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Improving biodiversity: How can digitalisation help?

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Credit: MAURO PIMENTEL / AFP

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This Discussion Paper builds on the findings of the European Policy Centre's (EPC) project, Digitalisation and Sustainability, which was commissioned by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and carried out between 2019 and 2020. The project considered the potential linkages between sustainability and digitalisation: how can digitalisation support the protection of the environment and ongoing climate action, and how can digital transformation be made more sustainable? A summary of the project findings was published as a Discussion Paper, "Towards a green, competitive and resilient EU economy: How can digitalisation help?", on 13 July 2020. It served to inform EU member states' ministers of environment about the rationale and prospects for aligning the EU's sustainability and digitalisation agendas at the start of Germany's Presidency of the Council of the European Union.

This Discussion Paper builds on the findings that specifically relate to improving biodiversity. Other areas covered in the project include the role of digitalisation in enhancing sustainable consumption and production (i.e. the circular economy), making agriculture and mobility more sustainable, and greening the ICT sector.

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List of abbreviations

AI	artificial intelligence
AI HLEG	High-Level Expert Group on Artificial Intelligence app application
BISE	Biodiversity Information System for Europe
BMU	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
CAP	Common Agricultural Policy
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DEP	Digital Europe Programme
ECA	European Court of Auditors
EEA	European Environment Agency
ESA	European Space Agency
EUNIS	European Nature Information System
GBIF	Global Biodiversity Information Facility
GEO	Group on Earth Observations
GEO BON	Group on Earth Observations Biodiversity Observation Network
GEOSS	Global Earth Observation System of Systems
GHG	greenhouse gas
GIS	geographic information system
GSWE	Global Surface Water Explorer
H2020	Horizon 2020
ICT	information and communications technology
IoT	Internet of things
JRC	Joint Research Centre
MFF	Multiannual Financial Framework
NGEU	Next Generation EU
NGO	non-governmental organisation
PAF	prioritised action framework

Executive summary

Although often overlooked, the enhancement of biodiversity and healthy ecosystems is central to the green transition and development of a more resilient and competitive European economy. It is essential for our survival and is the basis of a functioning society. Biodiversity and healthy ecosystems regulate the planet and provide clean water, air, food and medicine. They help combat climate change and achieve the EU's 2050 climate neutrality goals.

Digital solutions have supported the protection of biodiversity worldwide for decades. Collecting and managing data on the environment has been central to monitoring changes in biodiversity. Going forward, digital solutions supported by the likes of artificial intelligence (AI) and the Internet of things can further improve the data management needed for the monitoring, decision-making and law enforcement of biodiversity. They can also help green human activities and practices that have negative impacts on the environment. Moreover, digital solutions like online platforms and applications can raise awareness about biodiversity-related challenges and encourage citizens to support necessary measures.

However, aligning the digital and green transitions for the benefit of healthier ecosystems and biodiversity is still a work in progress. Barriers in data sharing remain. The deployment of digital solutions for improving data management and addressing harmful practices should be improved. Furthermore, digital solutions can only support a green transition fully if their own environmental and climate impacts are addressed.

There is not a moment to waste. Biodiversity is deteriorating rapidly across the globe. This is also the case in the EU, where the state of the environment is at a tipping point. The European Commission put forward a renewed, more ambitious Biodiversity Strategy in May 2020, but much remains to be done, including utilising the full potential of data and digital solutions for nature protection.

To ensure that digitalisation benefits biodiversity and the environment as a whole, the EU should do the following:

- Amidst the ongoing COVID-19 crisis and the looming climate and even wider sustainability crisis, it is time to recognise and address their nature-related causes and devise nature-based solutions.

- The implementation of the post-2020 Biodiversity Strategy must be aligned with the digital age. The EU should optimise data management and the use of digital solutions (e.g. AI, sensors, robotics) for the benefit of ecosystem restoration and nature protection.

- The EU's financing instruments should help address the loss of biodiversity, including by improving relevant data management, basing investment decisions on gathered knowledge, and developing and deploying needed digital solutions.

- The EU must encourage collaboration between relevant stakeholders, be they global or European, to optimise relevant data collection and sharing.

- The EU should use data from satellites, sensors and other sources more readily to launch infringement procedures against member states that are not complying with environmental regulation and rules.

- As a global leader in monitoring nature, the EU should continue to contribute to international biodiversity efforts actively by improving global biodiversity databases and electronic information exchange.

- The EU and its member states should use policies and financial instruments to green the digital transformation. They should limit the environmental and climate footprint of digital solutions when using them to address biodiversity challenges.

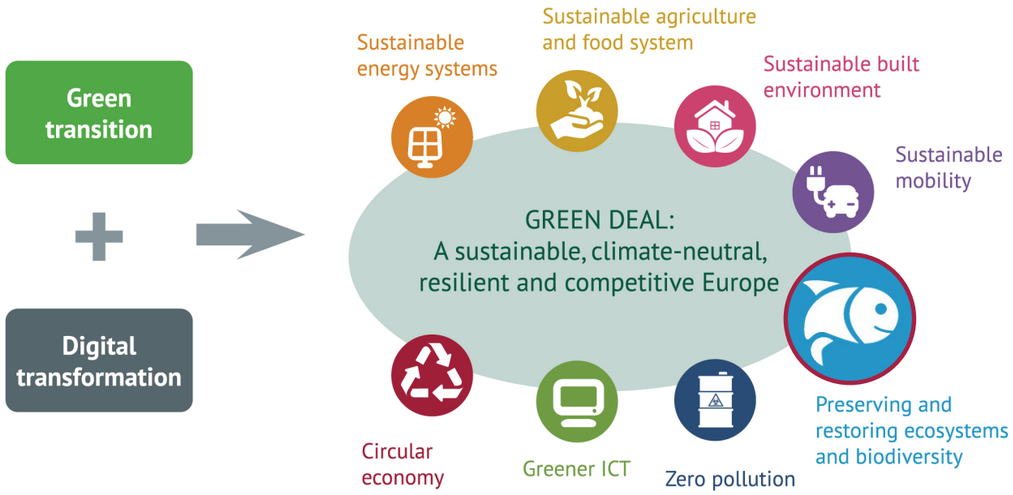
This Discussion Paper is part of a European Policy Centre project that focuses on the synergies between the green transition and the digital transformation. Although challenging, the EU increasingly recognises the related benefits. The European Green Deal and the EU's recovery efforts from the COVID-19 crisis emphasise these twin transitions strongly. Combining them into one endeavour could make digitalisation a key enabler for greater sustainability and contribute to a green recovery from the ongoing crisis. Furthermore, aligning the agendas will only enhance biodiversity and ensure healthier ecosystems.

Introduction

The EU, its member states and leaders are increasingly stressing both the challenge and opportunity that lie in the green and digital transitions. While achieving the two transitions is key to the EU's long-term prosperity, the aim should not just be to advance them separately. The EU must maximise the synergies between the two transitions to deliver its Green Deal. It should make full use of digital transformation to address Europe's biggest societal and environmental challenges. Restoring and improving our ecosystems and biodiversity with the help of digitalisation is a good place to start (see Figure 1).

The EU should make full use of digital transformation to address Europe's biggest societal and environmental challenges. Restoring and improving our ecosystems and biodiversity with the help of digitalisation is a good place to start.

Fig. 1



Ensuring long-term sustainable prosperity within the limits of our planet is the challenge of our lifetime. While the COVID-19 pandemic has temporarily shifted the world's attention from the climate, biodiversity and broader sustainability crises to managing the more immediate social and economic repercussions of the health crisis, it also provides an occasion for serious reflection.

The pandemic has generated significant public awareness of the fact that our economy and society must become much more resilient against human-made and natural global threats. People's well-being and business prospects will ultimately depend on our ability to address the ongoing climate and environmental crises. Recovering from the COVID-19 pandemic also offers an unprecedented opportunity to accelerate the transition towards a sustainable, climate-neutral and competitive economy. If managed well – that is, through the management of data and digitally-enabled solutions –, digitalisation could accelerate and support these efforts greatly. Digitalisation has already demonstrated its crucial role in supporting people, societies and economies during this crisis, and the growing understanding that we must become resilient and 'go digital' also creates political pressure for action.

Recovering from the COVID-19 pandemic offers an unprecedented opportunity to accelerate the transition towards a sustainable, climate-neutral and competitive economy. If managed well, digitalisation can accelerate and support these efforts greatly.

Healthy ecosystems with diverse biodiversity are essential for our survival and livelihoods. They provide the basis for functioning societies and economies. They supply clean water, air, food as well as medicines. They help regulate the Earth's climate by enabling carbon storage, hence reducing emissions of greenhouse gases (GHG) into the atmosphere and addressing global warming.[1] Natural capital could thus play an important role in helping meet the EU's 2050 climate neutrality goal, as well as the 2030 goal to reduce its GHG emissions by at least 55%, compared to 1990 levels.[2]

Safeguarding our ecosystems and biodiversity is crucial for ensuring sustainable prosperity for all Europeans. Businesses depend on natural capital.[3] Natura 2000, a network of protected sites and species of Community importance, is estimated to bring €200 to €300 billion per year to the EU economy.[4] And yet, the EU and other global players have undervalued and underplayed the importance of ecosystems and biodiversity for too long.

Ecosystems are deteriorating worldwide.[5] Nature is under siege as natural habitats shrink. Around a million species are facing extinction globally.[6] Biodiversity loss is accelerating at an unprecedented rate, notably due to unsustainable farming practices (e.g. intensive land use, use of pesticides and other harmful substances).[7] Other causes include mining; climate change; pollution; urban development; biofuels; and new, alien species, introduced by humans into existing habitats.[8] Moreover, illicit poaching and trafficking of wildlife continue to thwart efforts to protect and restore vital ecosystems and species.

Biodiversity loss is also very much a European problem. The lack of progress in protecting and conserving European biodiversity and nature is expected to result in the notable deterioration of nature and continued pollution of air, water and soil.[9] The conservation status of 60% of species and 77% of habitats in the Natura 2000 network is considered to be 'unfavourable' (i.e. inadequate or bad).[10] The EU member states are failing to achieve the set 2020 biodiversity goals. Moreover, the European Court of Auditors (ECA) has been critical of how Natura 2000 is managed, financed and monitored by the member states.[11]

The need to protect our surrounding environment and improve the interactions between humans and wildlife have been highlighted most recently by the COVID-19 pandemic. The same drivers that contribute to biodiversity loss are also bringing wildlife and people closer, thereby increasing their interactions. COVID-19, Ebola, SARS and MERS all originated from wildlife. Therefore, what happens in our nature matters for our health.[12] The power of nature's deadly arsenal is limitless: there are around 1.7 million unknown viruses in the animal kingdom.[13] It should thus be in the global and EU's interests to manage the related risks for human populations proactively.[14]

The basis for action exists. World leaders have agreed to Sustainable Development Goal 15; to protect, restore and promote the sustainable use of terrestrial ecosystems, manage forests sustainably, combat desertification, and halt and reverse land degradation and biodiversity loss.[15] Actors like the EU already have the knowledge, tools and solutions to tackle these challenges – but more action is needed.

The EU has a policy framework that addresses biodiversity loss within its borders. This framework was updated in 2020 with the adoption of the new EU Biodiversity Strategy for 2030. The framework sets targets and envisages a well-developed system for biodiversity monitoring and resource mapping. This provides a solid basis to assess the performance of EU policies, enable active surveillance and consequently contribute to the better enforcement of nature legislation. Moreover, the European Earth Observation Programme, or Copernicus, is an especially good example of a tool that the EU has at its disposal for monitoring and thus improving biodiversity, both in Europe and globally.

Arguably, as will be further elaborated in this Discussion Paper, restoring and improving biodiversity in Europe means better understanding of the scale of the problem, stronger political commitment to address the challenges, and strengthening governmental authorities' capacities to enforce environmental legislation.[16] Better data management and digital solutions (supported by e.g. artificial intelligence, the Internet of things, robotics, satellites, online platforms) can contribute to these efforts significantly. They can support monitoring and decision-making, as well as the implementation and enforcement of existing policies. They can also help green human activities and practices that have negative impacts on the environment, as well as raise awareness and encourage citizen engagement in nature protection (see section 1).

Restoring and improving biodiversity in Europe means better understanding of the scale of the problem, stronger political commitment to address the challenges, and strengthening governmental authorities' capacities to enforce environmental legislation. Better data management and digital solutions can contribute to these efforts significantly.

This Discussion Paper investigates how biodiversity can be improved with the help of digitalisation, focusing particularly on biodiversity monitoring and the enforcement of nature legislation in the EU. Due to the major impact of agriculture on biodiversity and the importance of biodiversity for food production, the Paper also studies how farming practices could become greener with the help of digitalisation and how digital tools can address consequences of biodiversity loss. Moreover, it explores the toolbox for action and provides policy recommendations for the way forward.

1. Digitalisation as an enabler

Digitalisation, which builds upon increased connectivity and improved data management,[17] has contributed to improving biodiversity in the EU and beyond over the past decades. Improved data management and the use of digitally-enabled solutions have helped the monitoring of biodiversity, create greater awareness around the biodiversity challenge and implement agreed measures.

Smartphones, satellites, sensors, cameras and robots are used to collect data that can be turned into information and knowledge, and even support the enforcement of legislation. Artificial intelligence (AI) can be used to manage the growing amounts of data.

Online platforms and applications (apps) can be used to inform and empower citizens to contribute to improving biodiversity. Moreover, geographic information systems (GISs), numerous open databases, data platforms and online communities are essential to information sharing and can support decision-making.

The case studies below present some of the possibilities of using data and digital solutions to improve biodiversity, while also recognising some of the barriers to their development and deployment.

1.1. GATHERING AND MANAGING DATA

Collecting data (via e.g. sensors, drones, satellites, cameras or audio recordings) in databases and using AI-enabled solutions to process and manage vast amounts of data can improve and increase information and knowledge on biodiversity. Turning growing amounts of data into better information is key to the effective financing, decision-making and enforcement of existing rules on nature protection.

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Looking ahead, the possibilities are manifold. Image resolution and, thus, the usability of satellite observations are improving. Portable sensors can enable the continuous monitoring of environmental parameters. Moreover, the prospects of using AI to manage data is particularly interesting. Using AI to collect and process vast amounts of data can help public authorities monitor protected areas and even enforce legislation. AI solutions have already been used to create a forest inventory and fight illegal deforestation.[18] AI technology is also increasingly being used to ensure wildlife conservation, classify species and estimate the health of ecosystems.[19]

1.1.1. EU collaboration

The EU's **Copernicus programme** uses ***satellites*** and in-situ (i.e. on-site or local) observations to monitor the Earth and its ecosystems. The in-situ measurement systems include ***sensors*** placed on riverbanks, weather balloons and ships. In-situ data can be used to calibrate, verify and supplement the information provided by satellites, and thus provide reliable and consistent data over time. The programme provides data and information services openly and freely in areas such as atmosphere monitoring, marine environment monitoring, land monitoring and climate change.

The **European Space Agency** (ESA) has launched a new ***satellite*** that is equipped with an ***AI*** system dubbed Φ-sat-1. The task of the satellite is to collect a vast number of images from the Earth's surface, which the Φ-sat-1 will process to send the best to competent authorities for further analysis (while discarding images that are e.g. unclear because of cloud interference). The acquired data can improve assessments on the state of the environment, including changes in vegetation and water quality.

The **Biodiversity Information System for Europe** (BISE) is an ***online knowledge platform*** that contains data and information from various sources that are relevant for the implementation and monitoring of the EU's biodiversity policies. It also supports the EU in achieving its international commitments, the Convention on Biological Diversity (CBD) and decision-making in general. BISE contains additional tools, such as the Biodiversity Data Centre, which focuses on information relevant to the implementation of the EU's Habitat and Birds Directives; the interactive GIS tool, Natura 2000 Network Viewer; and the Target Cross-linking tool (demo version) that provides information on the links between the national biodiversity-related targets at the national, EU and global levels. All of these data platforms are available to the public. A knowledge base for BISE is the European Nature Information System (EUNIS).

LUCAS (Land Use and Coverage Area frame Survey) is an EU ***database*** that collects information on soil cover across the Union using standard sampling and analytical procedures. Every few years, researchers collect samples from more than 250,000 sample points throughout the EU before using computation techniques to make more general observations about the land use.

The European Commission's **Business @ Biodiversity Platform** is an initiative that facilitates discussions with companies concerning the links between business and biodiversity. The aim is to help integrate natural capital and biodiversity considerations into business practices.

1.1.2. Global solutions to global biodiversity challenges

The **Global Biodiversity Information Facility** (GBIF) is an international network and research infrastructure that is supported by world governments and provides open access to data about nature. The GBIF collects data from the participant countries and provides standards for governments on sharing their nature-related information.

The **Group on Earth Observations** (GEO) is a partnership between a hundred national governments and organisations that aims to enhance collaboration between different observation efforts and establish a Global Earth Observation System of Systems (GEOSS). The Group on Earth Observations Biodiversity Observation Network (GEO BON) is a global network that supports the GEO regarding biodiversity-related data. The European Biodiversity Observation Network is an EU initiative that supports the GEO BON.

Global Fishing Watch is a ***platform*** founded by Oceana, Skytruth and Google that helps visualise, track and share data about the global fishing activity. The information provided can be used to support policymaking for marine protection. For example, in 2017, data gathered from tuna fishing vessels in Mexico's Revillagigedo Archipelago provided sufficient evidence that the area was not as heavily populated in tuna as claimed by the fishing industry. As a result, the archipelago was turned into a marine reserve to protect its fauna.[20]

The **Global Surface Water Explorer** (GSWE) is a ***dataset*** developed by the European Commission's Joint Research Centre (JRC) in the framework of the Copernicus programme. It maps the location and temporal distribution of water surfaces at the global scale over the last three decades and provides statistics on the extent and change of those water surfaces. The dataset, produced from NASA's Landsat ***satellite*** imagery, will support *inter alia* water resource management and biodiversity conservation. To help governments and citizens assess the state of play regarding water, the JRC, UN Environment and Google built a dedicated interface on top of the GSWE.

Global Forest Watch is a ***platform*** that provides data and tools for monitoring forests. This data is available free of charge and can help *inter alia* to monitor and manage forests and conduct research.

Google Earth Engine is a ***platform*** that combines a catalogue of satellite imagery and geospatial datasets with planetary-scale analysis capabilities. Scientists, researchers and developers can use the platform to detect and quantify changes and map trends on the Earth's surface.

Microsoft's **AI for Earth** is a ***platform*** that uses ***cloud*** technology and ***AI*** to facilitate the collection and processing of massive amounts of data and predict future biodiversity trends (e.g. population fluctuations, migration patterns). It helps researchers and decision-makers access information relevant to protect nature.

1.1.3. Other solutions for environmental monitoring and evaluation

SoilBio is a new method developed by SoilEssentials to measure the quality of soil. It uses satellite ***remote sensing*** to identify territories from which to sample nematodes, or roundworms. The presence and vitality of these organisms are regarded as indicators of healthy soil. This method can improve soil monitoring and potentially replace existing chemistry-based techniques for soil monitoring.

Automated Remote Biodiversity Monitoring Network, Wildbook and other solutions, developed by Sieve Analytics, Wild Me and ConservationMetrics respectively, process vast amounts of nature-related data (e.g. audio and visual data about wildlife) with the help of ***AI***. This significantly speeds up the processing of data and application of research results in decision-making processes.[21]

The automated tracking of insects is used in Dutch nature reserves. Insects are monitored with cameras coupled with ***software***. This has reduced the need to capture samples of insects.

RoboBees, developed by Harvard University's Wyss Institute for Biologically Inspired Engineering, are insect-inspired ***robots*** that could potentially provide high-resolution environmental monitoring.

The Economics of Ecosystems and Biodiversity (TEEB) initiative and numerous other efforts to estimate the economic value of ecosystem services, including carbon sequestration, form an essential basis for valuing healthy ecosystems and taking necessary measures for nature protection.[22] As such evaluations require complex assessments of different environmental, economic and even societal factors, managing the ***data*** and using ***AI*** to process the vast amounts of data can help in this effort.

1.2. ALIGNING AGRICULTURE AND BIODIVERSITY

Agricultural practices have significant adverse effects on biodiversity.[23] Intensive land use, pesticides and fertilisers destroy natural habitats.[24] Up to 37% of wetland loss in Europe is a result of land conversion for agricultural purposes.[25] Industrial and intensive agriculture is linked to the severe decline of insects and pollinators, which are vital for food security. A third of all insect species and at least one in ten pollinator species in Europe face extinction. Similar global trends of declining pollinators already affect a third of global food production and 75% of our most important crops that depend on pollination.[26] Moreover, run-off nutrients from the sector create one of the most significant pressures on the aquatic environment.[27]

Conversely, agriculture depends on biodiversity and healthy ecosystems. As explained above, pollinators are key to European and global food security. In addition, agriculture also depends on other environmental services

like water supply, the cycling of nutrients in soils and natural pest control.

This said, agriculture can also be part of the solution: sustainable, non-intensive and organic farming practices that use less pesticides and fertilisers can help improve biodiversity significantly, such as help diversify flora and fauna. Organic farming can also prove most beneficial for farmers.[28] Measures that improve soil quality or increase pollinators enhance food production and security.

Digital solutions can help make farming practices more sustainable, benefiting both farmers *and* nature. Given their close connection with rural and natural landscapes, farmers can act as providers of valuable data that improve the monitoring of biodiversity. Tools such as AI, the Internet of things (IoT) and aerial robots can gather data which also help farmers make better decisions and improve farming practices. Robots can partially substitute natural solutions. They can act as pollinators in the absence of bees and other insects, for example.

Digital solutions can help make farming practices more sustainable, benefiting both farmers and nature.

That being said, while digital solutions can provide solutions, they should not shift the focus from preventing and addressing the problem at its core. For example, while pollinating robots may sound like an interesting alternative, from environmental and economic standpoints, they are not the solution for declining bee populations.[29]

1.2.1. Enhancing biodiversity for food security

West Virginia University has developed **BrambleBee**, a ***robot vehicle*** that helps pollinate plants. The robot is tested on self-pollinating plants, namely blackberry plants. BrambleBee can also collect data on the plant it was in contact with, to assess its future yield.

Japan's **National Institute of Advanced Industrial Science and Technology** has developed a miniature flying ***drone*** that transports pollen between flowers. It is currently controlled manually, but the aim is to make the drone autonomous with the help of AI, Global Positioning System technology and high-resolution cameras.

1.2.2. Reducing the environmental impact of farming

Flourish is a project that has developed ***AI*** for precision farming. Aerial ***robots*** collect environmental data (on e.g. soil, crops, pests), which is then used by unmanned ground vehicles to spray optimal amounts of pesticides and fertilisers in the field. This reduces the emission of harmful chemicals into nature.

Libelium is a ***sensor technology and cloud-based management system*** that enhances farmers' productivity by allowing them to observe, measure and respond to the environmental conditions, diseases and pests that affect their agricultural production. This technology reduces the use of pesticides, fertilisers and water while still boosting yields.

Farmwave, **Taranis** and **Aerobotics** are examples of companies using ***AI*** to interpret ***smartphone, satellite and drone imagery*** of crops, to detect signs of pests and diseases as early as possible. Farmers can then target their interventions and reduce the use of pesticides.

Agrosmart is a Brazilian company developing a connected ***IoT*** app that will help farmers apply the correct amount of agrochemicals at the optimal moment, leading to a smaller environmental impact when combatting pests.

Indigo Agriculture, **Concentric** and **Pivot Bio** use ***algorithms and machine learning*** to identify microbes that farmers can use to promote crop growth and resilience instead of synthetic fertilisers.

1.3. AWARENESS-RAISING AND CITIZEN SCIENCE

Citizens can play an important role in addressing the biodiversity challenge. Several initiatives which already employ digital solutions – notably via the ubiquity and power of smartphones – are helping raise public awareness and/or enable citizens to provide crucial data to public authorities (i.e. citizen science). Building on people's passion for nature, citizen science initiatives can be used to gather valuable information on some species for environmental authorities.

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Recognising that not all citizens are tech-savvy and/or well-versed in research methodology and that their (unpaid) engagement can fade over time, citizens' involvement cannot be expected to reach an optimal level without being adequately supported. Close collaboration between public authorities, researchers and citizens and adequate training and encouragement would ensure citizen engagement and that the data they provide is of optimal quality (e.g. knowing what data to collect, how to collect it, how to share it).[30]

1.3.1. European data platforms

The **EuMon** project (2004-2008) created Europe's most comprehensive metadata catalogue of biodiversity monitoring activities, including voluntary activities. It also developed guidelines for conducting monitoring activities, including citizen science.

EU-Citizen.Science is a ***data platform*** developed under Horizon 2020 (H2020). It is used to share knowledge, initiate action and enable mutual learning among a wide range of stakeholders.

1.3.2. Digital solutions involving citizens

eBird is a mobile ***app*** and online community. Users share their bird sightings and explore hotspots worldwide. The data collected is used for research, conservational and educational purposes.

BirdTrack is a ***web-based data entry*** form that offers users, including citizens, the possibility to store and manage their tracking of bird migration movements and numbers throughout the UK and Ireland.

iNaturalist is an initiative of the California Academy of Sciences and National Geographic Society. It is a mobile ***app*** and online community in which users, including citizens, can record and share their observations as well as discuss findings. The observations are shared with scientific data repositories. More than a million people are currently signed up.

Sunbird Images has created over a hundred ***apps*** that provide a vast amount of information on flowers, plants and animals. This company also relies on ***AI*** to process collected data or identify species automatically, for instance. The user can identify the animal or plant species based on, for example, their sounds or visual appearances. Sunbird Images is also involved in specific citizen science projects in Germany, for which it has developed free apps. It also has a premium model, which requires users to pay for certain services (e.g. identifying bird sounds) and company-owned content.

1.4. CHALLENGES TO THE EFFICIENT AND EFFECTIVE USE OF DATA AND DIGITAL SOLUTIONS

Despite the significant prospects of using data and digital solutions to enhance biodiversity, they are not yet exploited to their fullest potential. Barriers include insufficient data collection, data (in)accessibility, lack of well-functioning digital infrastructures and technologies, and sub-optimal data processing and analysis. Moreover, the business case for innovative solutions is often lacking. Even when digital solutions are scalable, they cannot be expected to solve systemic problems related to nature protection. The digital transition may also exert negative environmental impacts.

1.4.1. Challenges regarding data management

An enormous amount of data on the state of biodiversity is already being collected and is made available. However, the right issues are not always being monitoring and thus analysed. Overall, better prioritisation is needed to determine what data is most important to collect and analyse in the long run. For instance, there is a lack of knowledge on the state and long-term trends of biodiversity in Europe, especially concerning soil and marine environments. The drivers of biodiversity loss (e.g. agriculture, mining, climate change, pollution, urban development, biofuels, new species in existing ecosystems) are monitored insufficiently.

Better prioritisation is needed to determine what data is most important to collect and analyse in the long run.

The availability of and access to needed data remains an issue. Data owners (e.g. public authorities, farmers and other stakeholders) still do not readily provide information to higher authorities, including the EU. While remote sensing technology can help, not all data can be gathered this way. The comprehensive monitoring of soil biodiversity, for example, still involves retrieving physical samples. Moreover, AI requires a large amount of data and samples, which is not always easy to obtain – especially regarding certain endangered species of flora and fauna.

Due to different responsibilities and interests, data collection, storage, processing and analysis are often fragmented across public administrations, the scientific community and non-governmental organisations (NGOs). Collecting and processing overlapping datasets, rather than sharing data, is redundant, highly inefficient and comes at an economic and environmental cost due to the high energy consumption of data collection and processing (especially if e.g. AI or machine learning is applied). A lack of standards on data management further hampers its optimal use for the benefit of biodiversity.

Data's true value will remain unexploited if it is not adequately analysed and thus turned into actionable knowledge. The EU's role in steering the process and enhancing data analysis for improved biodiversity is becoming ever more important as more data is produced. Data analytics could be greatly improved and optimised with the help of digital solutions like AI.

Challenges with managing data to produce citizen science include the unreliability of data gathered; insufficient skills for data management; selective interests; a lack of continuous, long-term involvement; and financial barriers (e.g. having to pay to access and share data).

1.4.2. Economic challenges

Despite the socioeconomic benefits of improved biodiversity, as described in the Introduction, they are often overshadowed by short-term priorities and the failure to value nature.

The business case for innovative solutions is often lacking due to existing market failures. While businesses have successfully developed both large- and small-scale solutions that help improve biodiversity, the business case is not always straightforward. As long as the existing economic model does not value nature and its 'services', and a functioning regulatory framework for improving biodiversity is absent, relevant stakeholders on the market, including businesses, will be hesitant to invest in solutions for nature protection.

The business case for innovative solutions is often lacking due to existing market failures.

1.4.3. The limits of digitalisation

Digital solutions alone, like apps or pollinator robots, cannot be expected to solve biodiversity challenges. Apps and appification can help raise awareness and even get people to 'protect the species they like', but will not be the silver bullet that addresses systemic problems. Solutions like pollinator robots may help respond to some past mistakes, but will not sufficiently address the core challenge – the drivers for biodiversity degradation.

Digital solutions are dependent on modern and well-functioning digital infrastructures and technologies (e.g. the Internet, 5G, IoT, AI, cloud computing). This can make environmental monitoring especially difficult in remote regions.

Digitalisation has significant environmental and climate footprints that must be addressed if the EU is to use digital tools in its quest for greater sustainability. Modern technologies like AI, IoT or cloud-based software require significant amounts of energy. Unused data can also be a form of waste if it takes up storage space, slows down machines and shortens the lifetime of its components (e.g. flash memory hardware). The same applies to, for example, obsolete websites that continue to consume energy. AI can also cause indirect adverse effects on the environment and society. This comes not only because of its energy consumption but also the parameters on which AI makes decisions can be harmful to the climate and environment (leading e.g. to higher pesticide usage). If the negative externalities of digital transformation are not considered when designing policies, they may outweigh its benefits or hamper a more general sustainable development agenda.

2. The policy framework for action

The von der Leyen Commission emphasises the twin green and digital transitions strongly. This is evident in the Green Deal as well as its follow-up measures. This section considers some of the policies and initiatives that are especially relevant for enhancing biodiversity with the help of digitalisation.

The EU's overarching strategic framework for biodiversity is built on its Biodiversity Strategy,[31] which is also linked with fulfilling the international commitments of the CBD. The new EU Biodiversity Strategy for 2030 provides a clear vision of how to improve biodiversity. It proposes 39 commitments, some of which could also support the EU's 2030 and 2050 climate objectives greatly. These suggestions include:

- converting at least 30% of the EU's land and 30% of seas into effectively managed and coherent protected areas;
- restoring degraded ecosystems and preventing any further damage to nature;
- restoring at least 25,000 kilometres of the EU's rivers to be free-flowing;
- reducing the use of pesticides by at least 50%;
- reversing the decline of pollinators;
- establishing biodiversity-rich landscape features on at least 10% of farmland;
- managing 25% of agricultural farmland under organic farming, and promoting the uptake of agroecological practices;
- planting over 3 billion diverse trees; and
- tackling fishing bycatch and seabed damage.

However, while the new Strategy recognises the importance of data, especially for strengthening law enforcement, references to digitalisation as an enabler for addressing biodiversity loss are otherwise limited.

Moreover, the Habitats Directive 92/43/EEC and Birds Directive 2009/147/EC (i.e. the Nature Directives) – the key components of the EU legislative framework on biodiversity – fail to make any reference to digitalisation as a tool that ensures the protection of habitats and species of Community interest. Thus, the EU's long-term strategic framework for biodiversity is not adequately aligned with the digital age.

While the new Biodiversity Strategy recognises the importance of data, especially for strengthening law enforcement, references to digitalisation as an enabler for addressing biodiversity loss are otherwise limited.

Regarding the EU's digital agenda, several measures are being taken to enhance the digital transition, thereby also establishing the basis for better use of data and digital solutions that can support biodiversity. This basis was laid out in February 2020 in the European Digital Strategy, and supplemented by the European strategy for data and White Paper on Artificial Intelligence. The Commission aims to ensure that digital technologies and online platforms respect principles of and around transparency, liability and personal data. Moreover, the EU aims to boost dataflows across Europe, notably by encouraging the free flow of non-personal data and reuse of public sector data. Lastly, as a response to many Europeans' lack of digital skills, the Commission's Digital Education Action Plan aims to support technology use and the development of digital skill education, while the European Skills Agenda aims to ensure that Europeans have the skills to work in a green and digital economy.

A closer look at the relevant policies and initiatives shows that while the basis for action exists, much work remains to be done to enhance the framework conditions that make digitalisation a true enabler and catalyst for restoring and improving biodiversity.

2.1. DATA FOR BIODIVERSITY

The Commission's European strategy for data, including its proposal to establish a 'common European Green Deal data space', provides a valuable basis for enhancing the access to and availability of data needed for climate action and environmental protection. The work on the data space has only started, and ensuring the efficient and effective collection, sharing and analysis of the data and information needed requires sufficient resources. It is worth noting that while the EU is traditionally adept in collecting data, creating concrete value from increasing amounts of data also requires enhancing the capabilities to analyse biodiversity trends.

Certain legal frameworks, including the Aarhus Convention and Directive on public access to environmental information 2003/4/EC, facilitate the access to data collected by public authorities. Nonetheless, exceptions can arise from the legislation (for e.g. technical, financial, security, confidentiality reasons), and limit access to the data or impair its quality. This can become problematic if, as a result, public authorities can, for example, hide environmental data that could be used against them in infringement procedures.[32] Environmental information from the private sector (e.g. farmers) can, in some cases, be even more difficult to access due to flat-out refusals or requests for financial compensation. As has been elaborated above and will be below, digital technologies, such as satellite imaging, can be used to address some of these challenges of compliance.

The INSPIRE (Infrastructure for Spatial Information in the European Community) Directive (2007/2/EC) is an important piece of legislation that establishes common rules for geospatial data across the member states. These rules apply *inter alia* to geospatial information for protected nature sites. Work under the INSPIRE Directive is an example of how the EU can establish standards for environmental data sharing and enable interoperability between different data platforms. Despite implementation gaps,[33] it is recognised that the Directive could serve as a basis for developing a common approach to environmental reporting.[34] For example, the EU's central data repository on information about protected areas is an example of ongoing efforts to collect data from member states in a standardised manner, based on the INSPIRE Directive.[35]

Work under the INSPIRE Directive is an example of how the EU can establish standards for environmental data sharing and enable interoperability between different data platforms.

While the EU's monitoring of biodiversity is well-established, with enormous amounts of data collected, the standardisation of data and its conversion into real value is yet to be attained. For example, EUNIS provides a sound basis for more systematic management of nature-related data, but would also benefit from being brought together with other datasets (e.g. global/national data sets on nature, water, climate, agriculture).

The EU Biodiversity Strategy for 2030 envisages a new European biodiversity governance framework, including a monitoring and review mechanism with a clear set of agreed indicators. These developments could optimise the collection, processing and analysis of data further.

Moreover, the Commission is working to establish a 'Biodiversity Knowledge Centre' in 2020 with the European Environment Agency (EEA) that will (i) track and assess progress in implementing biodiversity-related international instruments; (ii) foster cooperation and partnership, including between climate and biodiversity scientists; and (iii) underpin policy development. If the Centre were to benefit from the latest digital developments in biodiversity monitoring, this would ensure more unified data management and help improve decision-making.

If the Biodiversity Knowledge Centre were to benefit from the latest digital developments in biodiversity monitoring, this would ensure more unified data management and help improve decision-making.

National efforts to systematise data collection and processing can provide valuable lessons and input for these EU-level efforts. On a national level, Germany, for example, is trying to overcome data fragmentation across different public authorities via a Biodiversity Monitoring Centre, which is currently being developed by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). The Centre will work towards coordinating and standardising different federal units' and sectorial departments' reporting and support more effective data collection. It aims to expand and secure the national biodiversity monitoring scheme.

2.2. SUSTAINABLE ARTIFICIAL INTELLIGENCE

AI is one of the most transformative emerging technologies. The EU is emphasising its development strongly under its Digital Agenda. While the EU spent €3.2 billion on AI projects in 2016, it is expected to invest up to €20 billion per year under the 2021-27 Multiannual Financial Framework (MFF).[36]

Ethical and human-centred considerations influence the EU's approach to AI. As part of the High-Level Expert Group on Artificial Intelligence's (AI HLEG) ethics guidelines and investment recommendations, some links between AI and sustainability are also recognised.[37] The AI HLEG stresses that future AI development must consider environment- and sustainability-related challenges to avoid adverse environmental effects, and has thus called for the adoption of precautionary measures.[38]

The Commission's White Paper on Artificial Intelligence – the first step toward an AI regulation – suggests how the EU could support and promote the development and uptake of AI across Europe. It includes a list of possibilities for the development of ethical or trustworthy AI and recognises that soft law, standards and/or more strict regulation may be needed for the use of AI in areas like transport and energy. The White Paper notes that "digital technologies such as AI are a critical enabler for attaining the goals of the Green Deal"[39] and that AI systems generate environmental impacts throughout their lifecycle. Moreover, it suggests exploring, with the member states, how they can promote sustainable AI solutions that make choices that are positive for the environment. This is especially relevant for improving biodiversity, as AI offers many opportunities for better data management for biodiversity. However, AI can only provide sustainable prospects for environmental protection if its development and usage consider the resource usage and energy consumption of AI solutions.

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2.3. DIGITAL TOOLS FOR MONITORING COMPLIANCE AND ENFORCEMENT

Digital tools can be used to improve not only the compliance with and implementation and enforcement of existing legislation, like the Nature Directives, but also support efforts to reach the EU's commitments under the CBD (e.g. reverse biodiversity loss, tackle invasive alien species). Earth observation via remote sensing technologies (e.g. satellites) is used to monitor and assess the status of and changes in the environment. Earth observation is used as a support tool for the INSPIRE Directive, Shared Environmental Information System, Copernicus programme, GEOSS, Common Agricultural Policy (CAP) and Integrated Maritime Policy, for example.[40] Advanced earth observation can provide important additional support for the enforcement of nature legislation (e.g. using satellite imagery in court cases).[41]

Current technologies and those under development are making it increasingly easy to collect more data and thus monitor compliance, even in cases where stakeholders are hesitant to provide access to the data (e.g. farmers due to personal and business-sensitive data). The proposed 2021-27 European Space Programme envisages further support for environmental monitoring as part of the Copernicus programme. Moreover, the EEA and ESA's plans to use AI and machine learning to improve the efficiency of biodiversity data collection and processing (e.g. satellites equipped with high quality-imaging technology or AI) will be very welcome. The development of a digital twin of the planet Earth, as proposed by the Commission under the Green Deal and Digital Agenda, also offers exciting prospects for following planetary developments and sharing information that is useful for the monitoring and enforcement of rules on biodiversity.

The EU operates within a global framework for improving nature protection, ecosystems and biodiversity. While the post-2020 framework for the implementation of CBD is under development, the current 2011-20 framework already adopted a long-term vision: "By 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people."[42] The EU Biodiversity Strategy for 2030 also refers to this vision. Europe's experience and technological capabilities in monitoring planetary developments could also help achieve these global goals.

Recognising that the root cause of the COVID-19 pandemic likely lies in human interaction with wildlife,[43] it is also worth noting that global rules for managing these relations and digital tools that could support these efforts already exist. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) establishes rules for trading endangered species of wild fauna and flora, including outright bans for most endangered species. It is apparent, however, that CITES is insufficiently implemented and enforced. That is why the CITES Secretariat started an eCITES initiative in 2017 to automate permit procedure and electronic information exchange between customs, to facilitate the legal trade and hamper the illegal trade of endangered species. However, only one country has adopted eCITES so far, despite the relatively low costs of adopting the new system (estimated at $30 million in total for all 183 signatory states).[44]

2.4. EU FUNDING

Following the COVID-19 outbreak, the European Commission presented its new proposal for the 2021-27 MFF (€1.100 trillion) in May, together with the European recovery plan, Next Generation EU (NGEU) (€750 billion).[45] At the July EU Summit, EU leaders finally agreed on the size of the post-2020 MFF – slightly lower than the Commission's proposal (€1.074 trillion). They retained the proposed amount for NGEU, although the share of loans increased at the expense of the grants.[46] At the time of writing this Discussion Paper, the European Parliament is yet to give its final approval of the new MFF and NGEU. In any case, further complications can still be expected.[47]

The new budget proposal rightfully stresses the importance of a more green, digital and resilient Europe. As the MFF and NGEU signal what the EU sees as its priorities, this should provide a strong rationale to invest taxpayers' money in activities that enhance the EU's competitiveness and sustainability in practice, and increase investments in the joint green and digital transition.

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The ***Biodiversity Strategy*** envisages unlocking €20 billion per year for biodiversity through various sources, including EU funds and national and private funding. However, it is not specified how this goal is to be attained, nor is the need to invest €20 billion per year for biodiversity reflected in the proposed NGEU or new 2021-27 MFF.[48]

The ***Digital Europe Programme*** (DEP) is expected to play a key role in the deployment and uptake of digital technologies. The Commission proposed to allocate €8.2 billion to it, which member states reduced to €6.7 billion. The DEP is expected to focus on five major areas: supercomputers, AI, cybersecurity, digital skills and ensuring the deployment and uptake of digital technologies. Although not referring to biodiversity and nature explicitly, the proposed DEP establishes the general link between digital transformation and earth/environmental monitoring. The proposal recognises the importance of applying AI, high-performance computing, deployment, best use of digital capacities and interoperability for the benefit of the environment.[49] Considering the scale of investment needed in these areas, its share in the proposed budget appears extremely small. It is important to ensure that these investments are not reduced in the final budget and that the potential of digital technologies to address environmental challenges, including biodiversity and nature protection, is strongly emphasised.

H2020 is the EU's research and innovation programme from 2014 to 2020 and aims *inter alia* to contribute to sustainable development. The funding under H2020 addresses challenges related to "climate action, environment, resource efficiency and raw materials", including the "sustainable management of natural resources and ecosystems", as well as "food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy".[50] However, H2020 does not make clear reference to enhancing the development and uptake of digitally-enabled solutions for the management of natural resources and ecosystems.[51]

H2020 will be followed up by the post-2020 ***Horizon Europe programme***, for which €80.9 billion was envisaged in the Commission's proposal for the 2021-27 MFF (before being reduced to €75.9 billion after the July EU

Summit). The Commission envisaged an additional €13.5 billion for Horizon Europe via its recovery plan. However, this was reduced to €5 billion at the Summit. This means that the total figure for Horizon Europe (from both the 2021-27 MFF and NGEU) currently stands at €80.9 billion – the same amount as the Commission's initial proposal for the 2021-27 MFF alone.

The proposed programme aims *inter alia* to "contribute to tackling global challenges, including the Sustainable Development Goals."[52] One of the specific objectives is to "support the uptake of innovative solutions in industry and society to address global challenges".[53] Under this specific objective, a cluster of activities is envisaged, including one on "food and natural resources" (€10 billion). This cluster also includes support for biodiversity and natural capital. However, due to budget cuts following the July EU Summit, the figures mentioned above might be revised.

LIFE is the EU's only programme dedicated to environmental protection and climate action. Between 2014 and 2020, it totalled €3.5 billion of funds. The Commission proposed allocating €4.8 billion to the 2021-27 LIFE programme. This amount did not change following the July EU Summit.

The LIFE programme has a strong focus on nature protection and supports stakeholders involved in nature protection and the enhancement of Natura 2000 (e.g. rangers, NGOs, farmers). One of its aims is to "contribute to the shift towards a resource-efficient, low-carbon and [climate-resilient] economy".[54] LIFE working programmes for 2014-17 and 2018-20 also refer to agriculture.[55]

Neither the existing LIFE programme nor the proposal for post-2020 considers digitalisation to be an instrument that can improve biodiversity and environmental protection, or make agricultural practices more environmentally friendly.[56] However, there is a general reference "to develop, demonstrate and promote innovative techniques and approaches for reaching the objectives of the Union legislation and policy on environment and climate action" in the post-2020 proposal.[57] At the same time, considering that developing and deploying digital solutions comes at a high cost and that LIFE has a comparably small budget, there is a risk that the greater focus on digitalisation and innovation could absorb the envisaged support for the protection of biodiversity and natural capital.

The ***CAP*** provides subsidies in the form of 'direct payments' to EU's farmers. It also provides additional support to the EU's rural development via the European Agricultural Guarantee Fund and the European Agricultural Fund for Rural Development. The exact architecture of the CAP is specified under every seven-year MFF.[58] While the 2014-20 CAP linked the provision of financial assistance to farmers with more conditionalities on environmental and nature protection,[59] there are considerable shortcomings to the conditionalities and their implementation.[60]

In order to simplify and modernise the CAP, the Commission's proposal for a post-2020 CAP envisages a shift from a compliance base to a performance one. While this would replace the existing top-down, 'one size fits all' structure with a more flexible approach and thereby give national authorities a greater say on the measures to be taken, there is also a high risk that this would undermine the green agenda.

The Commission's proposal for a post-2020 CAP refers to both digitalisation and specific environmental and/or climate objectives.[62] The extent to which digitalisation is geared to achieving the environmental and climate objectives is, however, questionable. As it stands, digitalisation is envisaged to be a separate, cross-cutting objective which, according to the ECA, "leaves the indicators linked to this objective outside the scope of performance clearance and multiannual performance review."[63] If digitalisation was considered together alongside the environmental and climate objectives, it would lower the risk of digital tools being deployed without any consideration for sustainability.[64]

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The Commission's proposal for the Farm to Fork Strategy, published in May 2020, provides an additional push to adopt more holistic thinking when it comes to the future of agriculture in Europe. It is widely recognised that the CAP, focused primarily on production, is limited in its approach. The proposal also clearly recognises the link between digitalisation and achieving climate and environmental goals. As such, it should serve as a sound basis for ensuring that digitalisation is geared to achieving the diverse set of goals within the agricultural sector.

The pressing question is whether and to what extent the EU and national policymakers are willing to reform the CAP in alignment with the goals set out in the Green Deal, Farm to Fork Strategy and Biodiversity Strategy. The European Parliament voted in October against the Commission's proposals to cut subsidies for intensive industrial farming and the protection of grasslands and peatlands, a major reservoir of GHG emissions.[65] This signalled the Parliament's continued support for an archaic agricultural policy that would be detrimental to the European Green Deal, biodiversity and climate action. Negotiations on the future of the CAP continue between the Commission and the EU member states. The outcome will signal what the EU's actual priorities are, and whether it is ready to put its money where its mouth is and protect its nature and climate, as set out in the European Green Deal.

Prioritised action frameworks (PAFs) are planning tools that have so far helped coordinate the use of different financial instruments, including EU funds, for nature protection. Member states are expected to develop their own PAFs for their respective protected areas under Natura 2000. While EU financial instruments, like the LIFE programme and CAP, can be used to enhance biodiversity, not having one single fund for nature protection has raised criticism.[66] Nonetheless, as funds for biodiversity – specifically under LIFE – remain small, PAFs provide a certain level of coordination for using different EU funds.

2.5 POLICY RECOMMENDATIONS

Strategic direction

- ► Amidst the ongoing COVID-19 crisis and the looming climate and even wider sustainability crisis, it is time to recognise and address their nature-related causes and devise nature-based solutions. Functioning ecosystems, nature protection and improved human interactions with the environment are not nice-to-haves, but the basis for our well-being, welfare and sustainable prosperity. They are key to tackling the climate crisis.

Functioning ecosystems, nature protection and improved human interactions with the environment are not nice-to-haves, but the basis for our well-being, welfare and sustainable prosperity. They are key to tackling the climate crisis.

- More must be done to understand the state of environment, ecosystems and biodiversity, by optimising data collection, processing and especially analysis with the help of digital solutions, both in Europe and globally. In Europe, more knowledge is needed, especially on the state of and trends for biodiversity in Europe (i.e. soil and marine environments) and the drivers of biodiversity loss.
- Data management should be steered to improve knowledge about the true value of biodiversity and natural capital (e.g. soil, forests) for our economy, society and climate action.
- Science, compiled data and gathered knowledge should be clearly reflected in decision-making and policies. It should contribute to creating a more sustainable economy and society, where the value of nature and natural capital is recognised in policies, communication, investments and incentive structures for businesses and citizens.

- ► The post-2020 Biodiversity Strategy must be brought into the digital age. Building on the new governance framework, as envisaged in the Strategy, the EU should optimise data management and the use of digitally-enabled solutions (e.g. AI, robotics) for the benefit of ecosystem restoration and nature protection.

The post-2020 Biodiversity Strategy must be brought into the digital age.

- The EU must adopt a more strategic approach to using digital solutions to restore ecosystems on a large scale and help avert further biodiversity loss. This requires upgrading the current data monitoring and reporting systems accordingly.
- Data collection and consecutive analysis must help the EU meet its long-term priorities on biodiversity protection. Data must be turned into actionable knowledge that can support better decision-making and improve the implementation and enforcement of policies outlined in the Biodiversity Strategy and other relevant legislation. The European Green Deal data space should provide an overarching framework for standardising the collection, sharing, processing and analysis of data relevant to biodiversity protection.

- ► When applicable, the relevant EU funding programmes should help address the loss of biodiversity, by building on existing data and evidence and developing and deploying needed solutions. The DEP and Horizon Europe could play an important role in this regard.

- The EU should provide financial support for the development and deployment of digital solutions to address the biodiversity challenge. Satellites, drones, sensors, databases and more should be used to gather the data needed.
- The EU should accelerate the uptake of digital technologies (e.g. AI) to enhance data collection, processing and analytics, and thus optimise and modernise data management for the benefit of nature protection.

Enhance collaboration

- The EU must encourage collaboration between the relevant stakeholders to optimise data collection and sharing.
    - Environmental, climate, security, ocean and digital communities should be encouraged to collaborate, to assess the kind of data needed from satellites and other sources.
    - The EU should boost the collection and sharing of standardised environmental data via non-mandatory guidelines or legislative requirements, building on the INSPIRE Directive and ongoing developments at the member state level.
- The EU should support the establishment of a 'European Biodiversity Knowledge Centre' that streamlines the collection, monitoring and analysis of data needed to enhance biodiversity. More knowledge on the state and trends of biodiversity in Europe (including soil and marine environments) and the drivers of biodiversity loss and ecosystem collapse is needed. This Centre should help increase the interoperability of existing biodiversity databases at the EU, member state and subnational levels. It should build on existing tools like the EUNIS and aim to improve and optimise data management and analysis further at the EU level.
- The EU should explore ways to enhance biodiversity by engaging with businesses. Businesses should be guided to use online platforms, like the EU Business @ Biodiversity Platform, to exchange and integrate natural capital and biodiversity considerations into their practices.

The EU should explore ways to enhance biodiversity by engaging with businesses.

- The EU and its member states should create incentives for farmers to share data that can support more sustainable farming practices with other farmers, researchers and companies. The same holds for the provision of environment-related data to public authorities.
    - In order to foster trust, farmers should be educated and supported to understand both the benefits and risks related to sharing data.
    - CAP payments could be made conditional on farmers providing relevant data. Smart contracts (automatic execution of contractual commitments), coupled with digital tokens and technologies for greater transparency like blockchain, could be used to incentivise farmers further to share data relevant for sustainability.
    - The EU and its member states should explore how to make data from farmers anonymous. The data would thereby become less sensitive when shared with authorities in charge of the climate and environment, as well as academia, private companies and NGOs.
- The EU and its member states should continue to explore how to improve citizen science.
    - Rather than create new digital platforms, the EU should build on existing apps and platforms that are actively being used by citizens, to learn and exchange information about nature.
    - The Digital Education Action Plan and European Skills Agenda should support the education and training of citizens to collect and share data more effectively. This would increase the quality of data produced by citizen science. The support could include training on monitoring biodiversity with a common methodology and using digital tools (e.g. smartphones, online platforms) effectively. The DEP and LIFE could also provide similar support.

Improve compliance and enforcement

- The EU must ensure that the progress in implementing biodiversity policies and meeting its targets is measured appropriately. Earth monitoring combined with AI, for example, can be useful in this regard.
- The EU should use the available data from satellites, sensors and other sources more readily to start infringement procedures against member states that do not comply with environmental regulation and rules. Due to the major impact of farming practices on biodiversity, the use of data and digital solutions must be strongly interlinked with the enforcement of CAP rules, namely that farmers fulfil environmental conditionalities when receiving financial support.

The EU should use the available data from satellites, sensors and other sources more readily to start infringement procedures against member states that do not comply with environmental regulation and rules.

Use EU funding

- The EU must invest in improving data management and developing and deploying digital solutions to help protect biodiversity.

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- The EU must support infrastructural investments in connectivity (e.g. Internet coverage, fibre networks), in both urban and rural areas. Having a solid information and communications technology (ICT) infrastructure in place is the basic condition for monitoring biodiversity more efficiently and greening farming practices with the help of data and digital solutions.
- The EU should use Horizon Europe and the DEP to invest in the development and deployment of digital solutions that can benefit biodiversity (e.g. AI to gather and process data relevant to protecting nature). To ensure such support, the wording under the upcoming working programmes, which will define the mid-term agendas for Horizon Europe and Digital Europe, should contain references to investing in data management and digital solutions to support biodiversity protection.
- The EU should ensure that working programmes under LIFE contain cross-references to Horizon Europe and the DEP, to make investing in digitalisation for biodiversity more coordinated. Given LIFE's relatively low funding – which can hardly be increased at this point of MFF negotiations –, any possible funding for digitalisation projects should be assessed carefully. Looking ahead, the EU should consider expanding the financial scope of LIFE so that additional funds could support the use of data and digital solutions for biodiversity protection.
- The post-2020 CAP should ensure that the uptake of digitally-enabled solutions supports environmental and climate objectives, as suggested in the Farm to Fork Strategy. Member states' strategic plans, as envisaged under the CAP proposal for 2021-27,[67] must reflect the links between digitalisation and sustainability. The uptake of digital technologies under the CAP must contribute to more sustainable farming practices and avoid rebound effects (e.g. intensive farming).

Green ICT

- The EU and its member states should use policies and financial instruments to support digitalisation that is aligned with sustainability considerations. While digitalisation offers many possibilities for improving biodiversity, it can only provide sustainable, long-term solutions if the climate and environmental footprints of its solutions are addressed. The development and deployment of hardware and software must consider the energy and resource efficiency of digital solutions.

The EU and its member states should use policies and financial instruments to support digitalisation that is aligned with sustainability considerations.

- The EU should provide guidance, and possibly indicators, on the energy- and resource-efficient use of AI. For example, as suggested in the White Paper on Artificial Intelligence, the Commission should explore with member states how to promote sustainable AI solutions, which are trained to make choices that are positive for the environment. Moreover, more must be done to critically examine the resource usage and energy consumption of AI solutions, if they are to enhance biodiversity sustainably.

Enhance global cooperation

- The EU is a global leader in monitoring nature and should contribute to international biodiversity efforts actively. It can provide valuable input to the development of a global database. It should use the Africa-EU Partnership, for example, to provide ideas and tools for digitalisation, to address environmental challenges beyond the EU's borders.

The EU is a global leader in monitoring nature and should contribute to international biodiversity efforts actively.

- The EU and its member states, which are already signatories of CITES, should adopt eCITES and use diplomacy and financial support (if needed) to encourage its uptake across the globe. This would help combat the illegal trade of endangered species and thus prevent biodiversity loss.

Conclusion

The EU must tackle biodiversity loss if it is to ensure long-term, sustainable prosperity for all Europeans. As this Discussion Paper has argued, digital transformation can be a powerful enabler for healthy ecosystems, which are vital for our survival, the basis for a functioning society and key to combatting climate change. With its policy framework, existing solutions and expertise, the EU has a solid basis for turning digitalisation into a real catalyst for nature protection. However, more could be done to address the twin challenges of the digital and green transitions and use digitalisation to address challenges with biodiversity.

Digital transformation can be a powerful enabler for healthy ecosystems. However, more could be done to use digitalisation to address challenges with biodiversity.

Digital solutions have already contributed to the protection of biodiversity, and the possibilities are growing by the day. Collecting and managing data on the environment via solutions like earth observation and remote sensing have been central to monitoring changes in biodiversity. The information gathered has been turned into greater knowledge on the scale of the challenge and used to act accordingly. Going forward, digital solutions enabled by AI and the IoT, for example, can further improve data management needed for monitoring, decision-making and law enforcement. They can also help green human activities, including farming practices, that are major drivers of biodiversity loss. Digital solutions like online platforms and apps make it easier to raise awareness about biodiversity-related challenges and even encourage citizens to support necessary measures and gather data, thus enabling citizen science.

However, there are three main barriers to be addressed when it comes to using data and digital solutions to protect and improve biodiversity. First, the management of data should be improved. This entails improving what data is collected and thus enhancing knowledge on biodiversity-related challenges. Efforts are also needed to improve the sharing of data, which is often limited due to concerns over data ownership, data protection (i.e. personal and business-sensitive data), data privacy and (the lack of) data standards. This would otherwise hamper the monitoring and enforcement of nature policies and legislation.

Second, improving data management to evaluate the value of healthy ecosystems and biodiversity can help create a stronger economic rationale for action. Improving knowledge on the scale of the challenge and needed measures – with stricter regulatory frameworks and financial support for action – can incentivise the development, use and scale-up of digital solutions for monitoring and improving biodiversity.

Third, digitalisation should be steered and guided if it is to become a real enabler and catalyst for sustainability. This requires addressing its own environmental and climate footprints while also ensuring that the solutions are addressing not just the consequences of biodiversity loss, but also its causes.

The European Commission's proposal for a Green Deal provides the direction for addressing the twin challenges of the green and digital transitions. The new EU Biodiversity Strategy for 2030 provides the groundwork for connecting nature protection and digital transformation. The EU and its member states should use this Strategy as a basis for developing a policy framework and action plan that harness the power of data and digital technologies to protect nature. They must use the available financial tools, including the MFF and NGEU, to support efforts to restore and improve biodiversity with the help of digitalisation.

It is high time to turn digitalisation into a catalyst for creating a better world; an enabler that helps Europeans and the global community operate within the planetary boundaries.

It is high time to turn digitalisation into a catalyst for creating a better world; an enabler that helps Europeans and the global community operate within the planetary boundaries. There is no better place to start than to use the power of data and digital solutions to protect biodiversity and create healthy ecosystems, and capture the related benefits for people, industry and the planet.

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