as 10 acres can enroll. By covering nearly all acres that are at risk of harvest, SilviaTerra's annual carbon rental market not only addresses the issue of leakage, but it also expands the supply of carbon available to buyers of carbon offsets.

Additionality

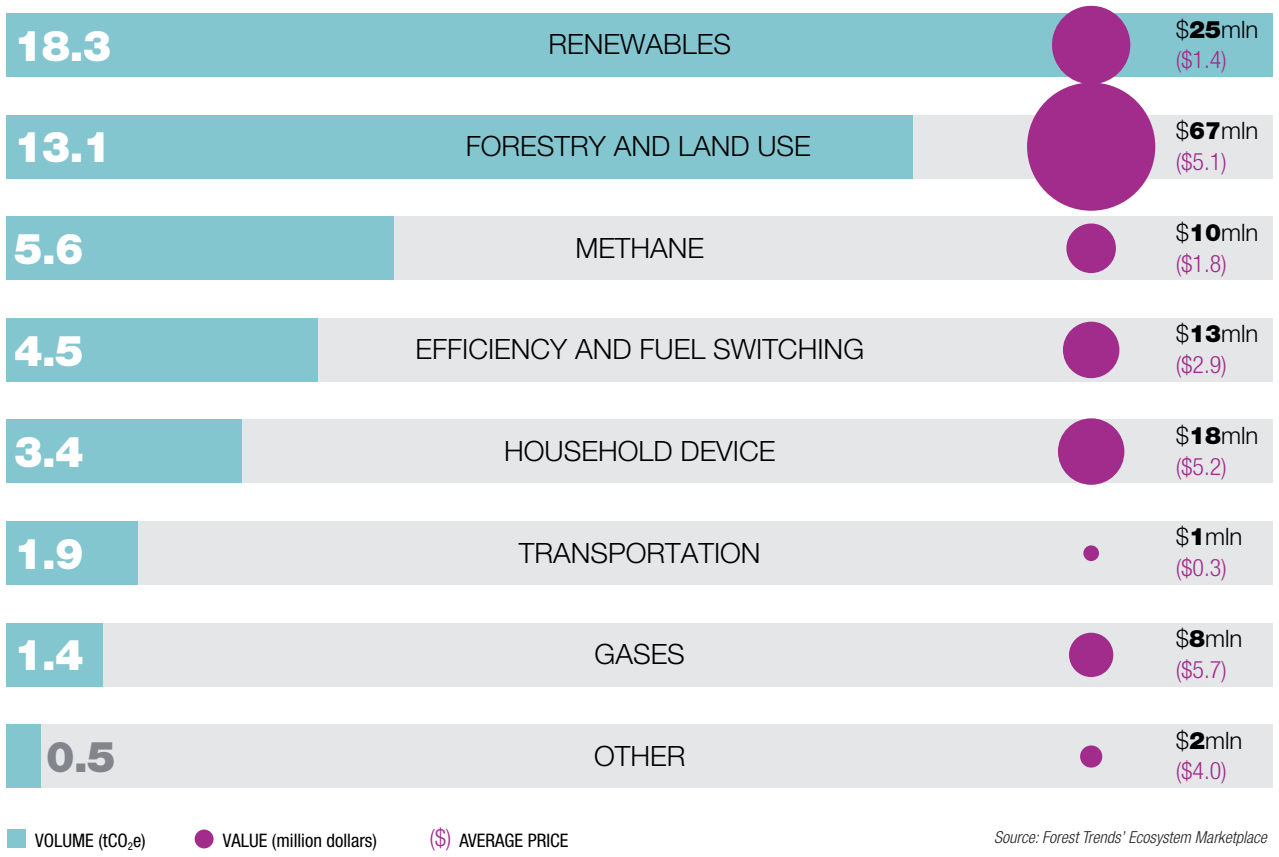
In the context of forest carbon markets, the goal isn't to change a landowner's behavior from harvest trees to don't harvest trees. Not all harvest activity has to be eliminated—after all, our society still needs to build houses out of wood and ship things in cardboard packages. The key is to reduce harvests from business as usual (BAU) levels. For example, a large landowner might annually harvest timber containing 100,000 tons of carbon. If they reduce their harvest to timber containing 80,000 tons of carbon, they should get credit for 20,000 tons of carbon. In technical terms, these 20,000 tons of carbon are additional compared to BAU. Thus, the assessment of BAU is a critical element of any carbon market.

However, as articles like the MIT Tech Review's recent "Landowners are earning millions for carbon cuts that may not occur" demonstrate, current BAU assessment is very crude. This leads to a classic problem in market design: adverse selection. If you own acres of swampy land or have really steep mountainsides covered with forests, it's nearly impossible to harvest that timber. However, existing markets may pay you to promise not to cut down those trees. A more effective, data-driven approach is to consider the economics of each acre individually. Given information about the sizes and species of trees, market conditions, transport costs, and a satellite-based analysis of past harvest behavior, it is possible to develop sophisticated models of the harvest risk of every acre. This type of analysis was impossible under the old paper-and-pencil measurement paradigm. With SilviaTerra's Basemap and the power of cloud computing, this is now feasible. Better assessments of BAU harvest levels means that money can flow to acres where it actually changes behavior and sequesters more carbon.

The future of forest carbon

Shifting to an annual forest carbon rental market has its own set of challenges. For buyers to have confidence that they're actually changing management on the landscape, they need to have visibility on the carbon stocking on every acre, every year. This is the place where technology like SilviaTerra's is enabling new solutions for the future. Forests can be a powerful tool for offsetting carbon emissions from other parts of the global economy. If we use data to allocate our efforts intelligently, forests can certainly help buy us time to develop technology to decarbonize other sectors of our economy.

TRANSACTED VOLUME, VALUE AND AVERAGE PRICE BY PROJECT CATEGORY



Source: Forest Trends' Ecosystem Marketplace

In 2016, forest carbon credit transactions amounted to 13.1 tons of CO_2e. The market value of these transactions was 67 million dollars, which is an average of 5.1 dollars per tCO_2e. [Based on 717 transactions representing 48.8 tCO_2e in 2016]

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Urban areas/From the source of the problem to contributing to the solution

How the "Nature" of the City is Changing

Green infrastructure that is well-planned, managed and integrated into the urban fabric is an instrument that can effectively, efficiently and inexpensively cope with the growing challenges posed by climate change

MICHELA CONIGLIARO AND SIMONE BORELLI

Michela Conigliaro has worked, since 2012, on the Urban Forestry programme of the FAO's Forestry Department, where she supports the Urban and Peri-Urban Forestry Programme.

Simone Borelli has worked for FAO for over 20 years in various posts and is currently responsible for the Forestry Departments' Agroforestry and Urban Forestry programmes. In this capacity, he provides technical support for FAO field projects and policy advice to member countries.

It is widely recognized that urban areas make a decisive contribution to accelerating climate change. While covering only three percent of the earth's surface, cities are home to more than half of the world's population, and they are responsible for 60-80 percent of energy consumption, at least 70 percent of global carbon dioxide emissions, and significant quantities of other greenhouse gases resulting from the human activities concentrated there. As a consequence of their expansion at the expense of urban and peri-urban natural systems, they also indirectly contribute to the increase in carbon dioxide through deforestation. These figures are alarming considering that by 2030 (according to current projections), cities will be home to more than 60 percent of the world's population, with a consequent increase in land use and resources, demand for services and emissions.

However, urban areas are highly vulnerable to the effects of climate change. Around 60 percent of urban population lives in areas at high risk of exposure to at least one type of natural disaster, particularly flood and drought. Because of climate change, extreme weather events are →

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LIMA (Peru) is carrying out projects to reforest urban degraded slopes, substantially reducing the threat of landslides and landslips, thus improving the safety of local communities living in disadvantaged and precarious sites.

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PHOENIX (Arizona, US) is investing to increase tree cover from 12 percent to 25 percent by 2030 to mitigate high local temperatures, (37.8 °C for 109 days a year). This increase could lower the average local temperature by as much as 2.4 °C.

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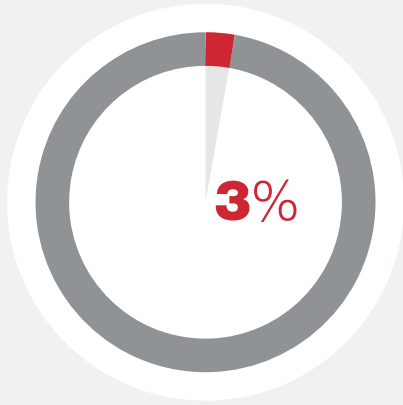
In **NAIROBI** (Kenya) the degradation of peri-urban forests has caused a severe reduction in the water supply, leading the local government to plan the recovery of these forests.

Green cities around the wo



Urban areas cover 3% of the earth's surface

Cities are home to 50% of the world population

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FUZHOU (China) is investing in expanding its urban forest, which at the moment already covers more than 43 percent of the surface, to achieve its vision of an "opening the window and seeing green; leaving home and seeing gardens; walking in the shade."

© PHILADELPHIA WATER DEPARTMENT

In 2011 **PHILADELPHIA** (Pennsylvania, US) began investing in a plan to reduce the volume of rainwater that reaches the Delaware river and often floods the city. The use of conventional engineering solutions would have involved greater costs and less benefits.

increasingly affecting cities around the world, and in the coming decades, they are expected to become the main threat to food security and to the well-being and life of hundreds of millions of inhabitants of urban and peri-urban areas. Rising sea levels, the increase in the frequency and intensity of precipitation, floods, cyclones and storms, and the increasing alternation between extreme hot and cold weather are tangible threats, especially for third world cities that are already coping with growing poverty, food shortages, lack of resources and the consequences of urbanization that are too often inadequately planned. It is in these cities, particularly in Africa and Asia, that 90 percent of urban population growth in the coming decades will be concentrated.

Sustainable cities, the New Urban Agenda

The urgency of concentrating actions in urban areas to reduce climate-changing emissions and increase the resilience of urban communities by mitigating the effects of climate change has been widely supported in global agreements on sustainable development. The 2030 Agenda for Sustainable Development, signed at the UN in 2015, makes sustainability one of the 17 essential goals to be achieved by 2030 (SDG11: make cities and human settlements inclusive, safe, resilient and sustainable). The New Urban Agenda (NUA) was drafted on this sustainable development goal and adopted in Quito (Ecuador) in 2016 during the "Habitat III" conference. The NUA is an action-oriented document that defines various global objectives to rethink the way we build, manage and live in cities, and it is based on the assumption that a well-planned and managed urbanization can be a powerful tool for sustainable development in both de-

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VITORIA-GASTEIZ (Spain) began an ambitious project in the 1990s to create a green belt around the city to recover degraded areas and create new recreational areas. To date, the green belt measures 800 hectares in size.

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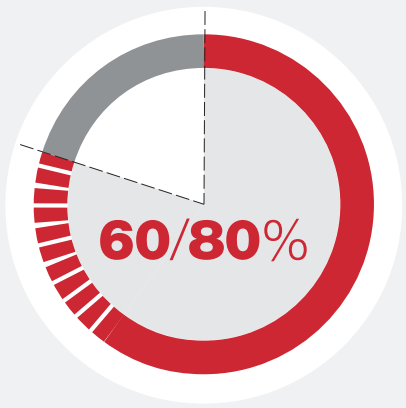
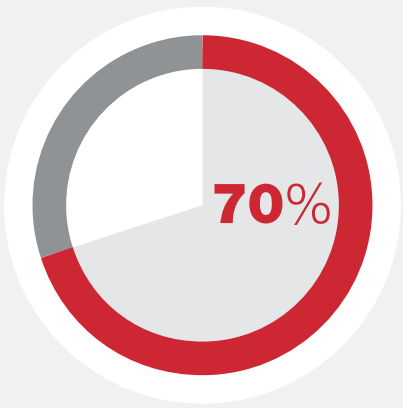
NIAMEY and **TAHOUA** (Niger) have created a band of plantations close to urban areas to recover the landscape, shield the city against sandstorms, fix dunes and provide a protective buffer against the advancing desert.

rld: 10 virtuous examples



Cities are responsible for 60-80% of energy consumption



Urban areas are responsible for 70% of global CO_2 emissions

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In **BEIJING** (China) 2.4 million trees in the city center remove more than 1200 tons of pollutants from the air. These gases and particulates are the main cause of the growing onset of respiratory diseases among children and adults in urban communities.

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In 2011 **VANCOUVER** (Canada) launched the Greenest City Action Plan with the aim of becoming the greenest city in the world by 2020. “Improving access to green spaces builds the community and improves the health of residents,” the Plan suggests.

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MILAN (Italy) has recently launched the ForestaMi program with the aim of becoming the greenest city in Italy, with 3 million new trees to be planted by 2030.

veloping and developed countries. In the Paris Agreement on Climate Change (2015), the first universal and legally binding climate agreement, the signatory countries committed themselves to limiting the average increase in global temperature to 1.5 °C and recognized the key role and responsibility that cities have in achieving that goal.

A well-planned, managed and integrated green infrastructure in the urban and peri-urban fabric can provide local administrators with a valuable tool to cope effectively, efficiently and inexpensively with the growing challenges faced by cities as a result of climate change. In particular, trees and forests, which together form the “urban forest” of a city, are able to provide a series of ecosystem services that contribute both to mitigating climate change and to adapting to its effects.

By intercepting rain with their foliage, retaining water and increasing the permeable surface of urban soils, trees help reduce the impact of rainfall and reduce the flow of rainwater, thus lessening the likelihood of flooding and consequent landslides. Various cities around the world, including Lima, Peru, are successfully carrying out projects to reforest degraded urban slopes, thereby substantially reducing the threat of landslides and landslips and improving the safety of local communities living in disadvantaged and precarious sites. Tree-lined systems are also important for their contribution to thermal comfort. By shading pedestrian paths, buildings and recreational areas, trees mitigate the urban heat island effect, enabling adaptation to the increasing heat waves of summer seasons, and also provide shelter from the heavy rains that are more frequent in rainy seasons. The city of Phoenix, Arizona, for example, plans to increase tree cover from 12 percent to 25 percent →

by 2030 to mitigate high temperatures, which can reach and sometimes exceed 37.8 °C 109 days a year. This increased coverage is estimated to decrease the local average temperature by a full 2.4 °C.

Green belts for air, water and the soil

Many cities have invested in the creation of "green belts" to provide citizens with easily accessible and usable recreational spaces, place limits on the urbanized area and create continuity with the peri-urban natural environment. For example, in the 1990s, the Spanish city Vitoria-Gasteiz began an ambitious project to create a green belt around the city to recover degraded areas and create new recreational spaces. To date, the green belt measures 800 hectares in size. These green belts also play an important protective role for urban communities. In many countries of the arid regions of the world, green belts are created with the aim of shielding cities from sandstorms, fixing dunes and ensuring protective bands against the advancement of the desert. Examples include the peri-urban plantations created near the cities of Niamey and Nahua in Niger to recover the landscape, and the Shelterbelt Three-North in which China began investing in 1978 to protect the city of Beijing from the devastating sandstorms originating from the neighboring Gobi and Taklamakan deserts.

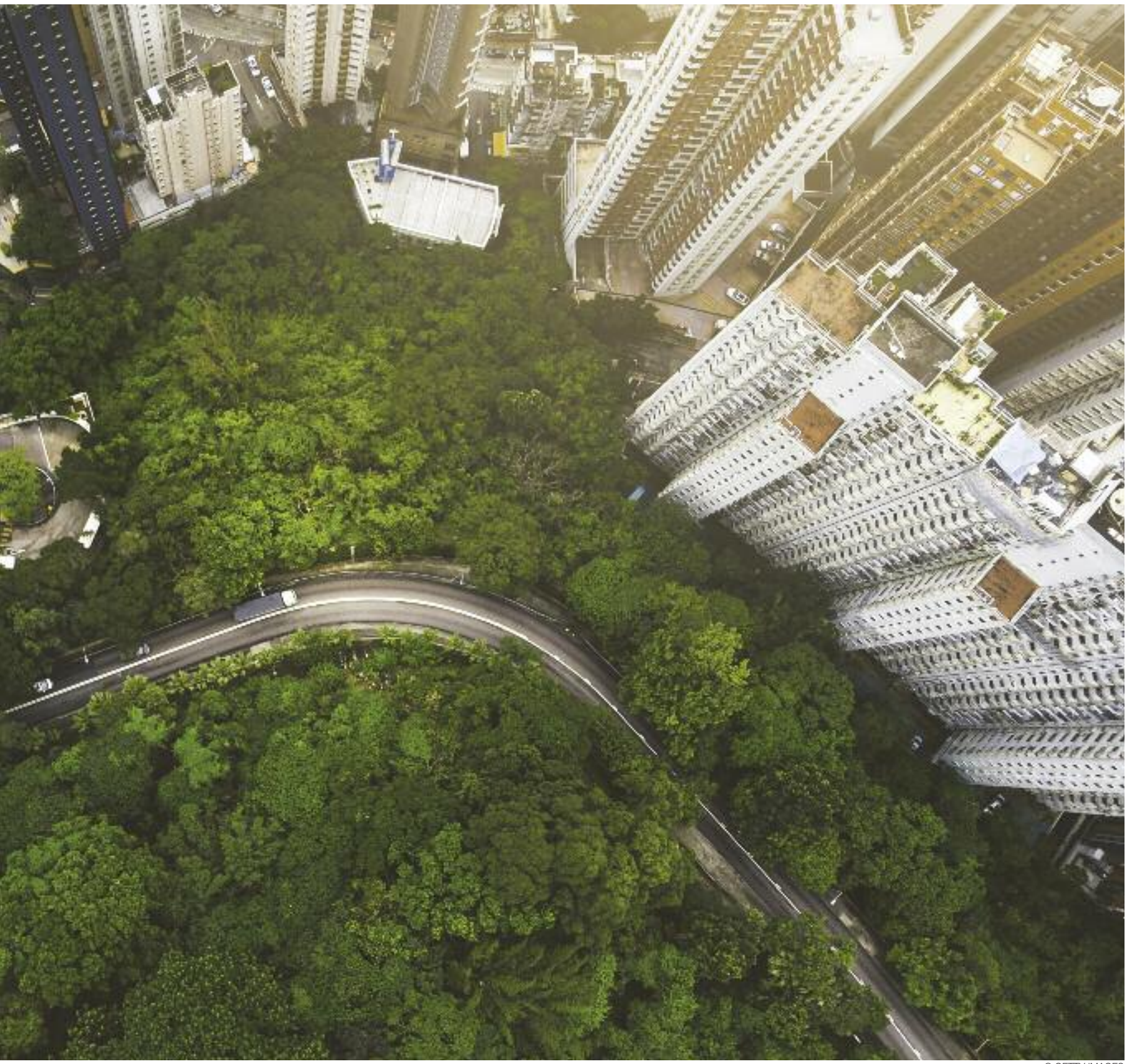
Natural forests bordering on urban areas are also fundamental in maintaining those river basins which are essential for guaranteeing the water supply to cities. In Kiambu County, Nairobi, Kenya, the degradation of peri-urban forests has caused a severe reduction in the water supply and has led the local government to plan the recovery of these forests. In 2011, the US city Philadelphia began investing in a plan to reduce the volume of rainwater that enters the Delaware River and often floods the city. Approval of the project was preceded by a careful analysis which confirmed that addressing the problem by investing in a green infrastructure in the river basin allowed less costly compliance with federal regulations with a greater overall benefit than would otherwise have been the case using conventional engineering solutions.

On a larger scale, trees and forests in urban and peri-urban areas also contribute to climate change mitigation. By absorbing carbon dioxide during the day, they contribute to reducing the carbon emissions generated by activities carried out in cities and neighboring areas which are indirectly necessary for their sustenance, for example, the peri-urban areas used for agriculture to produce food. Furthermore, the vegetation and soils of urban forests are large reserves of carbon, which they sequester and store in their biomass, further reducing total emissions. By shielding buildings from the sun and cold winds, tree-lined systems contribute to reducing energy consumption and therefore the emissions needed to refrigerate and artificially heat public and private buildings. Urban “green belts” also promote sustainable mobility, favoring the use of means of transport with little or no environmental impact such as bicycles, scooters and walking. Last but not least, peri-urban tree plantations can be created and managed as a renewable source of wood and firewood for urban consumption, thus limiting the exploitation of natural forests. In many African countries, firewood still accounts for 60-80 percent of the household fuel used for cooking and heating and can account for 50-90 percent of national energy consumption.

Finally, trees improve the quality of the urban environment. For example, acting as natural filters, they absorb the airborne pollutants generated by vehicle traffic, fossil fuels and industries. In Beijing (China), in 2002 alone, the 2.4 million trees in the city center removed more than 1200 tons of pollutants from the air. These gases and particulates are the main cause of the growing onset of respiratory diseases among children and adults in urban communities and, according to WHO data, cause the premature death of 3 million people each year. By providing high quality open spaces for recreation and physical activities, green public spaces promote healthier lifestyles and help counteract the onset of obesity and cardiovascular disease. It has also been amply demonstrated that the presence of trees and natural landscapes can have positive effects on people’s mental health, promote learning in children and accelerate the recovery of patients.

A value still often ignored

Too often, however, trees and forests are among the first resources to be sacrificed in the process of urban expansion, and there are still few cities that can boast a real urban green strategy that considers trees to be an integral element in planning and urban space management. The New Urban Agenda explicitly requires cities to engage in the sustainable management of natural resources in cities and human settlements, to reduce greenhouse gas emissions and air pollution and to promote risk reduction for natural and man-made disasters, to be accomplished through urban and local planning, infrastructure and basic services. Some cities have begun to invest in the planning, creation and sustainable management of urban forests as a tool to tackle urban problems for which traditional "gray" solutions such as asphalt, concrete and steel have been used so far. In 2011, for example, the administrators of the city of Vancouver launched the Greenest City Action Plan with the aim of becoming the world’s greenest city by 2020. As part of this initiative, an urban forestry strategy was adopted in 2014, a plan aimed at supporting the achievement of this objective and addressing the growing problems linked to the expansion of the built-up urban area, which, paradoxically, was also due to the success of the Greenest City Action Plan that attracted more and more people to move to the city. Supported by the “National Forest Cities” project launched in 2004 by the Chinese Government, the city of Fuzhou is investing in expanding its urban forest, which at the moment already covers more than 43 percent of its surface, to achieve the vision of “opening the window and seeing green; leaving home and seeing gardens; walking in the shade.” The



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city of Milan has recently launched the ForestaMi program with the aim of becoming the greenest city in Italy, with 3 million new trees to be planted by 2030. The involvement of institutions, companies, associations and citizens will be needed to achieve such an ambitious plan.

Investing in urban forests makes it possible to act synergistically in the context of climate change by integrating mitigation and adaptation actions. For the same service offered, green infrastructure can be cheaper to implement and maintain in the medium to long term, in addition to providing benefits that improve the quality of the urban environment. In order for the urban forest to optimize its benefits, it must be integrated into a well-conceived, managed and appropriately interconnected green system (green infrastructure), both functionally and structurally. Green islands—natural and semi-natural, urban and peri-urban—interconnected by corridors become the structural elements of a multifunctional green system that maximizes the anti-climate change effect, supports local biodiversity and increases the city's resilience to environmental and man-made stresses. In the coming years, green spaces will become increasingly important in providing citizens with the services needed to increase urban resilience to climate-dependent stresses. However, it is essential that urban forestry projects also take into account the climate and temperature projections for the coming decades, so as to ensure that the species selected, the maintenance techniques and the management plan proposed are sufficiently flexible to guarantee sustainable management of urban forests and the availability of all the services they provide.

THE IMPORTANCE OF GREEN BELTS

By shielding buildings from the sun and cold winds, tree-lined systems contribute to reducing energy consumption and therefore the emissions needed to refrigerate and artificially heat public and private buildings. Urban "green belts" also promote sustainable mobility, favoring the use of means of transport with little or no environmental impact such as bicycles, scooters and walking.

Urban forestry/From Vertical Woods to Forest Cities, rethinking the relationship between nature and cities

A New Alliance

The big challenge in the coming years will be to make urban areas the protagonists of a global campaign to reduce the triggers of the climate emergency. Urban forestation is one of the most effective tools for making this happen

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SMART FOREST CITY
Cancun will be the first Forest City of the new millennium. It will occupy an area of 557 hectares and house 130,000 people, and 400 hectares of green space with 7,500,000 plants, including 260,000 trees. The project is planned to absorb 116,000 tons of carbon dioxide and store 5,800 tons of CO_2 per year.

STEFANO BOERI

He is an architect, urban planner, professor at the Polytechnic of Milan and a visiting professor at several international universities. Directs the "Future City Lab" at Tongji University in Shanghai: a post-doctoral research program that explores the future of contemporary cities in terms of biodiversity and urban forestry.

t is well established that, starting from the period of urbanization induced in the nineteenth century by the birth of large-scale industry, cities can be considered responsible for producing as much as 75 percent of the CO_2 in the earth's atmosphere. The uncontrollable growth in CO_2 is the root cause of global warming and its effects on our planet's glaciers and oceans. Cities, where the majority of our species live, are also the main victims of the effects of global warming. Just think of the dramatic effects of flooding on the waterfronts of many coastal cities and the damage that a climate transfigured by warming oceans is causing to urban areas, which have become huge waterproof expanses, where water accumulates and flows without being absorbed by the soil. Think too of the worsening "heat island" effects that the increasing temperatures are creating in almost entirely mineral cities, let alone the shocking number of deaths that higher temperatures combined with air pollution are causing among the inhabitants of urbanized areas. Cities, however, currently have the resources and the potential to become the main players of a radical reversal in this trend, aimed at countering the dramatic effects of the climate emergency.

The magnitude and intensity of the climate emergency are such that the British environmentalist philosopher Timothy Morton classifies it as a hyper-object, i.e., an object that is so massively distributed in time and space as to transcend location itself. We are in fact faced with a multiplicity of effects that are often barely visible or only perceptible in the long term. Or to effects, such as the melting of permafrost in Siberia and rising sea levels in the Fiji islands, which may be geographically distant but are in reality closely connected, although at first sight they might be deceiving. Unsurprisingly, an authoritative newspaper like *The Guardian* recently proposed a substantial change in the terminology related to climate change, which is named and defined as a crisis or climate emergency. It is precisely the incredible acceleration in the evolution of this phenomenon in recent years, and its increasingly intense and devastating repercussions on the urban environment, that prompt the change of terminology and give us the measure of the gravity of a situation which, generally speaking, has already defeated us.

Cities and climate emergencies are also mutually intertwined with the growth of migratory flows which, due to the increasing uninhabitability of various areas of the planet, flow into urban areas, generating a real chain effect. In 2012 alone, as a result of around 300 environmental disasters →

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THE NANJIING VERTICAL FOREST, which is expected to be completed by 2020, is the third prototype, after Milan and Lausanne, of an urban demineralization and forestation project that Stefano Boeri Architetti is carrying out all over the world. It is also the first Vertical Forest created in Asia. The plants that will be installed on and around the two towers in Nanjing will reduce CO_2 emissions by about 18 tons and produce around 16.5 tons of oxygen each year.

(including hurricanes, floods and earthquakes) which hit China, the United States, the Philippines, Indonesia and Afghanistan in particular, there were more than 32 million climate refugees. adding to all those who are leaving their homelands due to creeping desertification and continuous famines, wars and relgious or gender-based persecutions or those linked to sexual orientation that increasingly characterize some African and Middle Eastern countries. According to the most recent estimates, between 200 and 250 million human beings will be forced to abandon their homes and move to cities by 2050, thus further increasing the factors that are the primary cause of the climate emergency itself.

From the perpetrators of the crisis to the protagonists of change

The big challenge in the coming years will be to alter the planet's cities' role, so they are no longer just contributors to and victims of our climate emergency, but also the protagonists of a global campaign to reduce and slow down its triggers. Urban forestation is one of the most effective tools for making this happen. The aim is not only to reduce the production of greenhouse gases to a minimum but also to absorb significant amounts of those already produced, and today the cheapest and most effective technology in nature to absorb CO_2 is photosynthesis by plants. Forests already absorb about 40 percent of the CO_2 produced by 76 percent of the cities. Significantly increasing forest areas in and around urban areas means bringing the most effective tool to absorb greenhouse gas to the place where it is produced. But the positive effects of forestation do not end there. Trees are also able to absorb pollutants such as fine dust and, thanks to the shade they provide, they attenuate the "heat island" effect of dense and congested urban centers, cooling the air temperature by 2-3 degrees centigrade and allowing the electricity used for air conditioning in urban interiors to be significantly reduced. In summary, Urban forestation helps to counteract the effects of climate change, reduce energy requirements and positively affect the urban microclimate and the physical and psychological well-being of the world's citizens.

The focus on Urban forestry policies is therefore particularly strong at this

GREEN RIVER
Fiume Verde [Green River] is an urban reforestation project for the redevelopment of the seven abandoned rail freight stations in Milan. The project is intended to create a continuous system of parks, woods, oases, orchards and gardens for public use across 90 percent of the seven stations, linked together by green corridors and cycle paths built on the stretches of railroad tracks. On the remaining 10 percent, high-density urban borders can be built to host activities that are now lacking in Milan's neighborhoods.

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time in history. The awareness-raising work started last year, with the first World Forum on Urban Forests in Mantua, continued with the second forum held at the Milan Triennale and organized jointly with FAO, SISEF and the Milan Polytechnic. Both provided important opportunities to compare urban forestation policies on a global scale, thanks to the contribution of professionals from different disciplines and meetings with representatives of the world of politics and institutions, without neglecting the important dialog with citizens.

Re-establishing a new alliance between Forests and Cities is today a global challenge that requires joint action between networks of cities and multiple countries, collaboration between different disciplines and coordination between various decision-making, political or institutional areas. As in the case of "ForestaMI," a project implemented thanks to a memorandum of understanding between the Municipality of Milan, Città Metropolitana di Milano, Parco Nord Milano and Parco agricolo sud Milano to build a strategic vision of the role of green areas in the Milanese metropolitan area, with the aim of bringing together, developing and enhancing the main green, permeable and tree-lined systems, and the life around them, within the perimeter of the Greater Metropolitan Park by 2030. This ambitious project provides for three million trees to be planted by 2030 and is already achieving remarkable success among business owners, institutions and individual citizens ready to take action to plant the greatest possible number of trees in the city. Milan is therefore doing a great deal to enhance its green infrastructure, which is very significant now that three years have passed since the "Un Fiume Verde per Milano" (a green river for Milan) project was launched, when we were already planning to recover the city's disused freight railroad stations by constructing a continuous linear park across the city, limiting land use and promoting the expansion of green wooded areas.

Grafting green buildings into an established fabric

In our work as an architecture and urban planning firm focused on urban forestry, we are involved in a variety of projects, from developing global visions and master plans, to purely architectural work, including interior and product design.

In urban areas, one of the ways of creating a forestry project is to graft green buildings into the heart of the consolidated urban fabric. This is precise work and reflects the scale of the building of which the planting integrated into the architecture becomes its main feature. The forefather of this approach is the Vertical Forest of Milan, a building designed to be inhabited by trees as much as by human beings that becomes an ecological device to counteract the effects of climate change. This is a new type of urban ecosystem which we are studying, developing and building in different countries, adjusting it to reflect the features of the climate where we find ourselves operating. The projects currently under way, from Nanjing to Utrecht, Cairo, Shanghai, Tirana and Lausanne, are experimenting with different construction technologies, architectural structures and plant selections depending on the project requirements and local environmental characteristics. This multidisciplinary work is made possible by the important collaboration between architects, landscapers, ethologists, agronomists and structural engineers.

Eindhoven in the Netherlands, for example, is building the "Trudo Vertical Forest," a vertical social housing forest providing low cost accommodation for young professionals and new families. The building is located in a formerly redeveloped industrial area and, by optimizing the materials and technologies used, as well as using prefabricated elements, it offers homes at controlled prices and a democratic distribution of green areas, meaning that each terrace contains a natural micro environment consisting of a tree and around 20 bushes.

Another example is the "Forêt Blanche" designed for Paris, which consists of a vertical forest made with a wooden structure. Wood is a material that allows us to continue our research into an increasingly sustainable form of architecture, particularly in terms of the materials used to ensure the least possible environmental impact.

FARINI FREIGHT STATION
Pursuing the concept of urban richness and variety, the Fiume Verde project associates a different scenario with each station. The Farini freight station is designed as a 550.000 m_2 green space, including, among other landscapes, a large lawned area for children (90,000 m_2) inspired by Fulvio Scaparro. Around the parks will be a constellation of large public structures currently lacking in the city, including a mosque.

In addition to the Vertical Woods in various cities of the world, we are currently working on various solutions that integrate nature in urban contexts, from the creation of green infrastructure systems to the establishment of real "forest cities."

In general, the challenge to which cities are called to respond is to exponentially multiply their number of trees, improving air quality and, consequently, the quality of life of their inhabitants: a challenge we must face immediately and all together.

Mitigation/The contribution of forests

Nature Alone Won't Save Us

The forestry and land use sector's efforts to reduce climate change are essential to the planet's survival. How can they be sustained and improved?

GIORGIO VACCHIANO

A researcher in forest management and planning at the State University of Milan, he develops simulation models to support sustainable forest management, mitigation and adaptation to climate change and natural disorders in temperate European forests. He is also a member of the Italian Society of Silviculture and Forest Ecology, the Ecological Society of America and advisor to the Pro Silva Italia Association.

The role of forests in mitigating the climate crisis is scientifically unequivocal. Globally, forests absorb about 2.4 Gt of carbon each year, equivalent to 24 percent of total fossil fuel emissions. Along with oceans, they help reduce the airborne fraction to 44 percent of all CO_2 emitted, removing the remaining 56 percent of emissions from the atmosphere.

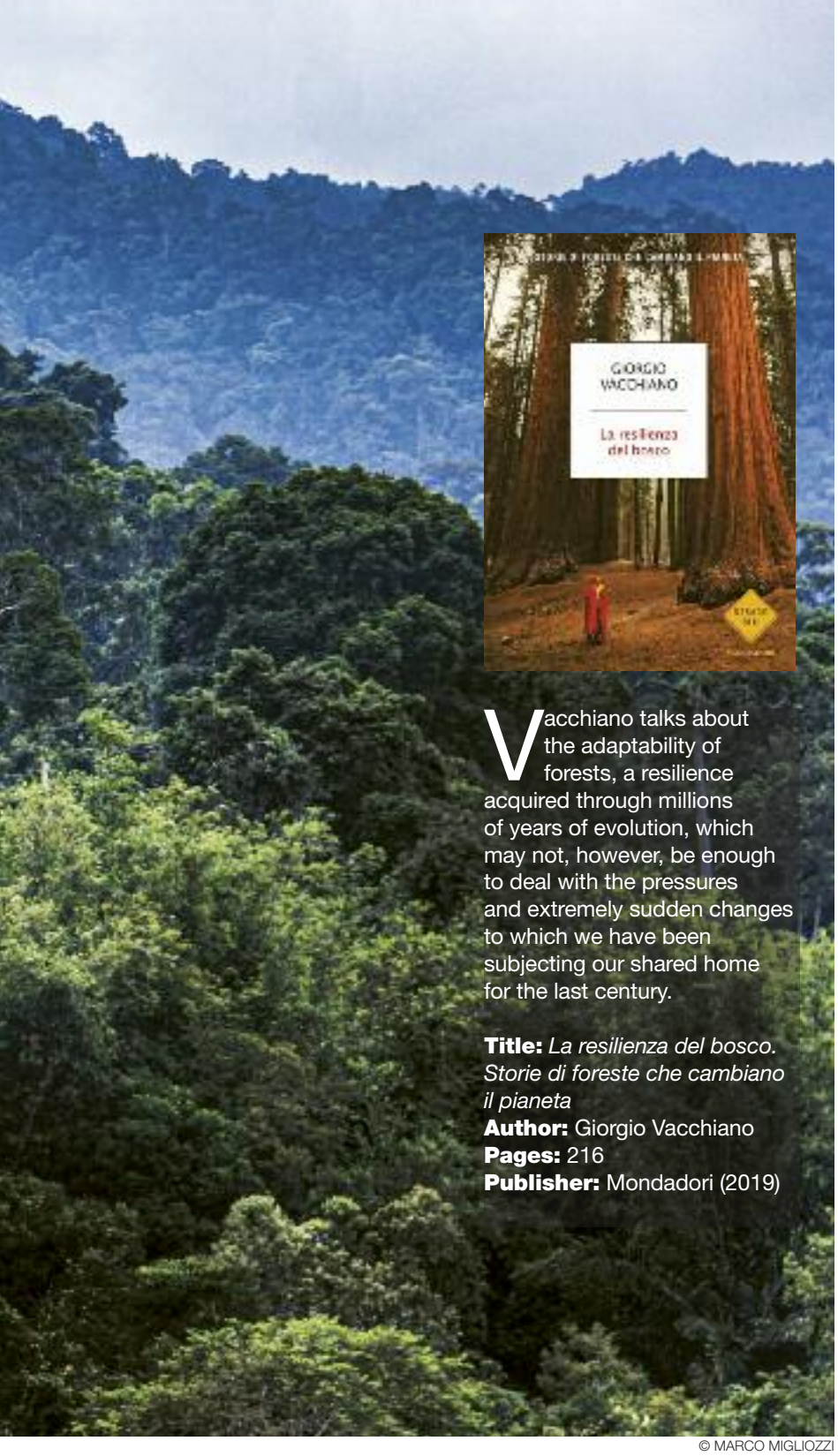
Meanwhile, deforestation, forest degradation, forest fires and other disturbances cause about 10 percent of all carbon emissions released into the atmosphere. The situation is not the same across the globe: while tropical and equatorial forests are subject to deforestation and degradation, the surface area and biomass of temperate and boreal ones are increasing due to the abandonment of marginal lands. This increase is not, however, enough to offset the losses, so the balance is negative. According to the Global Forest Resources Assessment (FRA) by the UN's Food and Agriculture Organization (FAO), our planet's forest cover fell from 31.6 percent in 1990 to 30.6 percent in 2015, with an average annual deforestation rate of around 5 million hectares, an area the size of Piedmont and Lombardy together.

Italy is also a net importer of products responsible for deforestation in a variety of more or less well-known and transparent sectors: soy, meat and animal hides, palm oil, high value timber and wood for bioenergy. The deforestation incorporated into imported products (wood, food and animal hides), added to the one still taking place in Italy, albeit to a lesser extent, almost exactly offsets the spontaneous forestation and reforestation work occurring in the country (currently around 50,000 hectares a year).

According to scenarios developed by the IPCC, in order for global warming to be limited to 1.5 °C, carbon dioxide emissions have to be zeroed between 2050 and 2060. From then onwards, "negative emissions," i.e., re-absorption of part of the CO_2 previously emitted into the atmosphere, will be required. The only technology currently in use to achieve this CO_2 re-absorption is photosynthesis. It is therefore scientifically, politically and economically relevant to ask if and how this contribution by the forestry sector to mitigating climate change can be sustained and improved.

NBSs can achieve a third of mitigation

The most authoritative response in this respect has come from Bronson W. Griscom et al. of James Madison University, who demonstrated in 2017 that Nature-Based Solutions (NBS) can "provide over one-third of the cost-effective climate mitigation needed between now and 2030" (Figure 1). This means two things: we need to reduce the use of fossil fuels—nature alone won't save us. But it can help us, if we play all the cards it offers us right. These solutions include a series of activities involving the conservation, restoration and improvement of vegetation and soil management that increase carbon



Vacchiano talks about the adaptability of forests, a resilience acquired through millions of years of evolution, which may not, however, be enough to deal with the pressures and extremely sudden changes to which we have been subjecting our shared home for the last century.

Title: *La resilienza del bosco. Storie di foreste che cambiano il pianeta*
Author: Giorgio Vacchiano
Pages: 216
Publisher: Mondadori (2019)

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storage or prevent greenhouse gas emissions in forests, wetlands, grasslands and farmland. Griscom estimates a contribution of 10 billion tons of CO_2 per year from reforestation (we emit around 50 every year), but shows twenty other strategies that can absorb carbon even more efficiently and economically: combating deforestation, active and sustainable management of existing forests, use of biochar as a soil improver in agriculture, rationalization of the use of fertilizers, and conservation agriculture (Figure 2).

The United Nations Framework Convention on Climate Change (UNFCCC) requires subscriber countries (197 out of 198) to describe and quantify the emissions and removals of man-made greenhouse gases, including those resulting from changes in land use and active management of agricultural land and forests, where human activity can make the difference to the natural dynamics of ecosystems. This reporting action is based on the method described in the Intergovernmental Panel on Climate Change in 2006. At the same time, every country is required to account for the quantity of emissions and removals of greenhouse gases for which human activities taking place within their territory are responsible, in order to achieve the emission reduction targets set for each country. For the European Union, the target set every year until 2030 provides for a 40 percent reduction in emissions compared with 1990, as required by the Climate and Energy Framework 2014 and the undertakings given under the Paris Agreement of 2015.

The targets set for 2030 are also consistent with the EU Forest Strategy 2013, which suggests improving the mitigation potential of forest resources in member states and reducing CO_2 emissions by recourse to active and planned forestry management and recommending the cascading use of wood (recycling and reusing raw materials and using biomass for energy purposes only when there are no better alternatives).

In November 2019, the European Parliament voted for the Commission to make these targets more ambitious, undertaking to achieve a reduction of 55 percent by 2030 and 100 percent by 2050 as a course of action that would be more compatible with the objectives of the Paris Agreement to limit global warming by the end of the century to well below 2 °C compared to the pre-industrial era.

Ever since the Kyoto Protocol, the international community has agreed that real mitigation can only be achieved when, through changes in human behavior, technology and policy, the greenhouse gas emissions of any sector are reduced (and the removals increased) compared to a basic business-as-usual scenario. The use of this benchmark eliminates the effects of natural variations in emissions and removals, such as may be due to forest aging, which generally slows down physiological activity, and guarantees that the benefits of mitigation are actually the result of behavioral changes, rather than simply the consequence of ecosystem processes that would have occurred in any case. This "additionality" criterion ensures that carbon removals by ecosystems are correctly attributed and economically valued.

The 2018 European Regulation

This additionality criterion was developed further by Regulation 2018/841, approved by the European Parliament on April 17, 2018, on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework. According to this regulation, emissions and removals must include live biomass, dead wood and carbon stored in forest timber products. The carbon flows of soil and litter (the other two forest reservoirs recognized by the IPCC, which often contain over half the carbon in forest ecosystems) can be ignored, provided that these sectors do not result in net emissions. Furthermore, the regulation requires each country to set a Forest Reference Level (FRL) for the period 2021-2030 based on the continuation of forest management practices documented for the reference period 2000-2009. The FRL therefore excludes the expected effects of any economic or energy policies, or the expected variations for the wood products market, which will then be accounted for a posteriori, resulting in a credit (if the carbon stored in forest reservoirs is greater than the reference level) or vice versa in a debit for the country in question. According to a recent analysis of possible reference levels on a European scale, the aging of European forests will lead to a 12-percent increase in wood harvesting, assuming that current management practices continue unchanged, but this increase is fully compatible with maintaining the carbon sink of the forest sector during the accounting period.

The credits generated by the land use, land-use change, and forestry (LULUCF) sector (including forests) can be used to offset any debits in other sectors (Effort Sharing Regulation), but only up to the maximum ceiling, which, for Italy for example, is set at 11.5 Mt CO_2 and, over 10 years, an average annual level of 3-6 percent of CO_2 removals generated annually by Italian forests (considering 100 percent of forest cover to be actively managed). Removals above this limit can be transferred to the next accounting period or to other EU member states that have recorded a debit in the forest sector.

This limit does not, however, apply to the carbon accumulated in dead wood (which is an important element for forest biodiversity) and in timber products, thus encouraging the use of timber resources as construction material, where carbon can remain stored for a long time and replace products with higher emission rates. In Italy, this might promote the development of mitigation strategies related to the use of timber for industrial purposes, which is produced in smaller quantities than fuel wood (16 percent of wood production in 2016), and therefore promote the effects of replacing other materials. A recent compendium of 52 scientific studies demonstrated that in all sectors, the replacement factor (CO_2 emissions avoided kg of timber used as a replacement for other materials) is on average 1.2 kgC/kgC. The new regulations can therefore promote the adoption of specific mitigation tools and the assessment of public and private investments to reduce carbon emissions in the forest sector.

In the Italian context, for example, carbon sequestration is one of the potentially remunerated services under the payment schemes for environmental services. The existence of a very low ceiling for the accounting of carbon credits that can be used to offset the emissions of other sectors could therefore provide renewed stimulus to the national voluntary carbon credit markets, which are currently still largely aimed at offsetting operations that take place in third countries.

By December 31, 2019, Italy is required to present its National Forestry Accounting Plan, stating the forest reference level for 2021-2025; a second proposal must be presented by June 30, 2023 for the period 2026-2030. Italian forests and the 12 billion trees they contain currently absorb around →

10 percent of the total emissions generated by the country. Between 1990 and 2015, they absorbed a maximum of 39 Mt of CO_2 per year. One percent of the carbon emitted is also sequestered within timber products, a percentage that is in line with the level across Europe. By the end of 2019, the country will also be introducing the new National Forestry Strategy under Legislative Decree 34/2018, the consolidation act on forests and forest supply chains. The NFAP predicts use to increase by about one third during the accounting period, compared to current levels. The Strategy also aims to sustainably intensify the wood harvest, currently stationery on 20-25 percent of the annual increase, due to a lack of investment in the forest sector in the country, which has led to 80 percent of the demand for wood being satisfied with imports from abroad, which, as we have seen, are not exempt from long-distance impacts on carbon, biodiversity and the environment.

The critical importance of accounting rules

The current international rules for reporting and accounting and the simplifications they entail may, however, give rise to uneven accounting depending on the assumptions made (for example, on the geographical and functional limits of the system examined), which fail to reflect the actual effects on the atmosphere. For example, previous IPCC reporting guidelines assumed that the carbon flow from the forest to wood products was balanced against the emissions of wood products at the end of their life cycle, and that in fact all the carbon taken from the forest ecosystems was instantly oxidized in the atmosphere. This simplification has led to an incorrect perception of the impacts of forestry management on the balance of greenhouse gases and removed incentives to prolong the carbon retention time in timber products.

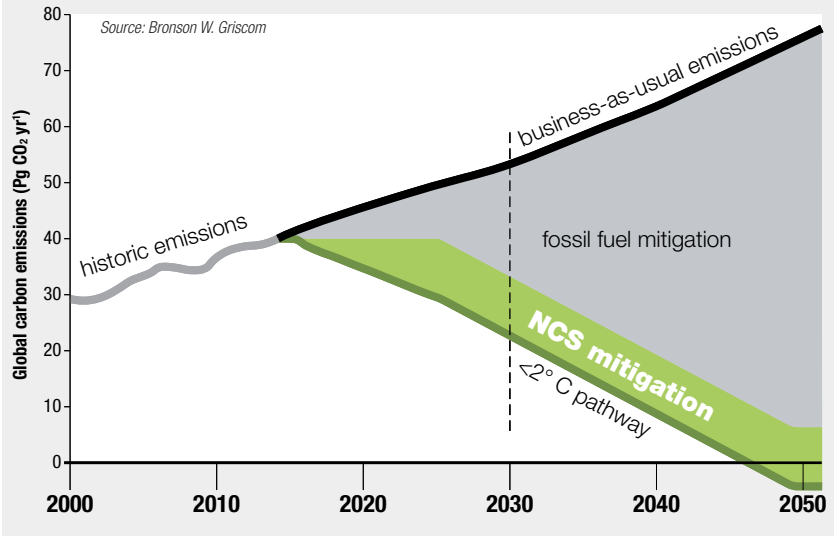
Likewise, an analysis of the life cycle of biomass used for energy production has meant that the activity does not impact on the forest carbon balance because the carbon emitted by combustion is reabsorbed by the existing forest surface in its biological cycle. Internationally, the emissions associated with harvesting wood for biomass must be accounted for in the country where the removal takes place, so the importing country can state that the imported biomass is carbon neutral. Globally, total emissions are fully accounted for, but this simplification fails to verify the impacts of how the wood is removed from the carbon stick of the forest ecosystem. On the contrary, the choice of raw material, the ecosystem of origin, the method used to cut down the trees and the distance from the point of use can have a significant influence on the extent and timing of the mitigation. This kind of accounting can therefore lead to decisions that fail to maximize the benefits of mitigation on climate change.

The analysis of mitigation options should instead be based on an integrated approach that considers the effects on carbon and greenhouse gas flows of three interconnected systems: forest ecosystems, wood products and other sectors, following the replacement of emission-intensive products such as cement, steel, plastic or fossil fuels. Mitigation efforts that aim to increase carbon uptake in one of these three sectors usually result in carbon reductions in one of the other two: for example, conservation measures aimed at reducing wood harvest rates increase carbon stored in tree biomass, but at the expense of carbon sequestrated from wood products or the benefits of substitution, causing an increase in emissions from fossil fuels and cement.

A special case is the use of live tree wood for the production and export of bioenergy pellets. Especially when production is not cascaded (e.g., by using the wood waste that would otherwise be unused) this activity has strong negative impacts on the greenhouse gas balance of the exporting country, while the importing country rarely manages to achieve a net reduction in actual emissions, due to the greater energy intensity of fossil fuels compared to biomass.

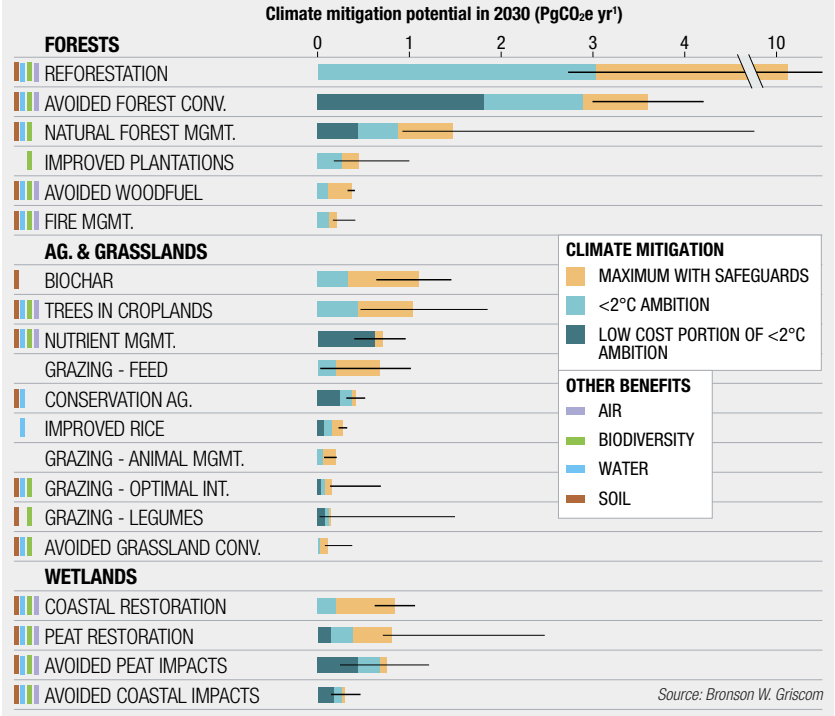
Recent research on the mitigation benefits of the entire forestry sector in Canada, Sweden and Switzerland has shown that the best strategy is to maximize the substitution effects with long-lasting wood products. When these are extracted through sustainable forest management, the benefit in terms of absorption fully offsets the decrease in carbon sequestered in forest biomass. Moreover, for these countries, the benefits of mitigation increase over time: as the states examined are not subject to deforestation, the potential of the forest sector to contribute to the reduction of greenhouse gas emissions in the short term is limited. In countries with high deforestation rates, obviously, short-term emission reductions can be achieved effectively through strategies to reduce deforestation. For example, while in the European Union, the LULUCF sector represents only one percent of the emission reductions included in the Nationally Determined Contributions proposed to comply with the objectives of the Paris agreement, this percentage rises to 42 percent for Russia, 60 percent for Indonesia and 122 percent for Brazil. To conclude, while the LULUCF sector, including forests, cannot on its own achieve all the emission mitigation needed to reach the goals of the Paris agreement, it is nonetheless a fundamental contributor to those "negative emissions" that will be needed from 2050 onwards. Its contribution is not limited to the planting of new forests (effective if done correctly, but expensive) or to the fight against deforestation (currently the single most effective and economical measure), but also the sustainable management of existing forests, especially by leveraging the effects of replacing wood as a long-lasting material with high technological performance. Italy, with the help of research, and in particular forest modeling, will need to quantify precisely the benefits achievable as a result of the actions envisaged by the new National Forest Strategy: sustainable intensification of forest uses, increase in investments in the sector and in forest supply chains, increase in the quantity of forests subject to planning, implementation of payment schemes for ecosystem services (also with the involvement of companies), and improvement of the resistance and resilience of forests to extreme events, to avoid unexpected carbon emissions associated with the impacts of climate change on fires and wind damage to forests.

1. CONTRIBUTION MADE TO MITIGATION BY NBSs



According to a 2017 study by James Madison University, nature-based solutions can provide over one-third of the cost-effective climate mitigation needed between now and 2030.

2. EFFECTIVENESS AND COST OF IMPLEMENTING NBSs



Reforestation can make a contribution to mitigation equal to 10 billion tons of CO_2 per year, but there are twenty strategies that can absorb carbon more efficiently and economically: from fighting deforestation to using conservation agriculture.

Beijing in Pole Position

Together with India, China is a leader in the world's afforestation efforts. Its commitment to restoring forest cover and urban greening has shown significant results

LI LIFAN

He is associate research professor at the Shanghai Academy of Social Sciences and Secretary General of Center for Shanghai Cooperation Organization Studies.

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NASA researchers published a paper in a recent issue of *Nature Sustainability* that found, based on the analysis of NASA satellite observations, that the global green area increased by five percent between 2000 and 2017. While China and India account for only nine percent of the world's total vegetation area, their contribution to the increase in global green reached about 33 percent. China's contribution alone accounts for about 25 percent of the increase in global greening. Analysis shows that 42 percent of China's contribution comes from afforestation and forestation and 32 percent from intensive agriculture; in contrast, 82 percent of India's contribution comes from intensive agriculture, an approach that allows people to grow more crops on the same area of land. China has largely improved the vegetation coverage of degraded land through effective ecological engineering governance. The contribution rate of global land improvement and restoration amounts to 19.13 percent. On November 22, 2019, China's Ministry of Science and Technology released the Annual Report "Global Ecological Environment Remote Sensing Monitoring 2019." The report revealed that China attaches great importance to afforestation. Using developed forestry science and technology, China has grown its area of artificial afforestation to the point where it ranked first in the world from 2000 to 2018, a period in which its forest growth rate was 26.90 percent. The ecological protection provided by national forest parks is remarkable and is the main factor for the increase of forest area in China.

Chinese commitments to environmental protection

China's green environmental protection projects mainly include atmospheric governance, terrestrial ecology, forest conservation, environmental restoration, municipal greening, green buildings and intensive agriculture: First, China has strengthened terrestrial ecology and actively responds to climate change. On April 17, 2018, Chinese scholars published seven research papers online in the internationally renowned academic journal *Proceedings of the National Academy of Sciences* (PNAS), which comprehensively and systematically reported the structure and functional characteristics of China's terrestrial ecosystem and its impact on climate. According to these papers, during the period 2001-2010, the average annual carbon sequestration in terrestrial ecosystems was 201 million tons, equivalent to offsetting 14.1 percent of China's fossil fuel carbon emissions during the same period. The main body contributed about 80 percent of carbon sequestration, while farmland and shrub ecosystems contributed 12 percent and 8 percent respectively. The carbon balance of grassland ecosystems was basically in equilibrium. In addition, China has improved the carbon sequestration capacity of terrestrial ecosystems through effective interventions. For example, major ecological projects in →

TREND IN ANNUAL AVERAGE LEAF AREA

(% per decade, 2000-2017)

IN CHINA AND INDIA

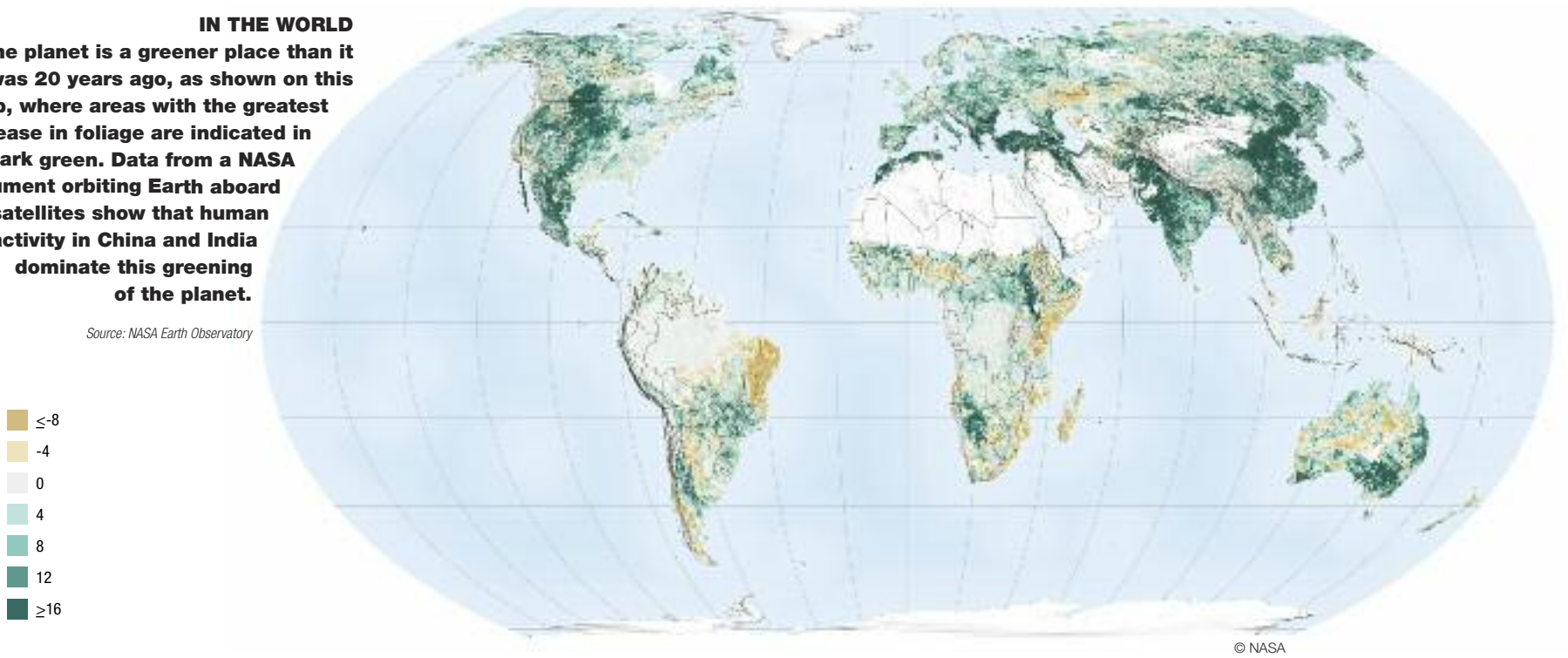
Over the last two decades, the Earth has seen an increase in foliage around the planet, measured in average leaf area per year on plants and trees. Data from NASA satellites shows that China and India are leading the increase in greening on land. The effect stems mainly from ambitious tree planting programs in China and intensive agriculture in both countries.

© NASA

IN THE WORLD

The planet is a greener place than it was 20 years ago, as shown on this map, where areas with the greatest increase in foliage are indicated in dark green. Data from a NASA instrument orbiting Earth aboard two satellites show that human activity in China and India dominate this greening of the planet.

Source: NASA Earth Observatory



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China, including natural forest protection projects, returning farmland to forests projects, returning farmland to grasslands projects, and riverside shelter forest projects, have contributed 36.8 percent (7.4 million tons) of total carbon sequestration in China's terrestrial ecosystems.

Second, measures are being taken to ensure the ability of forestry and grassland to respond to climate change through policies. On November 19, 2019, the State Forestry and Grassland Bureau (SFGB) issued a white paper entitled "Forestry and Grassland Climate Change Policies and Actions in 2018," meanwhile implementing "Strengthening Actions against Climate Change-China's National Independent Contributions" issued by the State Council, "Working plan for controlling greenhouse gas emissions," "Key points of forestry response to climate change during the 13th Five-Year Plan," and "Forestry Adaptation to Climate Change Action Plan (2016-2017)." These and other programs solidly promote the innovative development of forestry and grassland response to climate change and have contributed to progress made in many areas.

In the "Outline of the National Forest Land Protection and Utilization Plan (2010-2020)," the total amount of forest land used in construction projects has been controlled. Supervision of and innovation of the forest resource produces a new mechanism. China has promoted the establishment of a normalized supervision and enforcement mechanism, the first application of which combines remote sensing technology and ground-level on-site verification. This combined approach inspects 3043 county-level units' forest resource management and investigates illegal forest land use such as some logging, which destroyed forest resources in order to reduce resource losses. According to the National Forest Fire Prevention Plan (2016-2025), in 2018, a central budget of 1.7 billion RMB (217 million euros) was invested to implement nearly 140 types of forest and grassland fire prevention infrastructure projects and to build and maintain 12,000 kilometers of forest and grassland border fire isolation zones. Forest and grassland fire prevention and control capabilities have been improved and the number and loss from fires have been significantly reduced.Third, China has supported National Afforestation and its forest restoration has produced world-renowned achievements. The forest coverage rate has increased from 8.6 percent in the early days of the founding of New China to 21.66 percent, and the forest area has reached 208 million hectares. The area of planted forest conservation has reached 69.33 million hectares, ranking first in the world. China's has committed to forest restoration and sustainable development, improvement of the quality and stability of ecosystems and accelerated construction of an ecological security system, with forest and grass vegetation as its main body. China's plans include a forest coverage rate of 26 percent by 2035. At present, China is studying and formulating guidance on large-scale land greening operations that scientifically and in an orderly manner guides all localities and departments in the promotion of large-scale land greening operations.

A fundamental focus on urban greening

Fourth, China has actively adopted urban greening to improve its ability to cope with the greenhouse effect. The greening department has adopted measures such as house demolition, green construction and roof planting to comprehensively strengthen the greening of urban leisure parks, countryside recreation parks, urban roads and water systems. According to statistics, the green coverage area of urban built-up areas nationwide has reached 135.65 million hectares, or 37.37 percent of built-up areas, the green space rate is 33.29 percent and the per capita urban park has a green area of 9.71 square meters. In addition, China has actively promoted the greening of corridors in the transportation, railway, and water conservancy systems. The national highway greening mileage reached 1.677 million kilometers, accounting for 57.3 percent of the national highway greening mileage. At present, China's economy is developing rapidly, the pace of urbanization is gradually accelerating and the demand for landscaping has

greatly increased. In 2017, China's urban built-up area covered an area of about 2.325 million hectares and the green area of the built-up area was about 2.116 million hectares. The green coverage rate of the built-up area reached 40.52 percent.

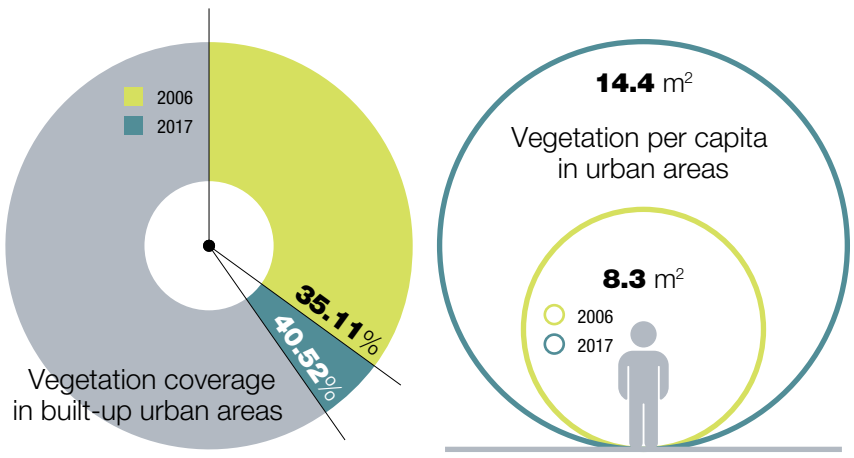
Fifth, China has strengthened green urban buildings. China's green building is an obvious improvement. At the end of 2017, there were 10,927 green building projects nationwide, an increase of more than 3000 from the previous year, and a green buildings' area of more than 1 billion square meters. In terms of scale, China's green buildings are equal to those of the advanced countries. China has more than 60 green standards and specifications, which are very detailed in content. In recent years, China has been promoting the construction of green buildings in cities. If we take Japan as a model, we see that vigorously developing green buildings can maximize the use of resources, minimize the impact on the environment and promote the optimization and upgrading of the construction industry. Sixth, China hopes to slow down the ecological degradation of farmland and grasslands. In the past ten years, China has focussed on farmland protection forests and the greening of villages and towns and vigorously promoted the greening of reclamation areas. The state implements major grassland ecological construction projects and centrally manages ecologically fragile and severely degraded grasslands, actions which have effectively curbed the momentum of accelerated degradation of grassland ecology across the country. Grassland ecology has improved significantly in some areas and all regions have stepped up efforts to protect and construct grasslands. The country has 62 million hectares of grassland fences, 98.67 million hectares of grazing bans, and a total of 28.67 million hectares of reserved grass.

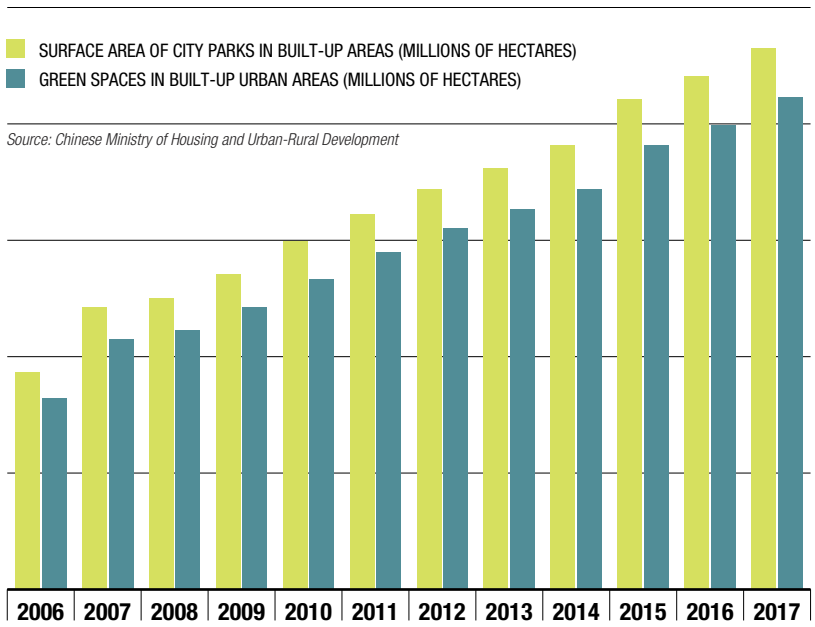
Problems with green governance in China

Although China has made remarkable achievements in afforestation and greening, there are still some outstanding problems in accelerating afforestation and greening for the future.

First, China has to face that the difficulty of afforestation of the existing suitable forest land has increased. 60 percent of the existing suitable forest land is distributed in Inner Mongolia and another five provinces in northwestern China, areas where drought, rocky desertification, and desertification are serious problems, making afforestation more difficult. China's forest area per unit area is 85.88 cubic meters per hectare, only 78 percent of the world average.

GREEN SPACES IN CHINESE CITIES, 2006-2017





Second, the design of urban green space is backward in China, and the design method is monotonous. For a long time, China's planning of urban green space has been weak. The common practice of Chinese cities in terms of design is to consider green space only after the city's planning is basically finalized. Further, attention was paid only to the two hard indicators of "per capita public green space area" and "urban green space rate," but without consideration of whether green space is convenient for urban residents to use and coordinated with the surrounding environment. Third, China has to recognize the uneven development of urban greening, especially the lagging development of urban greening in the western region. In addition, extreme climatic phenomena, such as the continuous large-scale drought in recent years, increased the difficulty of land greening and adversely affected the consolidation of greening. Fourth, China must face the high expense of urban greening as an important factor affecting the increase of urban green area is higher costs. During urban greening project construction, it is both necessary to purchase a large amount of vegetation and increase investment in human resources. At the same time, in order to give full play to the role of urban greening projects, people have to increase management efforts in the later stages. In 2014, major cities in China were actively constructing greening projects, about 238 billion RMB was used in the construction of urban landscaping projects and this part of the investment accounted for close to 50 percent of the total environmental infrastructure investment. Fifth, China faces the increase of an urban green area that will damage the original ecological environment. From the perspective of overall urban development and science, promoting the increase of urban green area does not necessarily promote the healthy development of a city. For example, the western region of China has severe water shortages and droughts and during the construction of greening projects large amounts of water are usually consumed. Therefore, expanding the greening area in this part of the region will not only increase the cost of water, it is more likely to cause the depletion of water resources. Therefore, if a large area of green land is planted locally, it will not only reduce the daily water consumption available to local residents but also cause serious damage to the original ecological water source.

How to strengthen green governance

Going forward, in order to achieve a sophisticated approach to coping with climate change and urbanization, China should actively increase the area of urban greening, and in the process of achieving energy conservation and emission reduction goals, the following measures can be fully applied:

First, learn from overseas experiences, such as those from France and Italy, and integrate three-dimensional landscape design with modern garden greening design concepts, an approach that greatly increases the utilization of only green areas. It not only provides a satisfying three-dimensional landscape effect and thereby gives people more visual enjoyment, but at the same time promotes the greening surface area and makes an important contribution to controlling urban pollution. Second, scientifically plan and manage the landscape greening of urban residential quarters. In the process of effectively protecting the urban environment, we should also increase the utilization of green areas on urban roads. From the perspective of the overall green area of the city, 35 percent to 40 percent of the total being urban road green area speaks to its key importance. Finally, China needs to strengthen technological innovation. According to the National Forestry and Grassland Long-term Scientific Research Base Plan (2018-2035), the first batch of 50 long-term scientific research bases will be established. The total number of national terrestrial ecosystem positioning observation and research stations involving the forestry and grassland industries has risen to 190, forming an observation and research network that basically covers the main ecological regions of the country. It should encourage innovation in green forestry and speed up the promotion and application of new technologies and new achievements such as improved varieties and high-yield cultivation techniques, forest management techniques, ecological restoration and pest control.

China should also continue to actively explore scientific measures to save energy resources, protect the ecological environment, promote national green governance and achieve sustainable social development.

EU/The Land Use and Forestry Sector in the Climate and Energy Framework for 2030

Enhanced Ambition

In the EU, the land use, land-use change and forestry sector has been a relatively stable net sink of GHGs. However, as the demand for timber and biomass increases because of the need to switch from fossil fuel-based energy to energy produced from renewable sources, this carbon sink is at risk of declining

A satellite image of Europe; the urban areas are illuminated, while the green areas are dark.

SEITA ROMPPANEN

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Forests play an essential role in meeting the climate goals agreed in Paris in 2015. The Paris Agreement aims to hold the increase in the global average temperature to below 2 °C and to pursue efforts to limit the temperature increase to 1.5 °C. It also requires its parties to take concrete steps to conserve and enhance zero greenhouse gas (GHG) sinks and reservoirs. About one-third of anthropogenic CO_2 emissions are removed by terrestrial ecosystems, mainly forests. When this carbon sink is reduced due to natural causes such as forest fires, or due to human activities such as deforestation, the carbon stored is released back into the atmosphere, thereby accelerating climate change. In the EU, the land use, land-use change and forestry (LULUCF) sector has been a relatively stable net sink of GHGs. However, it has been projected that as the demand for timber and biomass increases because of the need to switch from fossil fuel-based energy to energy produced from renewable sources, this carbon sink also risks declining in the EU. This is a cause of concern as the Paris Agreement's temperature goal requires reaching and sustaining net zero global anthropogenic CO_2 emissions between 2050-2075, and negative emissions (i.e., removal of CO_2 from the atmosphere) by the end of this century. Forest management represents a scientifically feasible and cost-effective way of removing carbon from the atmosphere, whereas other negative emissions technologies such as bioenergy with carbon capture and storage remain unproven.

The no-debit rule at the heart of the LULUCF Regulation

In 2014*, the EU agreed that all sectors should contribute to the EU's 2030 emission reduction target, including the land use sector. The LULUCF Regulation adopted in May 2018 creates a third pillar under the EU 2030 climate and energy policy framework, complementing the existing two pillars made of the EU Emissions Trading System (EU ETS) that covers energy-intensive industries and the power sector, and the regulation of the non-ETS sectors under the Effort-Sharing Regulation. The Regulation is a part of the EU's revised legal framework to implement its Nationally Determined Contribution under the Paris Agreement. The Regulation will apply from January 2021 onwards and follows two compliance periods: 2021-2025 and 2026-2030. In October 2014, the European Council agreed that by 2030 the EU would reduce GHG emissions by at least 40 percent from 1990 levels, increase the share of renewable energy in final energy consumption to at least 32 percent →

Emission trends

GHG emissions decreased in the majority of sectors between 1990 and 2016, with t he notable exception of avion transport. Since 2000, the net reported annual LULUCF sink has averaged 320 $MtCO_2e$, with an unfavorable declining trend over recent years. According to the EU Reference Scenario 2016, the net reported LULUCF sink in the EU is expected to shrink by about 10% between 2010 and 2020.

Source: European Environment Agency

and improve energy efficiency by at least 27 percent compared to 2005. The LULUCF Regulation is built around the so-called no-debit rule that requires EU Member States to ensure that emissions from the LULUCF sector do not exceed removals from 2021 to 2030. In other words, the LULUCF sector may not become a net source of GHG emissions. For the Member States to comply with the legally binding no-debit rule, the Regulation lays down further rules for the accounting of emissions and removals from LULUCF as well as for checking Member States' compliance with the rules. Although the no-debit rule is a central starting point, the new LULUCF regulation neither prohibits EU Member States from reducing their sinks nor pushes them to increase them.

Compliance towards the no-debit rule is measured through a land-based approach to accounting. There are five land accounting categories under the Regulation: afforested and forested land, managed cropland, grassland and wetland, managed forest land, harvested wood products and natural disturbances. A land-based approach considers the change in the carbon stock in all carbon pools on all land areas.

Flexibilities can help the Member States comply with the no-debit rule

The Regulation provides for general flexibilities and for a specified managed forest land flexibility. Flexibilities, for example, enable Member States to use allocations from the Effort Sharing sectors to meet their commitments. Member States can buy and sell net removals from and to other Member States, balance emissions from one land category against removals in another within the LULUCF sector and enhance removals or reduce emissions in the LULUCF sector to support compliance in other sectors. Member States may also bank net removals from the first to the second compliance period.

Wetlands and biomass

The LULUCF Regulation makes accounting of managed wetlands mandatory from the second compliance period onwards. Reporting is required during the first period for all Member States. Wetlands are effective ecosystems for storing and sequestering carbon and their inclusion should be an incentive for Member States to develop new measures on wetlands such as restoring previously drained peatlands.

The inclusion of emissions in the accounting of the use of biomass for energy is another first for the LULUCF Regulation—these emissions can be counted as zero in the energy sector if they are measured in the LULUCF sector. Forest biomass is set to play a key role on the European energy transition agenda, but its use in energy should be facilitated only if it is sustainable and contributes to climate mitigation. Overall, forest-based bioenergy is an important and underlying issue for the Regulation.

The controversy over the accounting for emissions and removals from managed forest land

The legal provision that has gained the most attention concerns the accounting of emissions and removals from managed forest land is the Forest Reference Level (FRL) that is included in the National Forestry Accounting Plans (NFAPs) and required by the Regulation. In many ways, the FRL is the Regulation's key regulatory instrument. In principle, the FRL compares the level and size of forest carbon to an earlier point in time. The LULUCF Regulation is an instrument that urges Member States to harness the climate mitigation

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potential vested in forest management in a way that compromises neither climate efforts nor national plans that boost the growth of bio-based economies. The FRLs are at the heart of making this balance happen. Guided by the loose criteria under the Regulation and a non-binding Guidance Document, the Member States were requested to calculate their own FRLs in their NFAPs (for the first compliance period) and submit this proposal to the European Commission by the end of 2018. The Commission undertook a technical assessment to determine whether the proposed FRLs meet the requirements under the Regulation and subsequently proposed revisions. All Member States that had submitted their FRLs by the set deadline received proposals for revisions; they have until the end of 2019 to submit their revised FRLs, after which the Commission confirms the FRLs to be applied by the Member States.

The provision on FRL must be interpreted in the context of the rest of the article, which includes other relevant articles, recitals and annexes in the LULUCF Regulation. The Regulation guides the rather wide discretion and flexibility given to the Member States to establish FRLs through a set of preconditions that relate to continuity, sustainability of forest management practices, age-related characteristics and the overarching objective to maintain or strengthen long-term carbon deposits.

Centrally, according to the Regulation's Article 8, the FRL is tied to the continuation of sustainable forest management practices as they were documented in 2000-2009. The Regulation assumes that projected forest management practices, including harvest volumes, will not substantially change from the reference period but will continue as they were in 2000-2009. With "continuity" as the starting point, the objective of the FRL is to transparently, completely and consistently reflect the impacts of changes in forest management practices in relation to the reference period. Furthermore, due to national circumstances as well as the differences in the way forests develop and are managed in Member States, the Regulation does not exhaustively define sustainable forest management practices. These practices refer to all activities to manage a forest and to practices that are aimed at fulfilling specific functions in a forest over time. Such activities could include planting of trees, the schedule and intensity of harvesting, and final cut.

Finally, as the age-related characteristics of a forest vary during the compliance period, forest management practices may need to be adapted. For example, the total harvest volume can fluctuate from year to year and can also differ from the total harvest volume during the reference period as the forest reaches harvest maturity. But the Member States are required to demonstrate through their FRLs how the age-related characteristics develop in the forest over time.

FRLs need to be in line with other imperative requirements of the Regulation

The LULUCF Regulation contains several clear references to the need to maintain, enhance and strengthen sinks in the context of the EU's long-term climate strategy. Managed forest land flexibility allows Member States to temporarily increase their harvest intensity in accordance with sustainable forest management practices, provided that this increase is consistent with the Paris Agreement's objective and the EU collectively meets its no-debit rule. The purpose of the flexibilities is to help Member States meet their no-debit commitment rather than to compromise the EU's GHG emission reduction targets. If a Member State increases its harvests in the short-term beyond what is assumed under the continuation of sustainable forest management practices, the increase would likely need to be justified both in light of the climate targets and because otherwise the Member State could not maintain and enhance the sink in the long term.

Moreover, actions taken within the LULUCF sector and actions within other sectors are interrelated. If the FRL is met or exceeded through the removal of emissions, the excess can be used to offset emissions in another land use category or in the Effort Sharing sectors. From a climate perspective, a reduction in the forest sink leads to more CO_2 emissions, even if forests are managed sustainably. If the LULUCF sector is a source of emissions, it must be compensated for by action in other sectors. If a Member State allows its sink to decline in the long term, it is required to compensate for this decline elsewhere through, for instance, stronger emission reductions in sectors such as transport or agriculture.

The Regulation gives the EU Member States considerable room for discretion in sustainable forest management but also trusts that climate impacts of the decisions made are accounted for in a transparent and reliable manner. The aim of the FRL is not to constrain the future forest management practices in the Member States, who retain their freedom to pursue and develop national management practices they consider appropriate under prevailing regulatory conditions. The process of determining the FRLs affords Member States the opportunity to imbue sustainable forest management with content that not only enables full compliance with the no-debit commitment but also addresses the need to maintain or strengthen long-term carbon sinks.

The Regulation is a work in progress toward enhanced climate ambition

Member States are required to report the balance of total emissions and total removals from the LULUCF sector to the Commission for its review. The Regulation entitles the Commission to make proposals, based on the compliance check, to ensure that the integrity of the EU's overall 2030 GHG reduction target and its contribution to the Paris goals are respected. In fact, the Regulation's review clause is explicitly tied to the Paris Agreement's long-term goals and ambition mechanism. In this context, the Commission is entitled to make proposals for additional EU policies and measures, in view of a necessary increase in GHG emission reductions and removals.

The Regulation is a dynamic legislative instrument whose exact working will develop along with its implementation. However, together with the overarching urgency to tackle climate change through cross-cutting and holistic approaches, the Regulation centrally underlines the need to craft progressive and ambitious climate policies in relation to forests.

* In October 2014, the European Council agreed that the EU would by 2030:
(1) reduce GHG emissions by at least 40% (from 1990 levels);
(2) increase the share of renewable energy in final energy consumption to at least 32%);
(3) improve energy efficiency by at least 27% (compared to 2005).

Regulations/The legislative path to environmental protection

On the Front Line

The European Union's active and innovative forestry policy is a success story that demonstrates its ability to build policies not expressly addressed in treaties and to rely instead on participation with supranational organizations

ROBERTO DI GIOVAN PAOLO

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Europe. A continent inhabited for centuries and densely populated. It may be surprising to talk about forests in a continent with so much history, but the European Union's commitment to forests and to everything that revolves around them, in terms of work, commitment to energy use and respect for the environment, demonstrates how the EU succeeds in building policies even when they are not expressly stated in treaties. In fact, both the founding treaties and the reforming treaties written do not expressly mention forests, so there is no obligation to build a common forestry policy. Thus, European actions are "voluntary" and leave responsibility in the hands of nation states. This absence of any mention of forests in treaties (apart from the EU's joint commitments to third countries) is mainly due to the fact that in the past there was less willingness to engage in joint projects and that the focus was on building a union between states rather than a federation, as is the case today. Above all, however, the absence was due to the fact that the definition of a forest differs in each of the member states. Indeed, the Eurostat uses a classification system created by the United Nations with its Food and Agriculture Organization (FAO), which says that a forest is "land with tree cover or density equivalent to more than 10 percent and a surface area of over 0.5 hectares; the trees should reach a minimum height of 5 m in situ in the mature phase." This definition has been commonly used in the European Union and accepted because it is attributable to a supranational body (the UNFAO) of which all EU countries are members. However, and fortunately, considering the importance of forests and wooded areas in Europe, over time both the European Parliament (since 1997) and the European Commission (at the beginning of this century) have presented and approved documents to harmonize the different policies of individual countries, thus respecting the treaty literally but, in substance, also putting the EU in a position to have an increasingly committed forest policy, especially in view of the progress made by the various COP meetings on climate change, and particularly, of course, the decisive one held in December 2015 in Paris.

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The extent of European forests

To date, European Union forests extend over 182 million hectares, which represent 5 percent of the world surface and cover 43 percent of Europe's land area; the six member states with the largest forest cover are Sweden, Finland, Spain, France, Germany and Poland and represent two thirds of European forest areas. Obviously, their importance varies considerably and therefore, while more than 60 percent of Finland, Sweden and Slovenia are covered by forests, this proportion drops considerably in other states such as the Netherlands and the United Kingdom, where it is only 11 percent.

It is worth noting the steady improvement in the reforestation trend, as a result of which European Union land covered by forests grew between 1990 and 2010 by about 11 million hectares, thanks to natural expansion but also reforestation work. This trend has been growing further in recent years, particularly in view of the greater attention paid to the environment and climate change.

The European Union's increasing focus on forests, while having to respect the letter of treaties but in substance earmarking funds based on joint international commitments, is obviously also due to the multifunctional nature of forests. Forests play a role both environmentally and as an ecosystem, contributing to protect the soil, participating in the water cycle and helping to regulate the local climate, thereby also participating in global climate control. They are also a place of work and the source of considerable socioeconomic value. The use of forests generates resources, especially timber: of the 182 million hectares of forests, 134 million are available for wood production, the main use of which is to generate energy, with 42 percent of it being used for this purpose. 24 percent ends up in sawmills, 17 percent feeds the paper industry and 12 percent is turned into panels. Roughly half of the renewable energy used in the EU comes from wood. Forests don't stop there. They supply industrial products that are not associated with wood, e.g., food, cork, resins and oils. They play in important role in the leisure, hunting and tourism industries. In employment terms, this represents about 1 percent of the European Union's GDP (5 percent in Finland) and provides jobs for 2.6 million people.

Focus on specific actions in the forestry sector

As mentioned above, apart from the basic documents drafted by the European Parliament in the late 1990s and the European Commission at the beginning of 2000 on the possibility of joint action, and despite the absence of an EU-wide legislative structural reference until September 2013, and the existence of a constantly updated multi-year action plan that started with the 2015 forest strategy, there is now a more general focus that establishes a list of specific actions to respond to challenges in the European forestry sector. The focus is mainly on the Common Agricultural Policy (CAP), which is the main source of European funding for forests. Around 90 percent of EU funds come from the European Rural Development Fund (ERDF), launched during the 2000-2013 programming period, in which about 5.4 billion euros were allocated through the co-financing of specific measures in the forestry sector. For the current period, 2014-2020, a single specific measure has been created that includes all aid for forestry investments, one which has benefited from increased funds compared to the previous major commitment. Alongside its commitment on the ground, the European Union has also undertaken a series of initiatives through a directive, renewed every year since 1999, on the marketing of forest reproductive material and plant health control.

In addition to the structural funds, there are specific programs such as the "Horizon 2020" program, which provides for the legally binding target of increasing the share of renewable energy in total energy consumption to 20 percent. There is also a provision included in the new EU framework that follows on from the COP25 commitments in Paris on the climate and energy, a provision which provides for this share of renewable energy to be increased to 27 percent by 2030. Based on this other supranational commitment relating to the COP-United Nations convention it is now possible to finance forestry projects under the cohesion policy through the European Regional Development Fund or even in the "Natura 2000" network, which is a European Nature Protection Network covering around 37.5 million hectares within the framework of the Union's environmental policy. It is therefore clear that the "key" to this framework of commitments was the fact that European countries participated in all of the United Nations framework conventions on climate change. On a pan-European level there is also the work of "Forest Europe," which continues to be the main political initiative in the forest sector and also embraces nations such as Norway that are not part of the European Union but fall within the wider European area. Furthermore–and this is no small thing–under the REDD+ program, the European Union finances projects aimed at reducing emissions from deforestation in Asia, Africa and Latin America.

A policy that has progressed beyond its initial limits

The European Union's forestry policy, therefore, is one of the most active externally and demonstrates the EU institution's strength in recent years at finding ingenious solutions to legislative problems by building on the common idea of participation in supranational organizations in the field. This has led to a commitment which, through common participation in the huge structural funds of the CAP, has seen both EU and individual countries play a starring role in implementing legislation and in which the European Union has been able to go beyond its own initial limits.

European forests

43%

Percentage of the **surface area of Europe** covered by forests

182

The **millions of hectares of forests covering** the surface area of Europe

42%

Share of harvested wood in European forests intended **for energy production**

50%

Roughly half of the **renewable energy used** in the Union comes from wood

2.6

The millions of people employed in jobs connected with forests (including the hunting and tourism sectors), representing **1 percent of European GDP**

Case study/The challenge for Italy

A Major Contribution

Since the end of World War II, the forested area of Italy has more or less doubled. Although this expansion is slowing, Italy can now expect approximately 70 million new trees per year

PAOLO MORI

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The scientific world unanimously agrees that the climate is changing. *Homo sapiens* appears to be significantly responsible for this change. There is less unanimity in terms of the second aspect, although the scientific evidence gathered by those who claim responsibility for our species clearly seems to be more solid than that from those who claim otherwise.

Humanity has benefited greatly by following scientific methods; once again, there is no reason to disbelieve the findings presented to us with increasing backing and evidence from researchers all over the world. Of course, critical faculties must remain alert to grasping every uncertainty, but until proven otherwise, countermeasures must be taken if we do not want to face catastrophic changes. This must be done because we are most probably responsible, but we should still do so even if we were not. Climate change does nothing for our well-being and that of our children and grandchildren either.

Greta Thunberg, who could be the daughter or granddaughter of many of the decision makers, has reminded us of this. The climate crisis did not start recently. Researchers had already undertaken a major awareness-raising campaign in June 1992 at the United Nations Conference on Environment and Development, where the United Nations Framework Convention on Climate Change was signed. In December 1997, after the third session of the Conference of the Parties (COP3), this led to the signing of the Kyoto Protocol by 186 states, which formally committed to reducing greenhouse gas emissions. The first phase of the protocol was in force between 2005 and 2012, the second between 2013 and 2020. Unfortunately, the balance sheet is negative: the protocol has not been complied with and greenhouse gas emissions have substantially increased, as have the average temperatures on Earth.

In December 2015, shortly after Pope Francis' encyclical "Laudato Si'," 196 states signed in Paris the new, binding COP21 agreement with new emissions reduction targets. It seemed that something might finally change, but with the arrival of Donald Trump in the presidency, the US—one of the worst greenhouse gas emitters—withdrew from the Agreement. In the meantime, other countries, although they have not withdrawn their signatures, do not appear to be doing enough. Emissions data tell us that in essence the Paris Agreement is not being complied with.

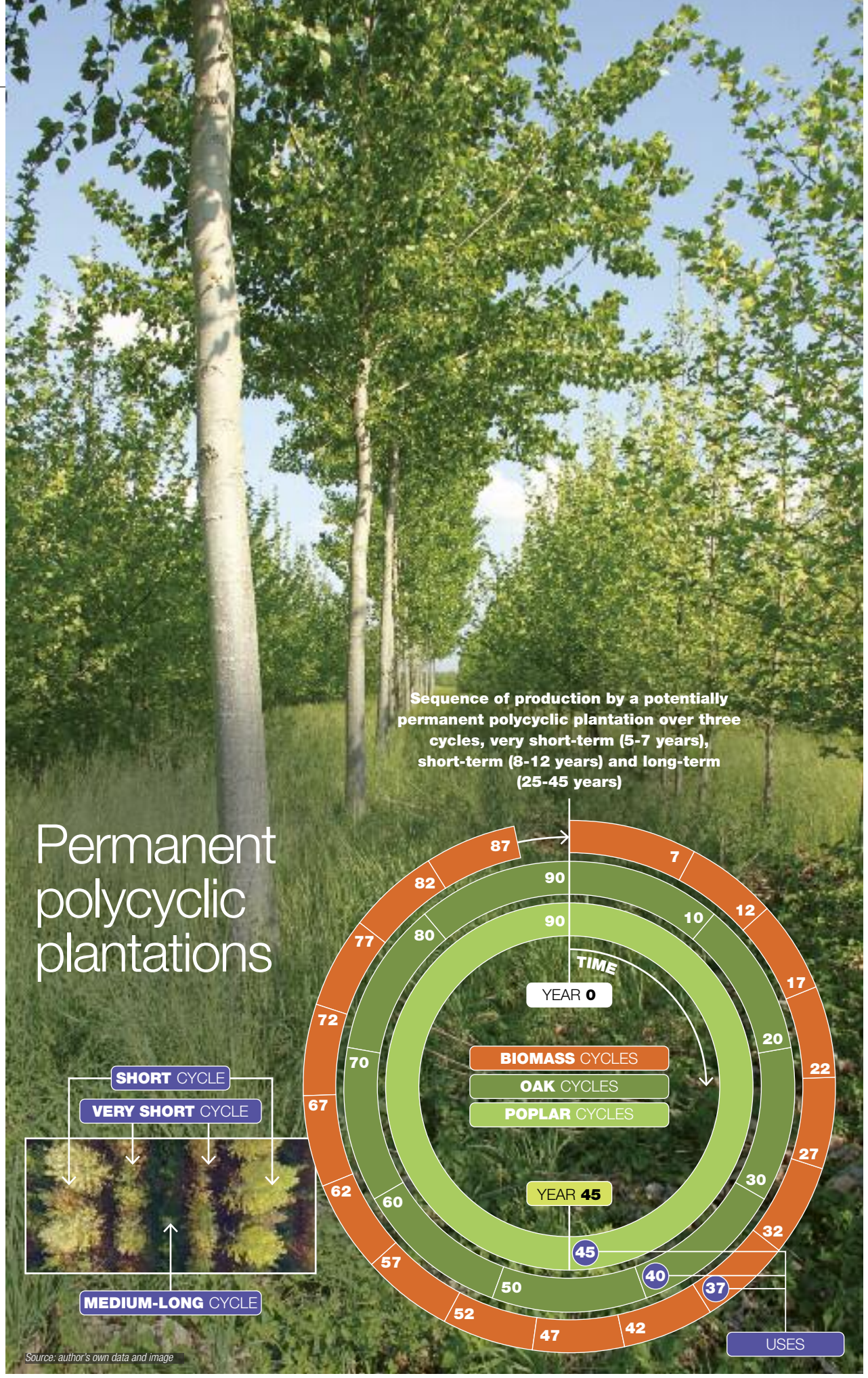
Thus, in 2018 those who were looking for concrete actions to save the climate found in Greta Thunberg and her Fridays for Future movement a lever to mobilize the consciences of (not only) students from the world over. The younger generations of Fridays for Future demand compliance with the COP21 Paris Agreement and for concrete action to be taken immediately to reduce emissions and storage of the CO_2 present in the atmosphere. There is no time to lose.

Trees to prevent emissions and to store CO_2

The appeal and demonstrations of the Fridays For Future movement have highlighted how everyone from young students to heads of state have a duty to play their part in reducing emissions and storing the CO_2 in the atmosphere. Even those who are involved in planting trees and managing forests can and must make their contribution, in both their personal and professional lives. Especially if well managed, trees can assist in both CO_2 storage and a reduction in emissions.

From when they are planted, or naturally take root, trees remove CO_2 from the atmosphere and store it in their trunks for a few decades. Some, if intended to produce valuable timber or if located in high forests, can store carbon dioxide for more than a century. Trees' role in the storage of CO_2 does not end with their felling. Wood that has suitable characteristics, generally induced by forest cultivation undertaken by humans (forestry), can be transformed into furniture, beams, fixtures, flooring, urban furnishings, wooden construction structures and/or panels, paper, cardboard and derivatives. In this case, the CO_2 removed from the atmosphere remains stored in these pieces for a long time, sometimes for many centuries. Just think of the beams of some of the Renaissance churches that still stand today.

Branches, stem parts that are not straight, trees that are thinning out to make room for producers of logs for pieces in which CO_2 will be stored, those of species not suitable for industrial or craft transformations and the products of forests managed mainly for the production of energy from renewable sources (coppice woods), all make their own major contribution to saving the climate. Today they can be transformed into energy through high-efficiency systems with very low fine dust emissions, the performance of which can clearly be compared to that of diesel- or methane-powered systems. A rough estimate states that for every 3.5 tons of wood processed into energy, the equivalent of the CO_2 emitted from the production of one ton of oil from fossil fuels can be →



avoided. It is clear that CO_2 emissions remain the point here, but in this case the advantage is that energy transformation does not alter the overall amount of carbon in the natural cycle and therefore does not contribute to exacerbating the climate crisis. The balance of wood production is not zero emissions of "fossil carbon" into the atmosphere, as fossil energy is required for the felling, preparation and transport of wood intended for energy purposes. However, it is not even remotely comparable to the CO_2 emitted from extraction, refining and transport for thousands of miles of many fossil fuels, especially when wood production and processing are on a local scale.

Are trees and wood the solution?

The scientific world has also been asking questions about the role of trees for some time, questions on which there is not always consensus. The prevailing position attaches great importance to the storage of CO_2 in arboreal formations of both artificial and natural origin. In this regard, in July 2019, the scientific journal *Science* published an article entitled "The global tree restoration potential" (Bastin et al.), claiming that if we can increase forest cover by 10 percent, to a minimum of 2 billion hectares, we would be able to counter a third of the world's CO_2 emissions. The main contributors to such an action could be Canada, the U.S., Russia, China, Brazil and Australia. Of these, Canada and Russia have already been in contact with the U.N.'s Food and Agriculture Organization (FAO) to take concrete action. The article has been noted widely and substantively by an extraordinary number of researchers. It has also had a huge media impact, so much so that Danilo Mollicone, a researcher at the FAO Environment and Climate Department and a co-author of the Bastin et al. article, stated at a meeting on the climate and forests organized by SISEF in Palermo on November 14, 2019 that the topic of "tree restoration" has entered the European Union agenda on forestry to such an extent that, in the upcoming schedule for 2021-2027, specific and significant resources will be earmarked for the planting of trees.

As a result of the actions of the European Union, the pressure exerted by Greta Thunberg and the Fridays for Future movement and the efforts of those who have been attempting to mobilize the scientific world for years, in October 2019, Italy promulgated the "Climate Decree" (Legislative Decree 111/2019 in OJ No. 241) allocating EUR 30 million for the creation of urban forests in eight metropolitan areas.

60 million trees in Italy

By the same token, the Laudato Si' Community, inspired by its namesake encyclical by Pope Francis, appealed in September 2019 for the planting of 60 million trees, one for each Italian citizen. The call was to do so immediately, to give a tangible sign of urgency to act to save the climate. Those running the appeal seemed to believe that planting a tree would be the easiest and most effective way to involve every Italian in making their small contribution to saving the climate.

It was immediately clear to those who work with trees and forests that this was an infeasible proposal in the immediate future. The reasons are essentially related to the fact that:

- It takes a long time to identify a total area of about 60,000 hectares (about 100,000 football fields, to allocate the 100 m^2 needed for the development of a large tree) to be legally made available by the holders to its rights, which is suitable to accommodate trees that must grow and store CO_2 for many years, and which is not suitable for food production by its owner;
- In Italy, forest nurseries are geographically well distributed in each region, but they are small and the fact that no reforestation has taken place for many years has resulted in a reduction in total production to less than 5 million seedlings per year (RaF Italia 2017-2018);
- Assuming that the people who still work in agriculture and forests are adept at planting (ISTAT), in

A WARNING AT COP 25
Throughout his pontificate, Pope Francis has always demonstrated great sensitivity toward the environment. He passed on his latest message to delegates at the United Nations Climate Change Conference in Madrid. "We must seriously ask ourselves if there is the political will to allocate with honesty, responsibility and courage, more human, financial and technological resources [to the climate crisis]." Photo: the Pope during a pastoral visit.

Laudato Si', an appeal by Pope Francis

"The urgent challenge of protecting our common home includes the concern of uniting the whole human family in the search for sustainable and integral development, because we know that things can change." With these words in his encyclical Laudato Si' in May 2015, **Pope Francis** brought to the world stage the topic of respecting and protecting the environment. "I make an urgent call to renew dialog on how we are building the future of the planet. We need a confrontation that unites us all, because the environmental challenge we are experiencing, and its human roots, are about every one of us and affect us all."
As he explains in the encyclical, Bergoglio is not the first pope to deal with the "ecological problem." **Paul VI** stigmatized the "reckless exploitation of nature" by man. "He risks destroying it," he said, "and in turn becoming a victim of such a breakdown."
In his first encyclical, **John Paul II** observed that humans seem "not to perceive other meanings of their natural environment, but only those that serve the purpose of immediate use and consumption," subsequently recommending a "global ecological conversion."
Finally, in 2007, **Benedict XVI** called on governments to "eliminate the structural causes of the dysfunctions of the world economy and correct growth patterns that seem unable to ensure respect for the environment."

Italy under two percent of citizens are able to plant a tree and look after it until it can grow independently and store atmospheric CO_2 in its wood in the long term.

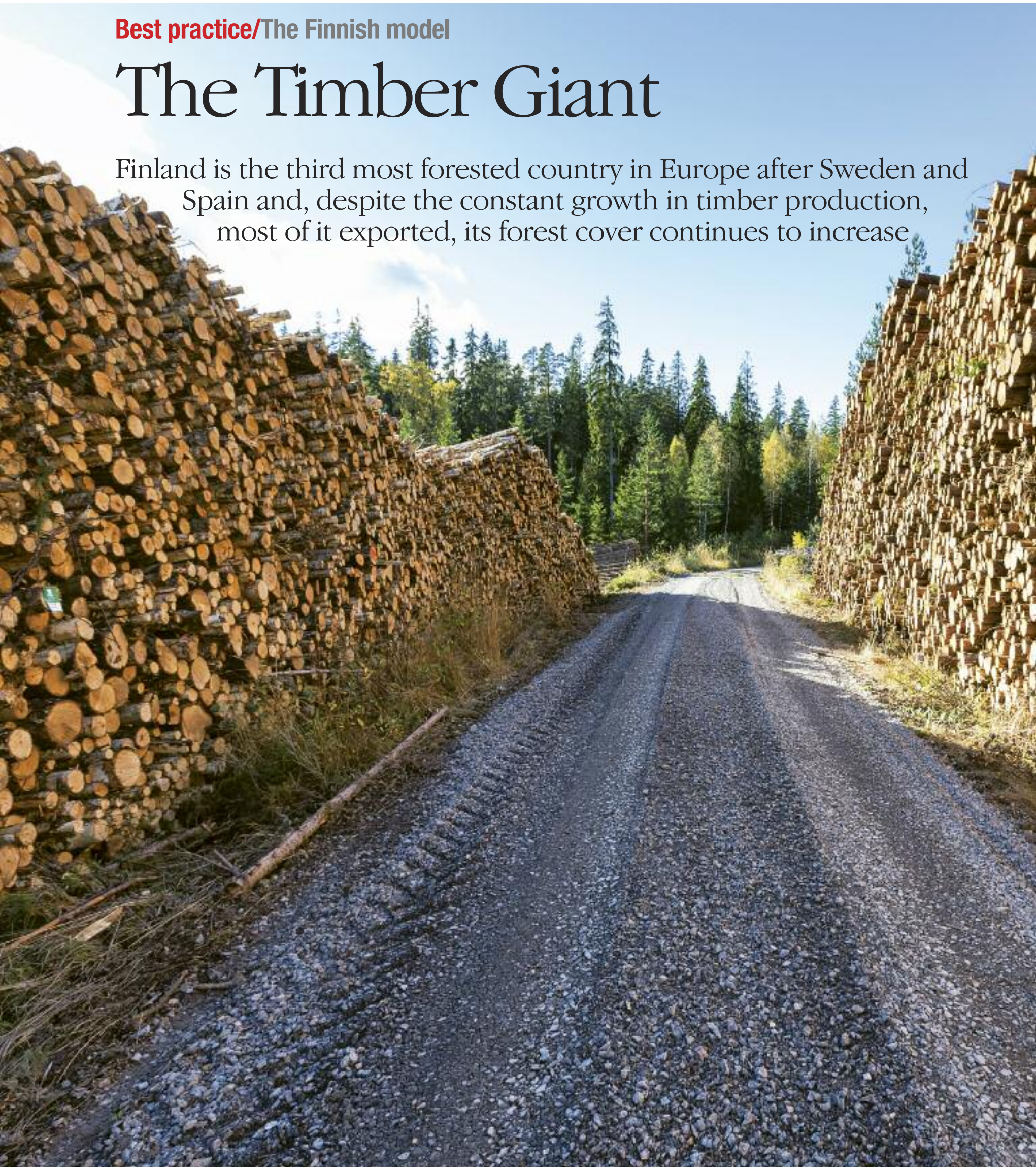
Despite these macroscopic difficulties, a group of 12 stakeholders at a national level accepted the appeal of the Laudato Si' community. The challenge has united the scientific world (SISEF and CREA FL and CREA PB), local authorities that may have land available (UNCEM), professionals from the agriculture and forestry sector (CONAF), land operators (Alleanza delle Cooperative Italiane), the largest forest certification schemes (FSC and PEFC), some of the major Italian environmental groups (Legambiente, WWF), certain producers of energy from wood (AIEL) and those dealing with internal communications to the sector (Compagnia delle Foreste). A website was immediately published for people to sign up (www.60milionidialberi.it). In little more than a month, over 300 bodies had offered to contribute to planting trees. These include the Ministry of Agriculture and Forestry (MIPAAF), environmental associations at a national level (Lipu and the Wigwam Network), as well as strong participation from many regional associations and private companies.

A flexible strategy is required

The variety of environments, of usable tree species, of standards to be complied with and of people involved is a great challenge for all those who have signed up to the Laudato Si' Community appeal. It is clear that we need common rules and solutions that can be adapted to each case.
One example, which has started recently in Italy, is polycyclic plantations. These are plantations where high-quality and energy trees of different ages can coexist. When one is used, the others continue to grow and new trees are planted in the freed space, which immediately begin to store CO_2. Between 2013 and 2018, the LIFE InBioWood (www.inbiowood.eu) project was developed in the Veneto. In addition to over 25 hectares of demonstration plantations, the project has 45 km of polycyclic plantations. Anyone wishing to replicate their success can use the planning manual and an app, which enables newbie technicians to independently create polycyclic plantations and avoid the most common mistakes. Alongside this solution, which is very flexible and suitable for agricultural, suburban and urban locations, other traditional, more rigid options are available, although these are definitely well-suited to certain specific situations. It is a matter of providing tools to choose the most suitable solution each time.
While planting trees is important, we should not forget that Italian forests are booming and their management can contribute to saving the climate far more than planting 60 million trees. Since the end of World War II, the forested area of Italy has more or less doubled. Although this expansion is slowing, in the last ten years forests have reconquered derelict farms in the mountains and hills, at the rate of one football field every six minutes (RaF Italia 2017-2018). This results in approximately 70 million new trees every year (INFC 2005). If managed with appropriate forestry, these trees will contribute to saving the climate to a greater extent than if left to natural evolution.
In Italy, the forests are expanding, although this is not happening everywhere in the world. Not making the best use of our resources means essentially using those of others, also leading to deforestation. The contribution of tree and forestry specialists to mitigating the climate crisis consists simply of planting trees or fostering their natural renewal, managing trees with crop treatments (plantations) or forestry, felling trees at the appropriate time (due to thinning or use at the end of the production cycle), then replanting or encouraging natural renewal, in a continuous and renewable cycle that keeps us in line with the natural cycle through which we have evolved. Nothing more and nothing less.

The Timber Giant

Finland is the third most forested country in Europe after Sweden and Spain and, despite the constant growth in timber production, most of it exported, its forest cover continues to increase



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DAVIDE TABARELLI

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ith climate change now a global emergency, international political commitments are being made to cut CO_2 emissions through treaties such as those signed in Kyoto in 1997 and Paris in 2015. In turn, the governments of individual countries are announcing equally ambitious objectives, often followed by the administrations of individual cities. Long-term objectives are being set over twenty or thirty years, far longer than the mandates received by politicians through elections. 22 years have passed since the Kyoto agreement, now somewhat forgotten, as it was replaced by the one signed in Paris, but the objective set at the time has been completely missed, given that, rather than falling, emissions have increased by almost 50 percent. Despite the fact that only four years have passed since the Paris agreement, the trend is still up. This failure highlights the difficulties involved in turning big political statements into effective actions. Awareness of this gap has resulted in policies whose objective has changed from achieving a reduction to simply balancing emissions. In essence, once CO_2 emissions are offset by absorption, the objective is still achieved.

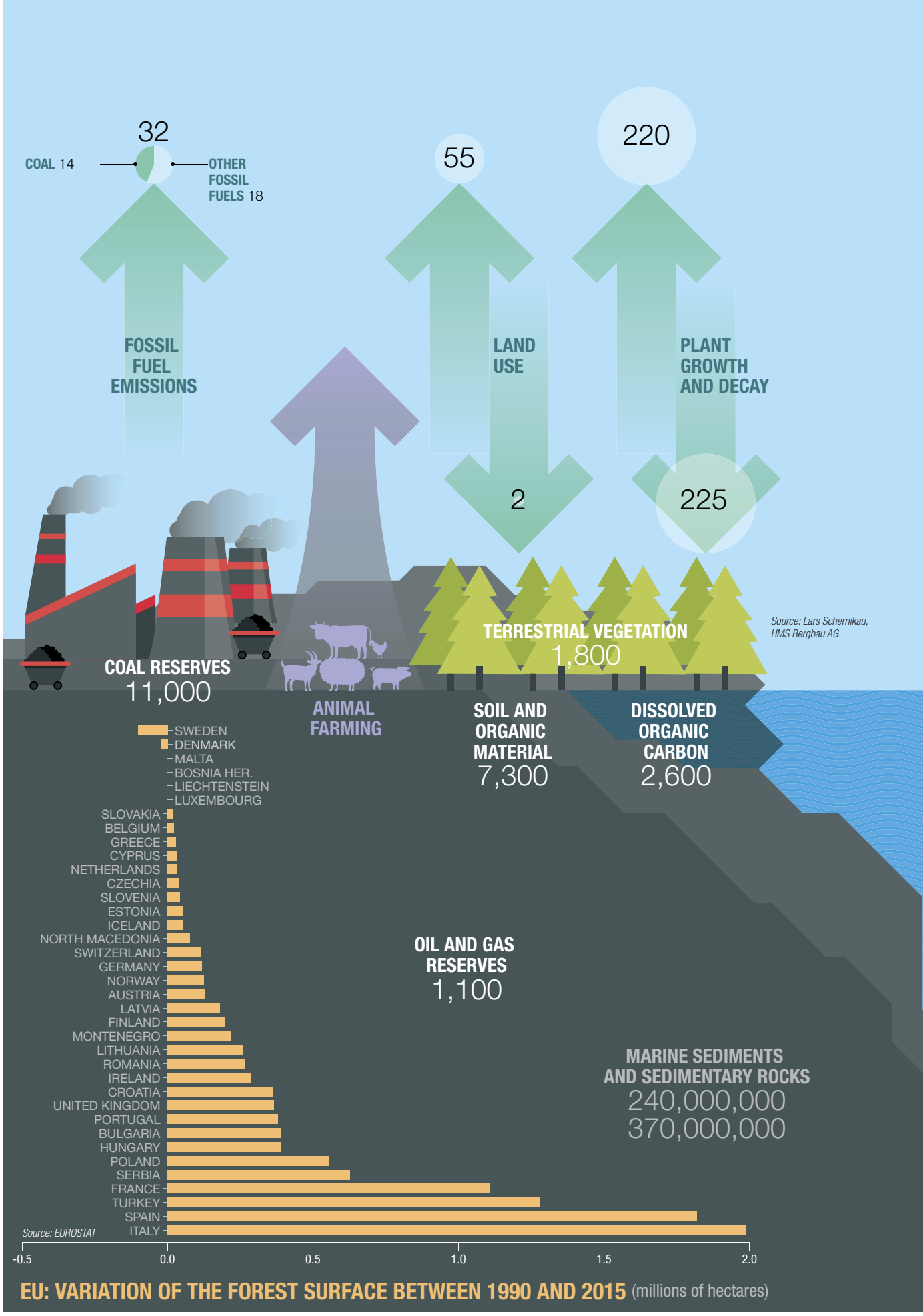
Emission absorption techniques, a work in progress

The techniques for absorbing CO_2 from the atmosphere are not simple. For decades, attempts have been made with underground storage, using filters to capture it from the air or the smoke from power plants, subsequently injecting it into the subsoil in a kind of cycle that puts the carbon back where it came from when the fossil fuels were extracted. The process is as easy to describe as it is difficult to implement. CO_2 is widely dispersed in the atmosphere and according to statistics accounts for 420 parts per million, i.e., 0.042 percent of the air. Capturing a substance with such low density is very expensive. Even if new technologies allowed us to capture it with more effectively, the fact remains that at high concentrations CO_2 is toxic and dangerous to transport. Injecting it into the subsoil is equivalent to storing a hazardous substance, essentially a special waste, that would require constant control of the deposit with monitoring constraints that could last for decades. Having noted the difficulty of capturing and storing the gas, research has taken the path of reusing CO_2 by experimenting with cements on the surfaces of buildings that absorb it from the atmosphere. Equally interesting is the cultivation of algae, where photosynthesis, the chemical process underlying all life on earth, uses CO_2 to produce chlorophyll. Synthetic photosynthesis now performed in a laboratory could soon →

drive the process towards growing particular types of plants capable of absorbing CO_2 in large quantities and everywhere, while at the same time contributing to solving the problem of food shortages for the growing world population.

Figures for the contribution of forests

While waiting for research to give more effective results, there is a rediscovery of the potential offered by the expansion of forests, where humans lived for millennia, harvesting their fruits, using wood as a material to build houses and tools and to make fire, their first and greatest technological innovation. Focusing on absorption by plants, however, requires us to reflect on carbon balances and carbon cycles in the atmosphere, to better understand the complexity of the issue. Emissions from fossil fuels produced by man, which are growing strongly, are approximately 32 billion tons a year, while the amount absorbed by plants through photosynthesis is estimated at around 225 billion, offset by emissions due to the decay of the plants themselves of roughly 220 billion, with a net positive capture effect of 5 billion, about one sixth of human emissions from fuels. Inevitably, any effort made to increase forest cover is positive in terms of absorption. The UN Food and Agriculture Organization (FAO) estimates that global deforestation is slowing down. While it continues in areas where there are greater numbers of poor people who live in forests, particularly in Sub-Saharan Africa and the Amazon, the trend in some wealthy regions, particularly Europe, has reversed. Here, for a while now, there has been talk of a circular economy, aimed at reducing the impact of the use of resources. The economic model that involves caring for forests has always considered the regeneration and overall use of the material, with associated positive effects, such as the maintenance of biodiversity, protection of the soil, water purification, support for local communities in peripheral rural areas, and in difficult and economically weak areas. The recent vision set out by the European Union in the climate and energy package for total decarbonization by 2050 refers specifically to energy communities, where consumers produce their energy with biomass, or wood, for traditional use in heating systems or to produce biogas from which to extract biomethane. This will see a return to the tradition of forest communities, where wood becomes the main source of energy and also building material. Apart from being evocative, the cultivation of wood through reforestation is well suited to this model, boosting and strengthening it.



The Italian and Finnish models compared

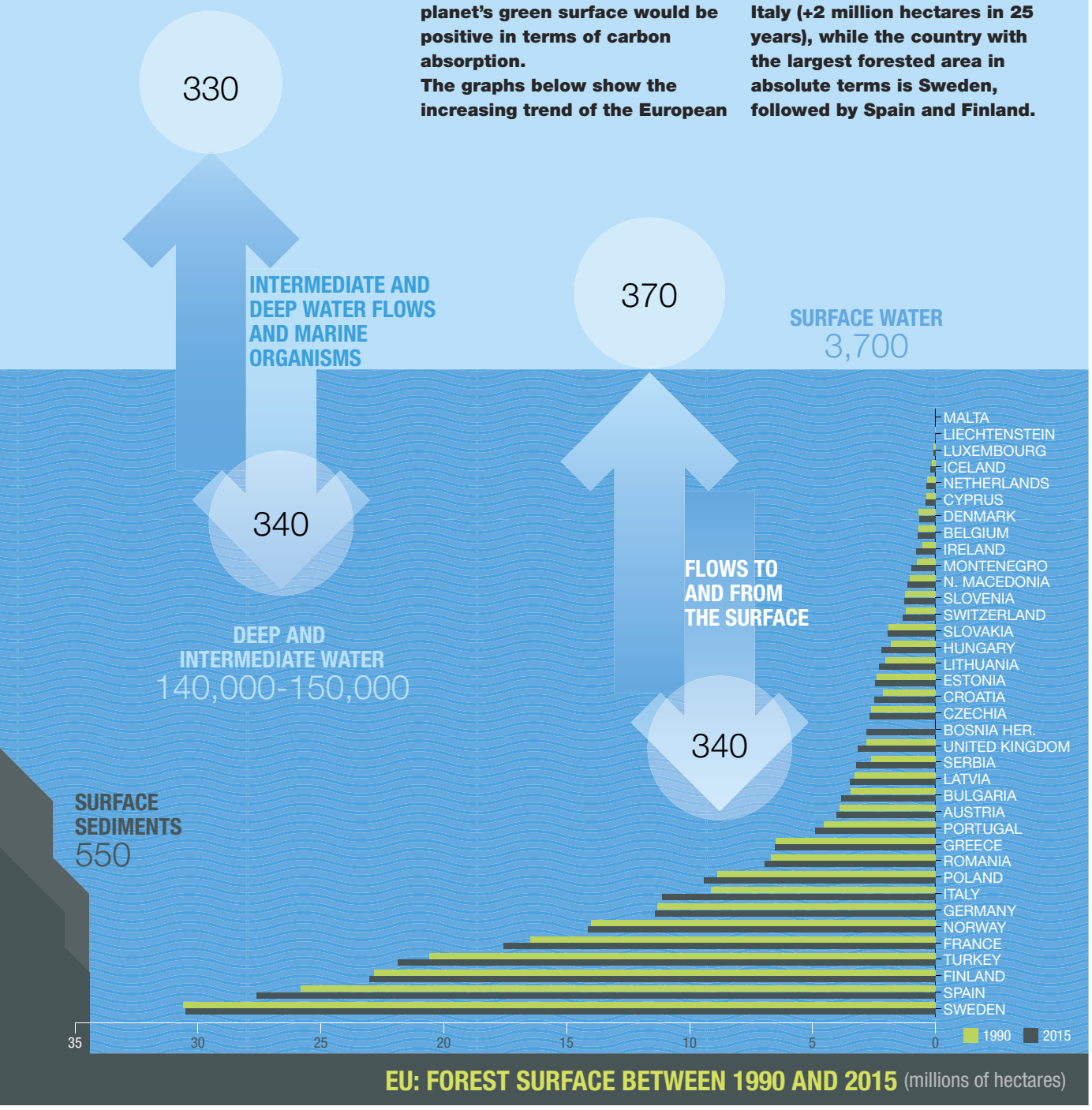
In Europe, after centuries of deforestation to make room for agriculture and livestock, forests are rapidly expanding, which is positive news and will hopefully lead to the same happening in the rest of the world. This improvement does not free Europe from the paradox of being strongly critical of deforestation in countries where it is essential for the purpose of expanding agriculture. The rules of development are very clear and show that the transition from rural subsistence to intensive agriculture is the first step on the development path. It also serves to slow down the inevitable migration of billions of people from the countryside to the cities. The return of forests to Europe is not as virtuous as it seems, as it stems from the abandonment of agriculture, which is no longer profitable, in some cases because food is imported from countries that are slowly emerging from absolute poverty.

Statistics show that between 1990 and 2015, European forested areas increased by 8 million hectares, an area equivalent to the size of Scotland. The greatest contributor is Italy, a relatively small country, which over 25 years has seen its forest cover increase from 2 million to over 11 million hectares, more than one third of its entire surface area of almost 30 million hectares. On average, Italian forests have absorbed around 30 million tons of CO_2 per year, seven percent of total emissions. As has happened all over Europe, in Italy the return of forests is a result of farming being abandoned, a consequence of the process of impoverishment that leads to a disor-

Forests and the carbon cycle

(DATA IN BILLIONS OF TONS OF CO_2 EQUIVALENT)

The earth's vegetation absorbs about 225 billion tons of CO_2 equivalent per year and emits 220 tons, the net effect being five billion tons of capture per year. This volume is equal to one sixth of the global fossil fuel emissions produced by humans (32 billion tons of CO_2 equivalent per year). It is therefore evident that any effort to increase the planet's green surface would be positive in terms of carbon absorption.
The graphs below show the increasing trend of the European Union's forested areas: between 1990 and 2015, European forests increased by 8 million hectares, an area equal to the whole of Scotland. The greatest contributor to this increase is Italy (+2 million hectares in 25 years), while the country with the largest forested area in absolute terms is Sweden, followed by Spain and Finland.



EU: FOREST SURFACE BETWEEN 1990 AND 2015 (millions of hectares)

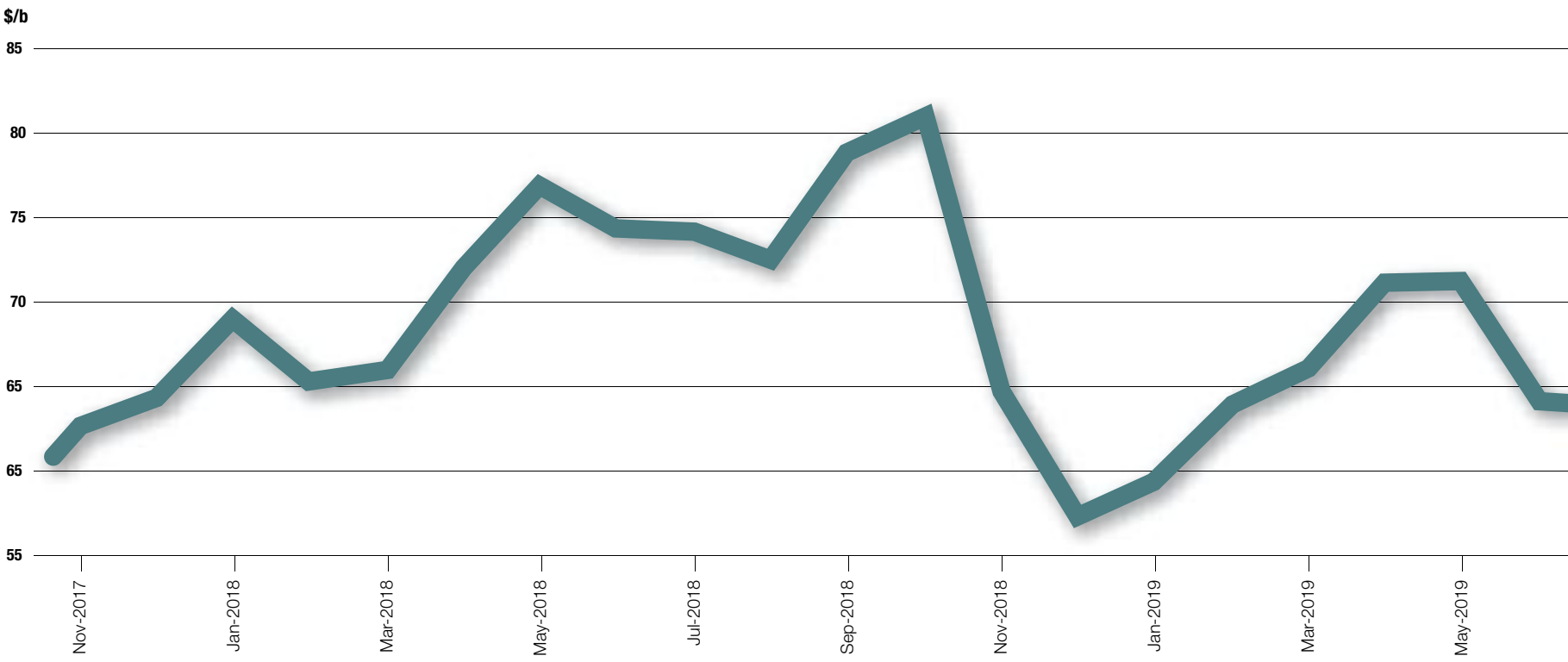
derly increase in forest land and the emergence of other problems. The farming crisis also extends to forestry and the mountain economy, both of which are suffering from depopulation and unemployment. Neglect facilitates fires, as fallen branches are no longer collected, undergrowth that is easier to ignite develops and sudden heavy rains clog up the water courses and worsen hydrogeological instability.
The abundance of wood in other European countries, particularly in the East, has led to the paradox that production in Italy is falling in favor of imports while forests are increasingly being abandoned. One European country that has experienced a virtuous process in forest management is Finland, which has always lived in symbiosis with the wood produced and cultivated in its forests. Finland is the third most forested country in Europe after Sweden and Spain and, despite the constant growth in timber production, most of it exported, its forest cover continues to increase. The country is a global benchmark for forest management policies, both because of its traditional aspects and those associated with technological innovation.

Wood economy

Forests have always been managed by cooperatives, for the benefit of rural communities that live in areas that could not survive without the timber economy. Äänekoski, a small town of 20,000 inhabitants 300 kilometers north of Helsinki, is home to one of the world's biggest tree processing plants, mostly conifers cut from nearby forests.
The company Metsä owns the plant and has just completed a restructuring with 1.3 billion euros of investment. Metsä in turn is owned by a cooperative of 103,000 members, who are also small land owners in the forests where the wood is harvested. In 2018, Metsä had a turnover of 2.5 billion euros, with production plants in 15 countries. The new plant is the most advanced, where profits are made and the forest is helped to grow. For each tree that is cut, 4 are planted, then, over the years, the less luxuriant ones are cut and only the strongest are left to grow, until they are between 60 and 70 years old. The ones that are cut down end up in the factory to make chipboard and paper pulp. Nothing in the factory is wasted. The most valuable part is the boards destined for construction and the furniture industry, but there are also pruning and sawdust that end up in plywood. The plant's heat and electricity are produced by burning other waste. The factory has a research department that has already started producing new sheets made with waste that are particularly suitable for high quality prints. The most interesting developments relate to new applications, starting with the replacement of cement and steel in large buildings. In these cases, not only does the wood store the carbon absorbed during growth, but it also allows the substitution of two materials that produce the most CO_2 during their production processes. The ambition is even to replace the plastic in the packaging with wood material developed in such a way as to be completely aseptic, as required by the law on food preservation. This would allow the containers to be freed of the plastic currently trapped among the timber and then fully recycle without burning it.
Even more innovative is the research being done to develop new textile fibers that can compete with those derived from oil and, above all, cotton, which requires vast agricultural areas and enormous volumes of water. There is no shortage of criticism for the factory among the local community, which is more attentive to the environment and would like less use of chemicals and diesel, while others, who are more fundamentalist, would like the forests to be left intact and completely untouched. These criticisms fuel discussion and involve the direct participation of the families making up the cooperative. The ensuing investments create a word class state-of-the-art timber economy that extends spontaneously to the surrounding environment, in a virtuous cycle that has lasted for millennia.

data

BRENT PRICE



What's Certain is Uncertain

MARKET PERFORMANCE

Prepared by
ANNA CAPALBO, SIMONA SERAFINI
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Geopolitical and macroeconomic risk: certainly uncertain

In the second half of 2019, the succession of weak economic signals reversed the upward trend in the price of crude oil. Brent has only rebounded in conjunction with geopolitical events, particularly since the September 14 attack in Saudi Arabia, reflecting fears of a potential conflict in the Gulf area. Once the critical issues had been overcome, the bullish effect of geopolitical risk dampened, while macroeconomic risk, largely linked to the swinging issue of the US-China tariff war, has driven heavy speculative sales in the futures markets since late summer, bringing the price back to around USD 60 per barrel. The fact that the prices have not seized a significant geopolitical premium ultimately indicates that expectations of an escalation are low and that there is confidence in the ability to cope with temporary disruptions, at least in the short term. There is also a long list of factors that remain uncertain—the US-China dispute, slowing US production growth, and US-Iran sanctions—which have held Brent prices down within the USD 60 per barrel range. On the other hand, geopolitical tensions are evident in related markets: higher transport costs and high price differentials for crude oil that "compensate" for cuts and disruptions, such as those in the Middle East.

What expectations do we have for the future? In the WEO 2019, IEA notes that, despite the themes of the energy transition and the related changes, "The world can't afford to relax about oil security." There are many reasons why policymakers continue to pay close attention to the safety of the oil market, even if they are pursuing a number of other important energy and environmental goals. The Middle East will remain the main net supplier of crude oil to the international markets, although the US challenge persists. Dependence on oil will not disappear rapidly and will continue to grow, especially in developing countries, and will shift to Asia, where Middle Eastern crude will remain central. No country is immune to these developments.

Global oil **DEMAND** increased by 1.1 Mb/d YoY in 3Q19, almost three times higher than the 2Q19 figure of 435 kb/d. The main contribution to growth comes from China, which in 3Q19 recorded a positive delta of 640 kb/d, followed by Russia and India. Demand for oil in the OECD, on the other hand, fell for the fourth quarter in a row: in 3Q19, it contracted by 40 Kb/d YoY, a less dramatic decline than in the previous two quarters given the sustained consumption of transport fuels (jet kerosene, diesel and gasoline).

- In the OECD, **demand** for oil remains stable after five quarters of continuous decline. Underlying a return of gasoline consumption in the automotive sector after 2015's Dieselgate are robust jet kerosene consumption, while LPG and naphtha continue to fall. The European petrochemical industry is suffering from the slowdown in economic activity and competition in North America, where the petrochemical industry continues to take advantage of the low cost of ethane.
- Demand for oil in **China** in September reached a record high of more than 14 Mb/d. The growth in oil demand in the country averaged 580 kb/d YoY in the first nine months of 2019, higher than the 490 kb/d recorded in 2018. In India, monsoon rains and flooding in the north in September reduced economic activity, leading to stagnation in demand for oil. Diesel and oil consumption is decreasing with sustained demand for LPG and gasoline.
- In 3Q19, **OECD America** demand increased, supported by seasonal gasoline consumption, although it was more moderate than in the past. Diesel is falling as a result of the slowdown in ongoing economic activity. LPG/ethane consumption contracted sharply in August due to the extraordinary shutdowns at petrochemical plants on the US Gulf Coast.

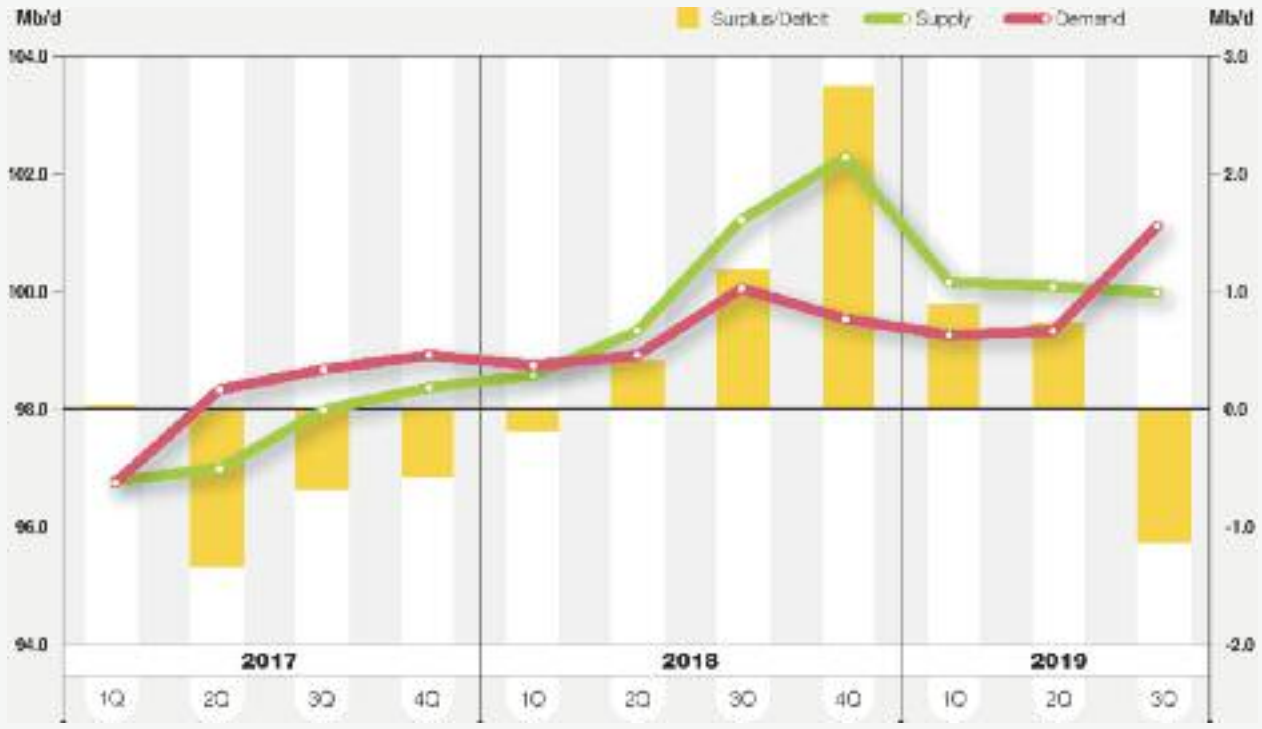
Oil **SUPPLY** has fallen constantly this year. In October, world production was about 1.7 Mb/d lower than at its peak at the end of 2018. The decline is driven by OPEC's strict controls on production, especially in Saudi Arabia, where cuts have greatly exceeded the agreed target. The intensification of geopolitical risk has further reduced supply, with the "full" sanctions against Iran and the "new" ones against Venezuela, which has cut 1.2 Mb/d from the

Source: EIA-DOE, Europe Brent Monthly Spot Price FOB

market compared to the end of 2018. In September, attacks on two major sites in the Saudi oil infrastructure, the latest in a series of these in the Straits of Hormuz, resulted in a "historic" loss of more than 5.7 Mb/d, or nearly 6 percent of world production. Markets are back on high alert in terms of geopolitical risk, although the return of production has been faster than expected. Since mid-year, OPEC has fallen below 30 Mb/d, its lowest figure in four years. Non-OPEC production, on the other hand, continues to grow, driven by record US crude, which has exceeded 12 Mb/d every month since April. The US growth rate has also slowed in recent months. Brazil is contributing to the growth of the non-OPEC countries to a considerable extent (0.3 Mb/d) for start-ups in the pre-salt fields. There are great expectations for the next meeting in early December, where the OPEC+ allies will have to assess the continuity of price-support cuts. October data:

- **OPEC** crude oil production is on the rise (1.1 Mb/d). Saudi Arabia is recovering since the September 14 attack (1.2 Mb/d), returning to above 10 Mb/d, the same levels as early this year. OPEC as a whole remains below 30 Mb/d.
- **NON-OPEC** is up slightly at 0.3 Mb/d, mainly due to the start-up at the beginning of the month of the Norwegian Johan Sverdrup field (+0.2 Mb/d). US production is growing, although modestly. In compliance with the agreements, Russia continues to contain its production, while remaining above the target.

SUPPLY/DEMAND BALANCE



Source: Eni's elaboration on IEA data

ANNUAL CHANGE IN GLOBAL DEMAND AND BY AREA

Source: Eni's elaboration on IEA data, annual change

ANNUAL CHANGE IN OIL SUPPLY

*Other: includes biofuels and processing gains

Source: Eni's elaboration on IEA data, annual change

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