



A PARTNERSHIP FOR OUR PLANET

Innovative Technology and Digital Solutions for
Fair and Effective Area-Based Conservation



Green List
Protected / Conserved Areas

Tech4Nature

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TECH4NATURE

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FOREWORD

Huawei and IUCN, the International Union for Conservation of Nature, began a collaboration in 2020 marked by innovation, commitment, and a shared vision for the future of nature conservation. The joint 'Tech4Nature' initiative has yielded positive conservation outcomes and has ignited a passion and set a clear pathway for harnessing technology to protect our planet's invaluable biodiversity.

At its core, Tech4Nature forges a blend of cutting-edge technology and the unwavering dedication to safeguarding our natural world. This partnership has thrived on the belief that by uniting IUCN's globally credible conservation standards, safeguards and tools with Huawei's technological expertise, we can spark transformative change in the field of nature conservation.

IUCN, as a global leader in conservation, has long been instrumental in providing the essential tools and knowledge needed to inform conservation decisions worldwide. The IUCN Green List of Protected and Conserved Areas Standard, the Red List of Threatened Species, the Red List of Ecosystems, and the Global Standard for Nature-based Solutions are just a few examples of the invaluable resources that guide our collective efforts to preserve our planet's precious ecosystems and species in a just and effective way.

Through initiatives like Tech4Nature, we have paved the way for these resources to evolve and reach new heights through the integration of cutting-edge technologies. This evolution is vital as we strive to meet the ambitious goals and targets set forth in the Kunming-Montreal Global Biodiversity Framework. Our journey thus far is a testament to the power of collaboration, and we invite organisations and partners who share our passion to join us in scaling up technology solutions that will have a

direct and measurable impact on conservation efforts worldwide.

In our pursuit of progress, we have achieved remarkable milestones. From acoustic monitoring of the elusive Hainan Gibbon in China to digitally-empowering local communities in Mauritius to conserve coral reefs, our work has spanned across continents, impacting diverse ecosystems and species. We've harnessed the capabilities of advanced data sensing, real-time transmission, machine learning, and artificial intelligence to enhance conservation efforts with early remarkable results.

As we celebrate these accomplishments, we are dedicated to an even more promising future. Our journey has revealed the potential of technology to safeguard nature's wonders and the stewards of our environment. It is a future shaped not by endings but by beginnings—a future where technology and conservation work hand-in-hand to achieve the scale of action we need to conserve, restore and sustainably manage ecosystems and bring biodiversity back from the brink.

As we begin a new chapter, we do so with optimism and a steadfast commitment to the transformative power of technology. Our partnership with Huawei and the Tech4Nature Initiative are set to lead us into a brighter, more sustainable future for nature conservation. Together, we embark on an extraordinary journey, and invite organisations and partners interested in Tech4Nature to join us on this endeavour, where the nexus of technology and conservation promises a future where the wonders of nature are protected as never before.

Grethel Aguilar
Director General, IUCN

FOREWORD

The Earth is our one and only home and we must protect it to ensure the continued well-being of humanity and the species that we share this home with.

It is increasingly clear that technology and partnerships are a powerful force for good that can underpin these efforts.

Launched in 2020 by IUCN and Huawei, Tech4Nature reflects our joint vision that technology, when leveraged appropriately, can drive successful outcomes in conservation and enable us to help the world's natural ecosystems flourish.

For both us and IUCN, Tech4Nature represents the first major partnership that either of us have undertaken in each other's domain of expertise. IUCN's global leadership in the nature conservation space coupled with Huawei's innovation capabilities have combined to achieve much more than if either of us acted alone.

Over the past three years, we have run flagship projects in five countries spanning Africa, Europe, Asia, and Latin America. We have demonstrated the potential of technologies like connectivity, IoT, cloud, big data, and AI to help us understand what exactly is going on in ecosystems, and develop targeted, data-driven management and protection measures. Tech4Nature solutions have been deployed in wetlands, ocean, mountain, and forest ecosystems, from coral restoration in Mauritius and carbon sequestration in Switzerland to protecting endangered species and ecosystems in Mexico, Spain, and China.

But, of course, we have much farther to go on a journey that is best traveled together.

Tech4Nature is not just a partnership between IUCN and Huawei. Local organizations, partners, and communities are crucial to the success of each and every project. They bring to bear unparalleled local expertise and knowledge, and serve as a force multiplier for what we can achieve in nature conservation.

Partnerships are the bridge between the nature conservation and technology sectors. This publication, Tech4Nature — *A Partnership for Our Planet*, is designed to help advance the digitalization of the nature conservation industry and empower potential partners on the journey ahead. The challenges and successes we have experienced in Tech4Nature so far have laid a solid foundation for the future, to expand our reach, to work with more partners, and to achieve conservation outcomes that make a real difference to the world.

Together, we can walk farther. Together, we can walk to a greener and sustainable future.

Tao Jingwen
Board Member and Chairman of the Corporate Sustainable Development Committee, Huawei



1. INTRODUCTION

As we confront the interlinked challenges of climate change, habitat loss, and biodiversity decline, the urgency to rethink our approach to nature conservation has never been more pressing. At the same time, this era of escalating environmental challenges is also marked by rapid technological advancement, and the potential for the responsible and

ethical use of technology to protect and conserve nature is clear.

As we stand at the crossroads of a pivotal decade, the imperative and the opportunity to harmonise innovation with conservation have never been more compelling.

1.1 The Tech4Nature partnership

[Tech4Nature](#) is a global partnership aimed at scaling-up success in nature conservation through digital technology innovation. Created by [IUCN](#) and the [Huawei TECH4ALL](#) programme, Tech4Nature is an open partnership to apply and promote digital solutions for fair and effective protected and conserved areas (PCAs). This growing partnership provides guidance on the appropriate use of technology in area-based conservation and directly involves the information and communications technology (ICT) sector in supporting nature conservation.

1. At the heart of the Tech4Nature partnership is the [IUCN Green List Standard](#), which describes the steps and processes required to achieve long-term success for people and nature for area-based conservation. The Standard guides and ensures appropriate and responsible deployment of technology in this partnership. In adopting the [IUCN Green List Standard](#), committed protected and conserved areas and their stakeholders build up a profile of actions and processes that allow them to set clear conservation objectives and demonstrate progress and successful results.

In order to make progress and maintain performance, many sites are using available technological tools and resources to enable improvements. The Tech4Nature partnership addresses key questions about technology use, relating to implementation, inclusive participation, and improved collaboration, such as:

- What are the technologies available that can help frame, set, and implement conservation objectives, and enable effective monitoring and measures of success? What ideas for new technologies, or adaptations of existing tools, could be harnessed for protected areas?
- Which technologies can best help engage people in participatory processes, and rights-based and gender-inclusive decision making?
- How can digital technology help connectivity between experts and practitioners alike, and support improved data management and analytics for decision making?

In promoting Tech4Nature, IUCN and Huawei identified five flagship protected areas to help pilot the use of ICT for nature conservation. These sites, in China, Mexico, Mauritius, Spain, and Switzerland, are using cutting-edge digital technology to address conservation needs for different ecosystem types and endangered species (see Case Studies in Chapter 6).

Participating sites are mentored through the Green List process, and their progress is reviewed, assured, and verified. Sites that meet all the criteria of the Standard are awarded Green List certificates, initially valid for five years, with continuous improvement expected to maintain and prolong this recognition. IUCN’s Green List evaluation system will benefit from more advanced digital applications, allowing for the better use of technology to help identify and understand conservation needs, and allow for the remote assessment, review, and evaluation of participating nature conservation areas and the sharing of lessons learned among the Green List community.

The Tech4Nature partnership is the first time that IUCN has engaged in a major way with the ICT sector, helping connect their knowhow and innovation with nature

conservation, using IUCN standards and safeguards to help guide the appropriate use of technology and achieve conservation successes.

There is growing momentum and buy-in from the conservation community both to use more technology and to develop and create new ways it can be applied. Tech4Nature is building on this momentum to inspire and help grow a community of technology providers focused on conservation.

The IUCN Nature 2030 programme recognises that technology is a key enabler for conservation success and the key to unlock opportunities and investment for different nature-based solutions and conservation efforts. The Tech4Nature partnership is one way that IUCN is helping build and emphasise the potential opportunities and application of different technologies for conservation impact.

In its Nature 2030 programme, IUCN outlines some of the potential technologies that can accelerate and facilitate the implementation of this programme and lead to positive impacts across the different areas of work (see Table 1).

Figure 1: The initial three years of Tech4Nature aimed to enable more than 300 protected areas in over 30 countries worldwide to evaluate their conservation success by 2023, through the IUCN Green List Standard for fair and effective area-based conservation.



People	Land	Water	Oceans	Climate
Blockchain to protect rights holders, ICT for greater environmental transparency and accountability, and legal education	Innovation in data sensing, big data and AI in conservation knowledge and insights	Innovation in data sensing and machine learning for freshwater species and freshwater ecosystems	Innovation in data sensing and machine learning for marine species and marine and coastal ecosystems	Innovation in data sensing, big data, and AI in climate change knowledge and insights

These technologies, in summary, refer to better data collection and analysis (data sensing, connectivity and analysis)

for improved decision making across conservation challenges.

1.2 About this publication

This Tech4Nature flagship publication presents cutting-edge technologies and digital solutions for the fair and effective management of protected and conserved areas and threatened species. It is intended to help conservationists, policymakers, and the ICT sector explore the multifaceted intersections of technology and nature and navigate the rapidly evolving and dynamic landscape on the use and potential of innovative technology in conservation.

This publication has three primary objectives:

- 1. Showcasing technological innovations** through a compendium of cutting-edge technologies, such as remote sensing, artificial intelligence, blockchain, and big-data analytics, and their applications for the fair and effective management of protected and conserved areas (PCAs) and threatened species. Real-world case studies show where these technologies are revolutionising decision-making processes that result in timely action for ecosystems and species.

- 2. Guiding policy and decision making** by providing policy makers, conservationists, the ICT sector, and other stakeholders with actionable insights into the integration of technology into PCA management. We emphasise the importance of robust policy frameworks, ethical considerations, and cross-sectoral collaborations to leverage the full potential of technology and digital solutions for conservation.

- 3. Fostering global collaboration** by catalysing partnerships among technology developers in the ICT sector, conservation organisations, governments, Indigenous Peoples and communities, youth groups, and academia and research institutes. By facilitating knowledge exchange and cross-disciplinary collaboration, Tech4Nature accelerates the development and adoption of technology-driven solutions.

In Chapter 2, we present a review of the role of technology in conservation, looking at the need for technological solutions to pressing challenges, the potential benefits of technology, and key practical and theoretical considerations about the use of technology. Chapter 3 discusses the role of Standards in appropriate technology use, looking at the example of the IUCN Green List. This is followed in Chapter 4 by a review of the ways that technology can help with implementation of the four main components of the Green List Standard – good governance, sound design and planning, effective

management, and successful conservation outcomes. Chapter 5 presents a similar review of how technology can help support the Global Biodiversity Framework 30x30 Target. Chapter 6 puts this theory into practice, with a series of five case studies from Tech4Nature flagship country projects. Finally, Chapters 7, 8, and 9 present a review of future directions and opportunities, recommendations for scaling up Tech4Nature efforts around the globe, and a call to action for all stakeholders to embrace the use of technology in conservation solutions.





2. THE ROLE OF DIGITAL TECHNOLOGY SOLUTIONS

2.1 The need for technology solutions to pressing conservation challenges

The planet faces many conservation challenges today, including climate change, invasive or alien species, illegal wildlife trade, zoonotic diseases, and ethical issues (Isabelle & Westerlund, 2022). Looking to the future, innovation will be vital for effectively and efficiently addressing these challenges and anticipating new ones (Lacona *et al.*, 2019). Innovations in the field of artificial intelligence (AI), for instance, are now offering diverse opportunities to tackle conservation challenges. Individuals, private and public sectors, governments, and nongovernmental and inter-governmental organisations need to collectively tap into this potential and foster the use of technology to accelerate conservation efforts.

The influence of digital technology on human interaction with biodiversity is not new. The first significant examples emerged during the 1970s and 1980s, as technology began to play a substantial role in the monitoring and tracking of animal populations. Digital technology has also had a multi-dimensional impact on people's engagement with various wildlife species and contributed to the dissemination of new knowledge about them to the public. Today, the proliferation of digital technologies has grown exponentially, resulting in their widespread adoption on a global scale. The swift advancement of digital innovations has normalised the use of cloud computing, big data analysis, blockchain, and artificial intelligence within everyday devices and applications.

Alongside technological progress, the incorporation and assimilation of advanced digital technologies – such as 5G networks, the Internet of Things (IoT), cloud computing, AI, big data analytics, robotics, and deployment of geospatial technologies – are significantly aiding in species recognition and identification, and the provision of relevant information. Moreover, digital technology plays a pivotal role in providing solutions for mitigating human-wildlife conflicts (HWC), combating illegal wildlife crime, planning anti-poaching strategies, combating invasive species, managing tourism visitation, calculating carbon footprints, restoring and rewilding habitats, and dealing with deforestation and climate change impacts that threaten the survival of both nature and people's livelihoods.

The significance of Protected and Conserved Areas (PCAs) in protecting biodiversity, ecosystems, and cultural heritage remains paramount. Successful administration of these areas hinges upon access to accurate, up-to-date information that supports decision making and fosters sustainable conservation practices. And effective governance and management demand comprehensive data and information on species populations, habitat integrity, distribution, threats, and other essential ecological, social, economic, and environmental attributes required for a full understanding of the entire ecosystem. Yet, most of the world's PCAs are in remote

locations and often face constraints in terms of information technology and resources.

Thus, there is an urgent need for more integration of novel technologies into conservation endeavours to help enhance monitoring and measurement of shifts in PCAs and the natural heritage they conserve. There are six key areas where technology can improve PCA work and outcomes:

1. Improved site management
2. Local community involvement
3. Species monitoring
4. Financing conservation in protected areas
5. Site visitation
6. Threat detection and alert.

2.2 The potential of digital technology in conservation and benefits for conservation practitioners

The importance of technology transfer and use is highlighted in Target 20 of the Kunming-Montreal Global Biodiversity Framework (GBF): “Capacity-building and development, technology transfer, and technical and scientific cooperation for implementation is strengthened.”

To achieve conservation outcomes that are both effective and equitable, it is crucial to establish a more robust monitoring and review framework to oversee the implementation of global area-based conservation policies by countries. This enhanced process will play a pivotal role in assessing progress, guiding implementation efforts, promoting learning, and ensuring the transparency and accountability necessary for procedural equity.

The following are examples of how digital technology solutions can be integrated into the governance and management of PCAs and threatened species:

a. Data Analysis and Reporting:

Provide tools for advanced spatial analysis, such as habitat modelling, species distribution mapping, and land cover change analysis. Generate

automated reports that highlight key findings, trends, and management recommendations.

b. Monitoring and Alert System:

Incorporate a monitoring component that tracks and alerts users to changes in key indicators, such as encroachment, poaching incidents, habitat loss, and climate-related impacts. Implement real-time data feeds and notifications to ensure timely response and adaptive management. This includes camera Traps, SMART, and radio telemetry.

- c. Spatial Data Integration:** Integrate geospatial data layers from diverse sources, including satellite imagery, remote-sensing data, biodiversity surveys, and socio-economic datasets, to create a comprehensive database for analysis and visualisation. Examples include ArcGIS and QGIS.

d. Interactive Mapping and

Visualisation: Develop an intuitive and user-friendly interface that allows users to visualise spatial data through interactive maps, charts, and graphs.

Users should be able to overlay different layers, zoom in and out, and customise the visualisation based on their specific requirements.

e. Collaboration and Data Sharing:

Enable collaboration and data sharing among stakeholders, allowing for the integration of local knowledge, community-based monitoring, and citizen science initiatives. Ensure data security, privacy, and appropriate access controls.

The potential of digital technology in conservation is vast and continues to expand. Conservation practitioners can leverage these tools to collect, analyse, and disseminate data more efficiently, enabling more effective and informed decision-making.

And while these opportunities for improvement exist, it is important to consider some of the challenges. Using technology

in natural environments is not an easy feat. These challenges include getting basic data, transmitting data over networks, and analysing data with AI, among others. This is because there are many different things and services that need to be managed.

When we try to use technology in places like protected areas and for managing species, we also have to deal with some difficulties related to sensing nature. Some devices and hardware may not work well in the wild. Existing equipment may struggle in very cold temperatures and tough conditions, and keeping the batteries charged can be a challenge. It's also essential to make sure that the technology we use doesn't harm the environment or the animals. Sometimes, the devices can't connect well or analyse data in real-time because the algorithms (rules for processing data) are not ready yet. This can be made worse by not having the technical knowledge needed to use these devices effectively.

2.3. The appropriate use of technology solutions

Through their various applications, new technologies offer a wide range of opportunities. However, they also pose important ethical issues worth taking into consideration when they are being deployed. For example, conservation surveillance technologies (CSTs) such as drones and remote cameras collect significant amounts of data on people as well as wildlife (Sandbrook et al., 2021).

When asked how they felt about being captured by camera-traps primarily set up for wildlife (human bycatch), people reported that it violated their privacy and was a source of fear (Sandbrook et al., 2018). Similar reactions to drones have been reported by several authors, including (Wich, et al., (2016),

who argue that the proliferation of technology such as drones has come with a set of ethical issues that need attention. In addition, some species such as manatees have been identified as sensitive to drones (Landeo-Yauri et al., 2021). It is therefore crucial to put rights, privacy, and security at the centre of discussions about further technology deployment, regardless of how important we as practitioners think those tools are. It's about finding the balance between the goal we're after and the best available technology that is appropriate and proportional in its use.

Conservation projects worldwide, including technology-oriented ones, seek to protect life on earth and ultimately sustain the means of survival for humankind. Putting the very

people, we are seeking to help at the centre of implementation will not only foster respect of people's rights and privacy, but also raise their awareness on the importance of these projects to themselves and their survival.

Proactively considering the human dimension of technological application to conservation can impact people's perception of the efforts and likely increase their engagement and improve results.

2.4 Key factors and considerations for successful implementation of technology in conservation

Below are some suggested Do's and Don'ts for the ethical, social, and practical integration of technology into conservation efforts.

Do

- 1. Do collaborate with local communities:** Engage local communities in the design and implementation of technological solutions. As Bennett and Dearden (2013) highlighted in their research on coastal communities in Thailand, it is important to involve local stakeholders to ensure the technology aligns with their needs and values.
- 2. Do ensure accessibility and affordability:** Design technologies that are accessible and affordable to local communities. The success of conservation efforts heavily depends on the participation of these communities.
- 3. Do monitor impact and effectiveness:** Continuously monitor the impact and effectiveness of the technology being implemented to conservation goals.
- 4. Do foster cross-disciplinary collaboration, particularly with social scientists, conservationists, and lawmakers:** Integrating conservation technology with various other disciplines can help implementers see projects through a much broader lens.
- 5. Do respect and value local knowledge and ethics:** Technology should not be used to ignore traditional knowledge or customs. Valuing those traditions and integrating them into the design and implementation of technology-related projects should be paramount.
- 6. Integrate local knowledge:** There is tremendous knowledge held with local and indigenous peoples' communities. When deploying a tech solution, find ways to include and use this knowledge and their participation.

Don't

1. Don't overlook socioeconomic

factors: A technology solution could be strong and still lead to project failure. For instance, a community facing nutrition and economic problems will tend to poach in a protected or conserved area regardless of the monitoring technology in place. In such cases, finding a solution targeting those underlying causes of poaching in the reserve would be the first priority.

2. Don't disregard privacy and data

security: It is vital to ensure the privacy and data security of individuals and communities involved. While this is usually disregarded, data breaches caused by inappropriate storage or use of people's personal data could jeopardise their social status and subsequently the implementing organisation.

3. Don't neglect sustainability: It is equally important to make sure that the projects using technology are sustainable. Meaning, that the needed and anticipated maintenance and repair are planned for, it can be reused and recyclable when no longer in use.

4. Don't ignore community ownership:

Imposing the use of a certain technology in a protected or conserved areas without prior consultation may increase the reluctance of the local community. It is important to acknowledge local people's ownership and genuinely collaborate to adopt whatever technology is needed.

Though by no means an exhaustive list, these considerations, and actions to ensure technology use in conservation is fair and effective are worth incorporating into decision-making processes.



3. THE ROLE OF STANDARDS IN APPROPRIATE TECHNOLOGY DEPLOYMENT

Standards such as the IUCN Green List can help ensure appropriate technology deployment for nature conservation and are crucial for ensuring effective and sustainable conservation efforts. Standards ensure that technology deployment aligns with conservation goals, minimises negative impacts, and maximises positive outcomes, contributing to the well-being of species, ecosystems, and communities.

Standards provide a structured and reliable framework to ensure that appropriate technologies are used effectively, sustainably, and ethically to achieve conservation goals. They guide practitioners in making informed and actionable decisions, conducting thorough assessments, monitoring and reporting on progress, and adapting strategies as needed.

3.1. Example of the IUCN Green List

The following are ways that Standards can play a role in ensuring appropriate technology deployment for nature conservation, using the IUCN Green List as an example:

- **Defining criteria for evaluation:** The IUCN Green List Standard establishes specific criteria that protected and conserved areas must meet to be recognised as well-managed. These criteria encompass ecological health, effective management, community involvement, and more. Similarly, in appropriate technology deployment, standards set out criteria, such as environmental impact, compatibility with local ecosystems, and social acceptability, that technologies must fulfil to ensure they are suitable for the conservation challenge they seek to address.
- **Ensuring sustainable impact:** The IUCN Green List ensures that protected and conserved areas demonstrate sustainable impact and benefits. Likewise, technology standards ensure that deployed technologies contribute to long-term conservation goals without causing social or environmental harm. The technology's benefits must outweigh potential negative consequences.
- **Guiding decision-making:** The Green List Standard guides protected and conserved area managers in making informed decisions that improve conservation outcomes. In the same way, technology standards must guide conservation practitioners in selecting technologies that are well-suited to the local context and to specific conservation challenges they aim to address.
- **Monitoring and adaptive management:** The Green List Standard emphasises monitoring and adaptive management for

protected and conserved areas. Similarly, technology standards require ongoing monitoring and evaluation of deployed technologies. This iterative process allows for adjustments and improvements based on real-world performance, ensuring that technologies remain effective and aligned with conservation goals.

- **Engaging stakeholders:** The Green List Standard promotes engagement with local communities and stakeholders. Technology standards should encourage involving stakeholders in the technology deployment process, fostering a sense of ownership, and ensuring that the technology's design and implementation reflect local needs and concerns.
- **Transparency and accountability:** The Green List Standard's transparency requirements ensure accountability to stakeholders. In the same vein, technology standards enhance transparency by requiring clear documentation of the technology's intended use, potential impacts, and mitigation measures. This transparency holds deployers accountable for their choices.
- **Capacity building:** The Green List Standard encourages capacity building among protected area managers. Similarly, technology standards contribute to capacity building by providing guidelines that educate practitioners about the best practices for technology deployment, fostering a knowledgeable workforce.
- **Continual improvement:** The Green List Standard evolves over time to incorporate new knowledge and experiences. Likewise, technology standards are subject to updates based on advancements in technology, conservation science, and lessons learned from past deployments, ensuring that the most up-to-date and effective technologies and approaches are used.
- **Facilitating collaboration:** The Green List Standard fosters collaboration among conservation organisations and agencies. Similarly, technology standards encourage collaboration between technology developers from the ICT sector, conservationists, and local communities to collectively address conservation challenges.

The IUCN Green List Standard

The future of life on Earth depends on our efforts to nurture and protect nature. On land and in the seas, the impacts of population growth, industrialisation, production, and consumption patterns are pushing our planet's ecological boundaries to the limit.



However, we can hope for change, and dream of a greener future. There is already a strong community of people fighting against environmental loss in and around protected and conserved areas (PCAs) worldwide. They live in remote and wild areas, in the countryside, in cities, in forests, mountains and savannahs, along our coasts and on islands, and out into the seas and oceans – in every part of our planet's rich and varied environment.

By strengthening the governance and management of PCAs, we can effectively safeguard our natural resources and cultural values, protect human health and well-being, and provide sustainable livelihoods.

The IUCN Green List is a global campaign for successful nature conservation. At its heart is the Green List Sustainability Standard, which provides a global benchmark for how to meet the environmental challenges of the 21st century.

The mission of the IUCN Green List is to increase the number of fairly governed, effectively managed PCAs that are able to demonstrate that they are achieving their stated conservation goals – and to recognise those that are already doing this.

A simple Theory of Change guides the Green List in its mission to ensure the delivery of direct, intermediate, and long-term results:

Direct results: Improving performance

- The IUCN Green List Standard provides a credible, global, aspirational framework for achieving nature conservation in protected and conserved areas.
- The evaluation identifies pathways and targets for interventions and support to achieve conservation success.
- Fairly governed and effectively managed PCAs that are achieving their objectives are identified, celebrated, and promoted.
- Community is engaged, knowledge is valued, and new incomes are generated.
- Training and capacity development lead to learning and professional competence, and vibrant networks of PCA experts and practitioners.
- Guidance materials and best practices and experience shared and widely available.

Intermediate results: Generating a positive value chain for protected and conserved areas.

- Greater recognition and support for PCAs as an equitable and effective conservation tool.
- More effective targeting and use of resources to achieve conservation impacts.
- Value for managers, communities, partners, stakeholders, and marginalised groups such as women, youth, or indigenous people.
- Value for governing agencies, donors, investors, and sponsors.
- New and additional investment in PCAs.

Long-term results

- The IUCN Green List programme aims primarily to achieve healthy protected and conserved areas. Effective systems of PCAs show positive conservation outcomes and are resilient to global changes and threats. In-situ conservation systems are consolidated, connected, integrated into wider landscape and seascapes, and conserve biodiversity and ecosystem functions and significant site values. Nature conservation efforts are mainstreamed across development sectors for nature-positive outcomes.

A PCA that meets the IUCN Green List Standard is certified and recognised as achieving ongoing results for people and nature in a fair and effective way.

Any PCA that gains 'Green List' status demonstrates:

- **Respect** for the local community through fair and meaningful engagement of rights-holders and stakeholders
- **Design** and planning that identifies the need to secure the important values of the area
- **Effective management** and monitoring of the status of these important values
- **Successful conservation results** for nature and for people
- **Clear contribution** to climate change responses, health and well-being, and other challenges.

The IUCN Green List Standard is organised into four components of successful nature conservation in PCAs.

The three baseline components are:

- Good Governance
- Sound Design and Planning
- Effective Management

These support the fourth component, **Successful Conservation Outcomes**, which attests to the achievement of an area's goals and objectives. Each component is supported by criteria and indicators to measure achievement. There are 17 criteria covering all four components.





4. HOW TECHNOLOGY CAN HELP IMPLEMENT THE IUCN GREEN LIST STANDARD

Protected and conserved areas (PCAs) cover a wide range of ecosystems and diverse habitats across the globe. These vital sites are home to varied biodiversity and an equally varied natural and cultural heritage. PCAs play a pivotal role in biodiversity conservation, ecosystem preservation, and sustainable development. Designating an area as legally protected is a key step toward creating a safe haven for threatened habitats and wildlife. But it is not enough. Protected areas must also be effectively managed so that countries can deliver on their national and global biodiversity targets.

But how can you tell if a protected area is effective? Given the geographical complexities and wide variety of PCAs, it is by no means a simple process to establish a universally applicable standard for site assessment to measure conservation outcomes and impact and monitor and improve the progress of the PCAs.

The Convention on Biological Diversity (CBD) identified the need for management standards in its 2004 Programme of Work on

Protected Areas. This was in recognition that standards can, among other things, determine which methods and approaches are most favourable and specify monitoring needs and adaptive management approaches.

The IUCN Green List Standard was developed to meet this need by providing a robust verification system to measure successful conservation outcomes and help countries and sites meet the different biodiversity targets qualitatively not just quantitatively in numbers. The Green List Standard is comprised of four main components, or pillars, of successful nature conservation: good governance, sound design and planning, effective management, and successful conservation outcomes. These components are in turn supported by a set of 17 rigorous criteria and 50 indicators, designed to help improve the effective management and governance of PCAs.

This chapter explores how technology can help PCAs achieve the four components of the IUCN Green List Global Standard.

4.1 Technology for good governance



Protected and conserved areas are essential guardians of biodiversity and ecosystems. However, their effectiveness hinges on robust governance structures and practices. Recognising this, the IUCN Green List Standard highlights 'Good Governance' as the bedrock of successful protected and conserved areas, ensuring effective decision making, transparency, resource allocation, community engagement, and legal compliance.

Governance describes the process of making decisions and ensuring the conditions for their effective implementation. It is about who holds the authority and responsibility for conserving nature, and who should be held accountable. Appropriate governance must be tailored to specific contexts. IUCN¹ and CBD² guidance recognise (and likewise encourage recognition and support for) four broad governance types³ (see Table 1).

Target 3 of the Kunming-Montreal Global Biodiversity Framework sets out an ambition to conserve 30% of terrestrial and inland waters and coastal and marine areas through protected areas and other effective area-based conservation measures (OECMs) by 2030. As outlined in the Target, these areas should be governed equitably and based on the recognition and respect of the rights of Indigenous Peoples and local communities, including over their traditional territories (see Box 1).⁴

Technology can help enhance governance within protected and conserved areas through (1) data transparency with rights-holders and stakeholders, which fosters collaboration and accountability; (2) stakeholder engagement, which allows diverse actors to participate in governance processes; and (3) data management, which ensures that ecological and social data used in decision making are accurate, up-to-date, readily available, and legally compliant.

Good governance is fundamental to the success of protected and conserved areas. The IUCN Green List Standard acknowledges this significance, and technology offers a powerful means to enhance governance. However, addressing challenges such as digital access and accessibility, data security, capacity building, privacy concerns, cost, and cultural sensitivity is essential.

By harnessing technology thoughtfully and in alignment with sound governance practices, protected and conserved areas can meet the IUCN Green List Standard criteria on governance. This integration ensures that the rights of Indigenous peoples and local communities are respected, conservation efforts are transparent, and global conservation targets are advanced, ultimately safeguarding biodiversity and ecosystems for current and future generations.

1 e.g. Borrini-Feyerabend et al., 2013; 2014

2 e.g. [CBD/COP/DEC/14/8](#)

3 Dudley, 2008; Borrini-Feyerabend et al., 2013

4 [COP15: Final text of Kunming-Montreal Global Biodiversity Framework | Convention on Biological Diversity \(cbd.int\)](#)

Table 1: The IUCN governance types

Governance by government	Including federal, national, and/or sub-national ministries/agencies and government-delegated management
Shared governance	Including collaborative (various degrees of decision-making authority) and co-governed governing bodies that include different (governmental and/or nongovernmental) actors as well as transboundary governance
Private governance	Including by individual land owners, and non-profit or for-profit organisations
Governance by Indigenous Peoples and local communities	Including territories and areas conserved by Indigenous Peoples and local communities. These are referred to in some CBD decisions as ICCAs and can also be known as 'territories of life', or other national and local terms as declared by Indigenous or local community governing actors.

BOX 1: A tool to help support governance by Indigenous Peoples and local communities

Governance by Indigenous Peoples and local communities is one of the defining characteristics of ICCAs-territories of life. The ICCAs-territories of life and their custodian Indigenous Peoples and local communities play a significant role in conserving nature, through their governance systems, values, knowledge, innovations, practices, and worldviews. ICCAs-territories of life are often without any legal recognition or protection, leaving them vulnerable to land grabbing and industries that exploit their natural resources and undermine their governance. Mapping and documenting territories of life can support communities in assessing and reinforcing the governance of their territories and areas, by supporting internal self-strengthening processes⁵ and increasing visibility.

In support of this goal, Digital Democracy, UNEP-WCMC, and Forest Peoples Programme have developed a mapping app, Mapeo for ICCAs, designed with and for communities to enable the custodian communities to map, monitor, and support their territories of life on their own terms. Custodian communities can use the information collected via the app to support their advocacy purposes and, should they wish to, contribute to global conservation databases to increase awareness of and action for territories of life at a global level.

Mapeo for ICCAs helps users create digital maps and gather images and information on critical features within their territories and areas. The app enables the custodian communities to do this in a participatory way, with multiple people working together to collectively agree on the mapped features. Information captured in the app is only shared if the custodians choose to do so and once they have followed a self-determined process of Free, Prior, and Informed Consent.

5 Borrini-Feyerabend, G., J. Campese, and T. Niederberger (eds). Strengthening your territory of life: guidance from communities for communities. Online version: ssprocess.iccaconsortium.org. The ICCA Consortium, 2021.

All data collected or created with Mapeo for ICCAs is stored directly on the device, and users share and synchronise their data with other devices, using peer-to-peer technology without the need for an internet connection. Users can then produce PDF reports of filtered data, or export data to other programs for further analysis or sharing with others.

While custodian communities of territories of life maintain ownership and control over their data, the app does provide a voluntary mechanism for the custodians to submit their data to global conservation databases. Such databases include the ICCA Registry and the Protected Planet Initiative. The ICCA Registry raises awareness of the significance of Indigenous Peoples and local community-led conservation practices, providing a much-needed evidence base to promote the recognition and support of ICCAs—territories of life worldwide. The Protected Planet Initiative provides global databases on protected areas and OECMs. It provides the basis for monitoring progress towards international targets on protected and conserved areas.

Mapeo for ICCAs can streamline the data submission process for Indigenous Peoples and local communities that want to report data on their territories of life and be represented in these databases. Custodians can more easily engage in expanding and improving information in the ICCA Registry and the Protected Planet Initiative, helping to demonstrate the importance of ICCAs—territories of life to national and international decision makers, and ensuring the collective conservation values of territories of life are better understood and can be counted towards global conservation targets. UNEP-WCMC and partners have **supported over 370 communities to self-report data** on their ICCAs-territories of life to the ICCA Registry, and there are **currently over 1,700 protected areas and OECMs reported to Protected Planet under the governance of Indigenous Peoples and local communities**. However, these represent only a fraction of the existing ICCAs-territories of life.⁶ Mapeo for ICCAs can strengthen and support the self-declaration and self-reporting by custodian communities in these databases.

6 UNEP-WCMC and ICCA Consortium (2021). A global spatial analysis of the estimated extent of territories and areas conserved by Indigenous peoples and local communities, Territories of Life: 2021 Report. UNEP-WCMC (Cambridge, UK) and ICCA Consortium (worldwide). <https://report.territoriesoflife.org/>

4.2 Technology for sound design and planning

Sound design and planning are critically important for protected and conserved areas. Based on a sound understanding of the site's natural, cultural, and socioeconomic values and context, proper planning lays the foundation for effective management of PCAs.

Sound design and planning ensures the effective protection of biodiversity, provision of ecosystem services, and mitigation of harmful activities. It facilitates habitat connectivity, sustainable resource management, climate resilience, scientific research, and education, all while respecting cultural values and supporting local communities, economies, and livelihoods. It also contributes to the long-term viability of these areas and aligns with global conservation goals.

As outlined by the IUCN Green List Standard, the sound design and planning component and criteria encompass a comprehensive and adaptive approach to the establishment and management of PCAs. This entails defining clear conservation objectives, ensuring ecological representation, establishing well-defined boundaries, and developing adaptable management plans. It emphasises stakeholder engagement, the integration of traditional knowledge, sustainable resource management, climate resilience, and the promotion of adaptive management. The Standard also emphasises the incorporation of PCAs into broader land- and seascapes, educational efforts, adherence to legal frameworks, and effective data management. These elements collectively contribute to the long-term effectiveness and sustainability of protected areas and ensure the longevity of their conservation outcomes.

In achieving the Standard, technology can play a pivotal role, facilitating the design and planning of these vital conservation areas by providing tools and solutions that enhance

the efficiency, effectiveness, and adaptability of conservation efforts.

Technology can contribute in multiple ways, including:

- **Data Collection and Analysis:** Technology facilitates the collection of real-time and high-resolution data on biodiversity, ecosystem health, and human activities within and around protected areas. Drones, satellite imagery, and remote sensors are invaluable tools for informed decision making, especially when leveraging machine learning and artificial intelligence (AI) to help the analysis of large data.
- **GIS and Mapping Tools:** Geographic Information Systems (GIS) and advanced mapping tools help visualise and analyse spatial data, ensuring precise delineation of boundaries and strategic representation of ecosystems. Mapping can also be used to capture local knowledge of communities in and around PCAs through participatory approaches and digitisation, as done in Participatory 3D Mapping exercises.
- **Monitoring and Surveillance:** Technology enables continuous monitoring of PCAs, from camera traps and acoustic sensors that track wildlife movements to satellite-based tracking systems that safeguard ecosystem integrity.
- **Visitor Management:** Online booking systems, visitor tracking apps, and digital signage assist in controlling visitor numbers, minimising



disturbances, raising awareness, and promoting responsible behaviour.

- **Stakeholder Engagement:** Technology fosters stakeholder engagement through social media, webinars, and virtual reality experiences, ensuring that diverse voices are heard and valued.
- **Predictive Modelling:** Technology aids in forecasting environmental changes and their impacts on protected areas, essential for designing adaptive management strategies.
- **Data Sharing and Collaboration:** Online platforms and databases enable the sharing of data and best practices globally, promoting shared learning and collaboration.

The integration of technology into protected area design and planning is not without challenges. High-tech solutions can be costly to acquire and maintain, limiting access for organisations with limited budgets. Remote areas may lack access to technology and reliable internet connectivity. Moreover, protecting sensitive ecological and location data from unauthorised access and cyber threats is a concern, raising issues of data privacy and security as well as determining

data ownership and establishing protocols for data sharing.

Effective technology use often requires specialised training and expertise, which can be resource-intensive and time-consuming. While technology can help with data collection through different devices, data overload can overwhelm conservation organisations, which is why planning for data analysis, through AI, machine learning, or other methods, needs to be carefully thought out and can be a challenge to set up. The use of technology can raise ethical and cultural concerns, particularly when involving Indigenous Peoples and local communities, and overreliance on technology may lead to a loss of traditional ecological knowledge and field-based monitoring skills.

Ultimately, technology offers powerful tools to enhance the design and planning process, promoting data-driven decision making, stakeholder engagement, and adaptive management. However, challenges such as cost, data security, and ethical concerns must be carefully addressed. By leveraging technology thoughtfully and in conjunction with traditional conservation practices, we can pave the way towards well-managed protected areas that meet the criteria set by the IUCN Green List Standard.

4.3 Technology for Effective Management



Protected and conserved areas are crucial for safeguarding biodiversity and ecosystems. However, their success, long-term viability, and ecological integrity hinge on effective management.

Effective Management ensures the conservation of biodiversity, protecting vulnerable species and habitats from threats such as habitat loss and poaching. Moreover, management allows for sustainable resource use, supporting local livelihoods and promoting a balance between conservation and development. Effective management also enhances the resilience of ecosystems in the face of climate change and other stressors, helping them adapt to changing conditions.

Component 3 of the IUCN Green List Standard focuses on Effective Management and encompasses a set of criteria that emphasize the importance of well-structured and accountable management practices within protected and conserved areas (PCAs). These criteria include requirements for robust management plans, adequate capacity-building efforts, ecosystem health prioritization, sustainable financing, and quality visitor experiences. Essentially, Component 3 aims to ensure that PCAs are not only established but also effectively managed to fulfil their conservation objectives while engaging and benefiting local communities and visitors.

Analysis of PCAs using the Green List Standard as a diagnostic tool can identify and assess management gaps and challenges and priority areas for investment of resources and capacity to enhance management effectiveness.

The Green List Standard can also help keep track of management plan operationalisation

by guiding the priorities and activities set under it to achieve successful conservation outcomes. Use of technology for automation and integration of the Standard offers numerous advantages that can streamline site monitoring and evaluation (M&E) processes, enhance site assessment efficiency, track investments, and improve overall conservation outcomes.

Regular monitoring and evaluation of sites for effective management is essential. This ensures that national objectives and international obligations are aligned, investments and capacity suit management needs, and conservation targets are met. Technology has the potential to revolutionise monitoring for assessing management effectiveness compilation, analysis, and reporting of site performance data; identify gaps for investment; and build capacity to scale-up management effectiveness. Visualising data and capturing conservation impact through the use of technology and automated systems with integrated linkages can improve decision making towards effective site management and conservation planning.

Aligning with the criteria of the Green List Standard, technology can improve management process in PCAs through the following ways:

- 1. Data-Driven Decision-Making:** through the collection, analysis, and visualization of data related to biodiversity, ecosystem health, and visitor use. Decision-makers can use this information to make informed choices.

- 2. Remote Sensing and GIS:** Geographic Information Systems (GIS) and remote sensing technologies provide valuable insights into habitat changes, deforestation, and wildlife movements, aiding in monitoring and management. The **Integration of sensor networks and data analytics** offers unprecedented insights into ecosystem dynamics. Deploying sensor technologies to monitor climate parameters, water quality, and species behaviour can support evidence-based decision making and foster a deeper understanding of the intricate relationships within protected ecosystems.
- 3. Predictive Modeling:** Advanced modelling techniques help predict the impacts of climate change and human activities on PCA ecosystems, supporting adaptive management.
- 4. Monitoring and Surveillance:** Technology allows for real-time monitoring of wildlife, visitor activities, and threats like poaching or illegal logging. Early warning systems can be implemented.
- 5. Visitor Management:** Digital tools can assist in managing visitor flows,

providing information, and promoting responsible tourism practices.

- 6. Communication and Outreach:** Websites, social media, and mobile apps enhance communication with the public, engage stakeholders, and educate visitors about conservation efforts.

While technology holds great promise for PCA management, it also presents unique challenges. Challenges such as access to technology, data security, capacity building, resource constraints, privacy concerns, and cultural sensitivity must be addressed.

By thoughtfully integrating technology into management practices and upholding the principles of the Green List Standard, PCAs can meet high conservation standards, safeguarding our planet's natural wonders. Technology-enabled management offers the promise of more effective, adaptive and interactive management with an efficient feedback loop that would be of significance for policymakers, local communities, and other stakeholders. It would also ensure transparent, and accountable conservation efforts, ensuring that protected areas thrive as havens for nature and people.

BOX 2: IUCN Green List software

IUCN Asia developed this automated software for the Green List site assessment to help sites carry out a detailed gap analysis against the Standard. This has helped enhance site data integration and tracking of progress, providing outputs for active management and capturing conservation impact. The software makes the process more interactive through the dashboard and other Interactive modules, offering value-added service to users. This software was rolled out in June 2023, after pilot trials in Saudi Arabia, Indonesia, Malaysia, Thailand, and some countries in Africa. The feedback has been very encouraging, with users saying that it is extremely easy to use and suited to their need.

The software also helps build a central repository of all the documentation, creating a digital library with easy retrieval of data and other information on a single screen. The automated process will also help produce easy-to-interpret structured reports, graphs, infographics, and other interactive resources, making this a one-of-a-kind integrated solution for site management.

Key features of the software include:

- An application to enhance and support easy uptake of the IUCN Green List
- A clear dashboard with easy navigation
- Efficient reporting
- Secure and accessible environment
- Identification of gaps
- Guidance for management actions where they are needed
- Compiling of site documentation and history
- Tracking of progress over time
- Measurement of conservation outcome through an evidence-based system
- Increased confidence of stakeholders, donors, and policy makers
- Increased transparency and accountability for site assessments.

4.4 Technology for Successful Conservation Outcomes



Digital technology solutions are indispensable tools in the conservation toolbox, playing a pivotal role in achieving successful conservation outcomes. Through improved data collection, analysis, and decision making, and enhanced public engagement, technology empowers conservationists to address the challenges faced by PCAs and threatened species. Moreover, adherence to Standards and the responsible deployment of technology are key factors in ensuring that these tools contribute to effective conservation strategies. As we move forward, the continued integration of technology, guided by appropriate standards, will be essential for the fair and effective management of PCAs and the species within and around them.

Technology can contribute to successful conservation outcomes in multiple ways, including:

- **Acting as a force multiplier**
Data analytics and machine learning: Digital technology allows for the analysis of vast datasets, enabling the identification of trends, patterns, and threats. Machine learning algorithms can predict potential risks to ecosystems and species, aiding in proactive conservation measures.
- **Enabling effective decision making**
Geospatial technology: Geographic Information Systems (GIS) and remote sensing tools facilitate spatial analysis, enabling better planning and

management at the end of a management cycle and the beginning of a new one.

- **Enhancing engagement and awareness**

Communication and education: Technology allows conservation organisations to engage with a broader audience through digital platforms, fostering awareness and support for conservation efforts.

Virtual Reality (VR) and Augmented Reality (AR): These technologies offer immersive experiences, allowing the public to explore protected areas and witness wildlife in their natural habitats, fostering a deeper connection with nature.

- **Promoting collaboration and standardisation:**

Open data and interoperability: The adoption of open data standards and interoperable systems is crucial for effective collaboration among different stakeholders, including governments, NGOs, and local communities.

Best practice sharing: Digital platforms can facilitate the sharing of best practices and lessons learned in conservation, enabling a more coordinated and efficient approach.





5. HOW TECHNOLOGY CAN HELP SUPPORT THE GLOBAL BIODIVERSITY FRAMEWORK 30X30 TARGET

In December 2022, Parties to the Convention on Biological Diversity (CBD) signed the Global Biodiversity Framework (GBF), a milestone moment for conservation. Target 3 of the GBF calls for a significant increase in protected area coverage across the globe, setting a target of 30% of land, freshwater, and oceans under protection by 2030 (30x30). Target 3 is complemented and accelerated by targets to halt the human-induced extinction of threatened species (Target 4) and to restore an additional 30% of the planet (Target 2). These three targets are tied together by a strong emphasis on participatory, integrated, and biodiversity-centric spatial planning (Target 1), providing governments with a roadmap for action by 2030.

One of the most important aspects of the new GBF is the strong focus on human-rights-based approaches to conservation that are embedded in all the targets, especially in Target 3, where Parties are encouraged to recognise the contributions that Indigenous Peoples and Local Communities (IPs and LCs) make to conservation. There is a specific focus on recognising diverse forms of governance

that go beyond the Protected Area model, with the GBF advocating for Other Effective Conservation Measures (OECMs) and the Third Pathway for IP territories. IPs and LCs have always made an outsized contribution to conservation, but they face many barriers in accessing funding and technical capacity, and having their land and seascapes recognised while still retaining their traditional rights over the area. As described below, technology can play a crucial role in bringing the power of data to stakeholders to help accelerate a locally led, ground-up movement to achieve the GBF.

The GBF also calls on the private sector to play a key role in transforming our relationship with nature. Target 15 in particular encourages businesses to monitor, assess, and disclose their impacts on biodiversity – a space where tech companies can shine by developing and scaling-up tools for businesses. Target 15 also asks businesses to support Target 16, which is focused on changing consumer behaviour to make nature-smart choices, by sharing information on how to move towards sustainable consumption patterns – another area where tech platforms can play a role.

5.1 Technology for transparency and reporting

To achieve the GBF 30x30 Target, unprecedented collaboration, data-driven decision making, and innovative approaches will be necessary. Technology plays a crucial role in supporting transparency and reporting on the implementation of this target,

facilitating effective monitoring, reporting, and verification of progress. Technology also serves as an enabler in the implementation of the 30x30 Target, offering an unparalleled suite of tools to monitor, report, and ensure transparency.

Some ways that technology can contribute, include:

- **Data driven decisions:** Technology enables the collection of vast amounts of data on biodiversity, ecosystems, and human activities in protected areas and OECMs. This data can be used at different levels, from site level all the way to national level to assess the current status of conservation efforts, identify threats and trends, and inform evidence-based policy decisions.
- **Predictive modelling:** Conservationists can leverage technology to create predictive models for various scenarios, such as climate change impacts or poaching trends. These models provide policymakers with tools to analyse complex scenarios and evaluate policy options by simulating the potential outcomes of different conservation strategies.**Real-time reporting and dashboards:** The creation of real-time reporting dashboards can provide up-to-date information on progress towards the 30x30 Target. Access to the dashboards can be differentiated in accordance with user-specific needs and permissions, i.e., policymakers, the conservation sector, local communities, and civil society can access the dashboards to input data, track progress, and identify challenges and areas for collaboration. Digital reporting systems can also ensure that progress toward the 30% conservation target is accurately tracked and reported.
- **Data Integration:** Technology allows for the integration of diverse datasets, including ecological, social, and economic information. This holistic view helps policymakers understand the complex interactions within protected areas and make well-informed decisions that consider multiple factors.
- **Transparency and Accountability:** Digital platforms and data-sharing mechanisms promote transparency in conservation efforts. Policymakers can use technology to make conservation data accessible to the public, civil society, and other stakeholders, fostering accountability and engagement. By making information easily accessible to the public through online portals, data visualisation tools, and open data initiatives, technology opens up the opportunity for anyone to review and validate the progress made towards the 30x30 Target.
- **Geographic Information Systems (GIS):** Such tools are used to map and analyse spatial data related to biodiversity conservation. These systems can help policymakers visualise spatial data, assess land-use changes, and identify and monitor potential threats to biodiversity. Thus, supporting informed decision-making about the allocation of conservation resources.
- **Citizen science and mobile applications:** Technology can facilitate citizen science, empowering local communities and park rangers to contribute to data collection and verification. Apps allow people to report observations of species, illegal activities, or changes in habitats, enhancing the breadth and accuracy of monitoring efforts.
- **Blockchain technology:** With its 'trust-less' immutable ledger system, blockchain can enhance transparency and accountability by creating tamper-

proof records of conservation actions and transactions related to protected and conserved areas. The use of such technology contributes to combatting the illegal wildlife trade and bolsters supply chain transparency.

- **Big data and AI:** Advanced analytics, powered by artificial intelligence, help process large datasets quickly and identify patterns that would take an inordinate amount of time and may be missed by manual analysis. Machine learning models can predict potential threats to biodiversity, such as poaching or ecosystem degradation or loss, based on historical data and current trends.
- **Data management and cloud-based platforms:** These platforms enable

the storage and seamless sharing of data and information about protected and conserved areas, species, and threats. They can facilitate data sharing and foster international peer-to-peer learning and collaboration in monitoring and reporting of progress towards the 30x30 Target.

- **Collaboration and knowledge sharing:** Online platforms and forums facilitate local, national and international collaboration among researchers, conservationists, policymakers, and NGOs. These spaces foster peer-to-peer learning, allowing for the exchange of best practices, lessons learned, and innovative technology and digital solutions to support the implementation of the 30x30 Target.

5.2 Best practices for using technology solutions in monitoring and reporting progress

The integration of technology solutions into monitoring and reporting requires a nuanced approach guided by best practices:

- **Robust data governance frameworks** ensure data quality, consistency, and interoperability, allowing diverse sources to contribute to national and sub-national level implementation of actions in support of 30x30.
- **Privacy considerations and data ethics** must underpin the collection and sharing of sensitive data and

information on biodiversity and local communities living within and around protected and conserved areas. This is particularly important when engaging with local communities and indigenous knowledge holders.

- **Adaptive management**, using the real-time data insights, enables necessary corrections and iterative improvements, ensuring that conservation efforts remain aligned with the 30x30 Target.

Technology for One Health

Zoonotic Disease Risk Monitoring, Surveillance and Prevention

The concept of One Health,^[1] where human health, animal health, and environmental health are intricately linked, has gained significant attention in recent years. One Health recognises the interdependence of human and animal health and the environment, emphasising the need for collaborative and holistic approaches to address complex health challenges across multi-sectors.

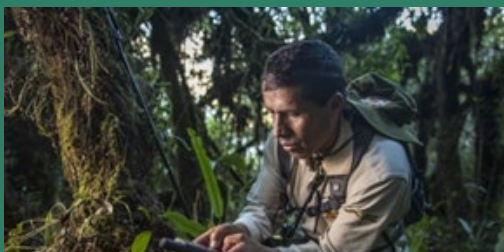
Among these challenges, zoonotic diseases which can be transmitted from animals to humans, stand out as a prominent concern. In an increasingly interconnected world, where humans, domesticated animals, and wildlife interact more and more often, there is an increasing risk of zoonotic spillovers. The COVID-19 pandemic has demonstrated to the whole world the devastating impact of zoonotic diseases.

The role of technology in One Health solutions has emerged as a crucial factor in preventing and reducing the risk and impact of zoonotic diseases. To effectively mitigate these risks, technologies are employed in zoonotic disease risk monitoring, surveillance, and prevention. These technologies enable early detection, rapid response, and informed decision making and action. Technology can be deployed for real-time communications and alerts for early detection; vaccine development and application; genetic and forensic laboratory equipment for animal and wildlife disease screening; and One Health data sharing to foster collaboration and enable experts to analyse interconnected factors that contribute to disease emergence, transmission, and prevention.

Below are some examples of how technologies have been used to detect, monitor, and prevent zoonotic disease transmissions between animals and humans.

- In northern Congo, hunters and community members were recruited to report morbidity and mortality events in wild animals, using mobile phones and radio networks to inform national authorities, facilitating information flow to veterinarians so that sampling could occur in the short timeframe needed before carcasses degrade. Reporting of these events expanded the surveillance system to allow for early warning and prevention of zoonotic diseases.
- In Bolivia, staff at a wildlife sanctuary trained in One Health approaches reported finding several dead howler monkeys in the surrounding area. An investigation was rapidly mobilised with national, university, and nongovernmental partners, leading to detection of yellow fever virus as the cause. Because of the proactive information sharing and effective multi-sectoral coordination, this information led to a preventive vaccination campaign and other risk reduction measures, helping to prevent any human cases.

- Ethiopian wolves (*Canis simensis*) are Africa's most endangered carnivore. While habitat loss is a major threat to species survival, infectious disease epizootics have had serious impacts on wolf populations. Since 1992, the wolves in the Bale Mountains have faced eight major outbreaks from rabies and canine distemper viruses. Outbreaks are prompted by introduction of the viruses from domestic dogs. The population density and social nature of the wolves allow for rapid virus transmission among and between packs; concerningly, outbreaks have resulted in extinctions of entire packs. To effectively manage this threat, a comprehensive conservation strategy, including preventive and reactive vaccination and disease monitoring in line with a One Health approach was developed and implemented.
- The Wildlife Health Surveillance Network was set up in Cambodia, Lao PDR, and Viet Nam to build and implement national wildlife health surveillance strategies, enhancing the ability of these nations to safely detect, monitor, trace, and report emerging pathogens in wildlife, to facilitate more rapid response and mitigation. An already proven open-source and cell-phone-based technology through the Spatial Monitoring and Reporting Tool (SMART) was deployed for monitoring and surveillance.
- A Biosafety Level 2 laboratory was built in Sabah, Malaysia, to avoid sending thousands of collected samples out of the state for pathogen screenings. The lab is used to screen samples for zoonotic disease, as well as genetic and forensic research. The laboratory detected 65 novel and 18 known viruses in Sabah, providing the Malaysian government with actionable data to inform risk mitigation policies at the national and state level.



Ranger using SMART cell-phone based technology for monitoring and surveillance © WCS

Technology plays a pivotal role in zoonotic disease risk monitoring and surveillance. By enabling early detection, data integration, real-time communication, and predictive modelling and screening, these technologies enhance our ability to respond effectively to emerging zoonotic threats and prevent their spread across species. However, there is still a need for better and more equal access to these technologies to improve monitoring and surveillance. For example, with

better access to mobile phones and connectivity to the mobile phone network, field workers, rangers, and local communities can help with monitoring and surveillance, and report morbidity and mortality events in wild animals to enable rapid response and mitigation.

[1] "One Health: an integrated, unifying approach that aims to sustainably balance and optimise the health of people, animals and ecosystems. It recognises the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and inter-dependent. The approach mobilises multiple sectors, disciplines and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems, while addressing the collective need for clean water, energy and air, safe and nutritious food, taking action on climate change, and contributing to sustainable development." One Health High-Level Expert Panel, 2021.



6. CASE STUDIES AND LESSONS LEARNED

This chapter spotlights inspiring case studies from the five Tech4Nature flagship countries and sites chosen by IUCN and Huawei to pilot the use of technology for nature conservation. The case studies demonstrate how Tech4Nature country projects have integrated technology to improve the fair and effective management of protected and conserved areas, supporting them on their Green List journeys.

Each case study includes a background summary of the situation and the challenges faced by the protected area managers; a list of the potential beneficiaries of the technology; a review of the different components, or Success Factors, that made up each project; and a summary of the impacts of the project on conservation goals. At the end of the chapter, we present a series of shorter summaries of other Tech4Nature country initiatives.

6.1 CASE STUDY 1

CHINA

Acoustic Monitoring for Improving the Conservation of Critically Endangered Hainan Gibbon



[CLICK HERE](#)

Summary

There are only 37 Hainan gibbons (*Nomascus hainanus*), which are listed as Critically Endangered on the IUCN Red List, currently living in the National Park of Hainan Tropical Rainforests, Hainan, China. Comprehensive tracking and monitoring are required for better conservation, but because of the difficulty in live tracking, acoustic equipment is needed for monitoring.

Tech4Nature is providing technical support for an acoustic monitoring project to track the Hainan gibbons. To date, full monitoring coverage of five family groups has been achieved, and automatic identification and real-time transmission of Hainan gibbon acoustic monitoring results has been realised.

Challenges

- Hainan Gibbon monitoring
- Biodiversity loss
- Relationship between humans and nature

Beneficiaries

- Hainan gibbons
- Local communities
- Protected areas communities
- Academia
- Visitors



© Hainan Institute of National Park



1. Field research

From late November to early December 2021, the Hainan Institute of National Park (HINP) worked with relevant experts and staff from the Bawangling Reserve to conduct field research in and around the five family groups (groups A - E) of gibbons in the reserve. The research team, which included 48 team members, set up eight station sites and 21 surveillance sites, covering the habitat of each Hainan gibbon population.



Enabling factors

- Past monitoring data of Hainan gibbons
- Participation of experienced experts
- Support from the Hainan Institute of National Park (HINP)



Lessons learned

The field research provided data support for the protection of Hainan gibbons and played a key role in the timely gathering of information and formulation of conservation plans.

2. Sound recording equipment layout and installation

Based on the research results, combined with the coverage of 4G signal, five sets of domestic automatic sound recording equipment with 4G signal, which has a real-time transmission function (product model: LBird-01211), as well as 15 sets of imported Song Meter recording equipment were installed in the typical environment of Hainan gibbons in the Bawangling Reserve.



Enabling factors

The field research results showed that group C and group E have strong 4G signal coverage, which can meet the remote transmission conditions for recording equipment as tested by technicians. Therefore, three and two sets of equipment were chosen to be deployed in group C and group E respectively.



Lessons learned

The equipment analyses the remotely acquired sound data, including the environment and location information, and uses individual vocal recognition in the layout area to identify gibbons.

3. Data quantification and database establishment

The raw sound data was imported into Adobe Audition 3.0 or Avisoft-SASLab Pro sound analysis software, resampled (Sample size: 44100 Hz; Window size: 1024 points), and then saved separately in WAV format. High-quality waveforms and sonograms were selected to measure characteristics of Hainan gibbon calls, to analyse the differences in acoustic indexes between individuals, and to build a database of Hainan gibbon sound patterns on an individual basis. Then, individual sound recognition using the implemented sound recognition model was

performed. Finally, the effectiveness of the sound acquisition was evaluated, and the accuracy of the sound recognition assessed. Evaluation of the effectiveness of the sound recognition was done mainly by comparing it with field research and other sound monitoring results.



Enabling factors

Based on the acquired time-frequency domain characteristics of Hainan gibbons, the parameters used for automatic recognition were determined in conjunction with the vocal database. The selected time-frequency parameters were imported into the automatic recognition software and the developed algorithm program, to automatically identify and extract Hainan gibbon calls from the recordings. Information such as the number of gibbons that may

be present in the sound data was evaluated by different clustering and discriminative methods.



Lessons learned

The fully automated acoustic monitoring equipment is of vital use for data processing in this project. The transmitted sound data is automatically stored in Huawei cloud space. Once the Hainan biodiversity sound pattern Huawei cloud database was established, individual sound recognition could be realised.

4. Sound pattern analysis

The manual screening of 532 Hainan gibbon acoustic samples has been completed, including those obtained during tracking and observation of gibbons using a portable recorder and those obtained using an automated recorder. During the screening process, the recordings were categorised as high, medium, or low quality. 44 high-quality recordings from seven individual callers were obtained. The seven individual callers were GAM1, GBM1,GBSA,GCM1,GCM2,GDM1,GEM1, where the letter after “G” represents the family group and the number after “M” or “S” represents the number of the individual adult or subadult male. Only about 40.9% of the recordings were made manually. The raw files of all the automated recordings were provided by the team of professor Wang Jichao, and the related data were backed up at Hainan Institute of National Park. The manual collection of recording data and sound pattern analysis were completed by the team of professor Fan Pengfei from Sun Yat-sen University.



Enabling factors

Mel-frequency cepstrum coefficients (MFCCs) is a method of extracting frequency envelope features by cepstrum after weakening the high-frequency information on the basis of human hearing [1]. The method has a wide range of applications in the field of human- and bioacoustics. In this study, MFCCs and the first-order and second-order differences (Δ , Δ^2) are used to achieve automated feature extraction.



Lessons learned

Five signature notes of the male Hainan gibbon have been identified (Fig.1), including boom note, aa note, pre-modulated note, modulated-R0 note, and modulated-R1 note.

According to the acoustic niche hypothesis, the calls of different species are differentiated in the time and frequency domains (see Fig. 2), so extracting features in a specific frequency range can greatly reduce

the influence of noise. The smaller the frequency range delineated, the more likely it is that more noise will be excluded. In addition, when the structure of each minimum recognition unit (MRU) is the same, the difficulty of recognition is greatly reduced. In view of the above situation, in this phase of the research, we tried (1) applying

pre only and (2) using pre + $n \times mR0$ as MRU, respectively, and comparing the classification results so as to determine the most appropriate feature extraction in the subsequent work. In the case of voice annotation, all the above steps can be implemented automatically by R language code.

5. Recognition modelling

Due to the excessive number of features, a tenfold cross-validated SVM-RFE was used to rank the importance of the features after extracting them. The features were then added sequentially for LDA classification to record the change in accuracy with the number of features selected. Finally, the best number of features was recorded as the input for the subsequent classifications (see Fig. 8). The highest accuracy for LDA classification was 89.2% (pre) / 95.6% (pre + $n \times mR0$).

Since none of the MFCCs extracted with a fixed number of windows achieved better results than the GMM fitting method for LDA classification (6-window: 86.6%; 10-window: 88.5%; 100-window: <80%), we tested the effectiveness of the other classifiers using only the features extracted by the GMM fitting method. In this test, we randomly selected 20% of the data as the test set, and the rest of the data were used to train the classifier, which was repeated 10 times for each kernel function to record the distribution of the accuracy. Among them, the classification effect of GMM is poor when using only pre as MRU, while the effect is generally better than using only pre when using pre + $n \times mR0$ as MRU.



Enabling factors

There are many classifiers that can be used for individual recognition. Considering the performances and possibilities of the classifiers, this research compared the classification effectiveness of three classifiers that have been developed in the field of gibbon bioacoustics or human sound pattern recognition, i.e., (1) linear discriminant analysis (LDA), (2) support vector machine (SVM), and (3) GMM (classification by determining the similarity between the data to be measured and the existing data).



Lessons learned

The basic method of sound pattern characteristics extraction has been identified, and a preliminary system method for individual sound recognition of Hainan gibbons has been established. Our preliminary results show that the existing system method is relatively reliable and will achieve the expected goals of the project. Among them, using pre + $n \times mR0$ as MRU, extracting sound pattern characteristics using GMM fitting method, and using linear SVM for classification would be more effective. In the follow-up work,

the data of rare individuals will be constantly supplemented, design of the algorithm system will be improved, the ability of the classifier to recognise unknown individuals will be given, and

the performance of the system will be comprehensively evaluated, so as to ultimately realise the recognition of individual sound of Hainan gibbons.

6. International symposium

The symposium was hosted by the Foreign Affairs Office of Hainan Province, Department of Natural Resources and Planning of Hainan Province, Department of Ecology and Environment of Hainan Province, and the Forestry Department of Hainan Province, and supported by the big data lab of the Research Institute for Eco-civilisation, the research think tank of Research Institute for Eco-civilisation, CASS, Institute of Zoology Chinese Academy of Sciences, Xishuangbanna Tropical Botanical Garden Chinese Academy of Sciences, Institute for Carbon Neutrality, Tsinghua University, Advanced Interdisciplinary Institute of Environment and Ecology, Huawei Technologies Co., Ltd., Hainan University, Hainan Normal University, Federation of Hainan Academicians, and the Sanya Research Base of the International Centre for Bamboo and Rattan.

The two-day symposium focused on conservation of the flagship species of tropical rainforest gibbons and conservation of tropical rainforest biodiversity, and consisted of a combination of online and offline activities.



Enabling factors

On the occasion of the third anniversary of the establishment of the Hainan Institute of National Park and the 8th international gibbon day (24 October 2022), the Forestry Department of Hainan Province, Wuzhishan municipal government, Hainan green island tropical rainforest public welfare foundation, and Hainan Institute of National Park co-sponsored the 2022 international tropical rainforest conservation symposium, focused on protecting tropical rainforests and realising ecological values, and supported by Eco Foundation Global (EFG).



Lessons learned

The Conference reached the following concrete results:

- Signing of the GGN Charter (Global Gibbon Conservation Network Charter)
- Announcement of the establishment of the first GGN Secretariat at the Hainan Institute of National Park, and the global launch of the GGN Logo
- The first time that a domestic conservation research organisation has initiated the establishment of an international organisation for the protection of a cherished species in one of China's five national parks, which is of historical significance
- Publication of the Global Gibbon Network declaration of conservation in the form of GGN joining hands with IUCN SSA, with the gibbon as the representative

- Introduction of the List of Priority Species for Conservation in Hainan Tropical Rainforest National Park with the case of KBAs, and official

release of the List of Priority Species for Conservation in Hainan Tropical Rainforest National Park.



© Hainan Tropical Rainforest National Park Administration

How do the Success Factors interact?

The three Success Factors were carried out in chronological order. Field research (BB1) was the basis for sound recording equipment layout and installation (BB2), and BB2 was the basis for data quantification and database establishment (BB3). The three blocks share a common goal of acoustic monitoring and recognition of individual Hainan gibbons. They are designed to allow for step-by-step data collection, storage, and analysis to achieve these objectives.

Impacts

Enhancing monitoring efficiency: The equipment installed in this project is activated by the sound of Hainan gibbons, and then records the data and transmits it back in real time. It can also realise automatic sound recognition, which improves the efficiency of monitoring and signifies a new stage in Hainan gibbon acoustic monitoring.

Assisting in biodiversity conservation: The establishment of the cloud database will provide a scientific basis for the discovery of potential solitary or groups of Hainan gibbon, contributing to biodiversity conservation in Hainan.

Contributing to the study of human society: Hainan gibbons have a complex acoustic communication system similar to humans, and a stable monogamous or bi-marital mate system. The study of their behaviours, beginning with acoustics, can help us better understand the origins of human society, family, language, and communication, and the evolution of other behaviours.

Increasing conservation awareness: The experience of applying sound recognition and precise monitoring technologies to Hainan gibbon conservation spotlights the need for stable long-term conservation of the gibbon population.

Story

In the past, when monitoring Hainan gibbons, our team members had to chase after them in the mountains, carrying cameras, GPS devices, and other equipment. But now, we employ technology for smart monitoring of Hainan gibbons, using infrared cameras, acoustic monitoring, and real-time monitoring equipment within the gibbon habitat. This way, we no longer have to worry about physical endurance, working in adverse weather conditions, or monitoring at night when humans need rest.

When a typhoon hit Hainan, causing landslides that obstructed many of the Hainan gibbons' activity routes among the mountains, we set up a rope corridor in the valleys affected by landslides, to better monitor their activity routes. We monitored and observed the gibbons to see if they would utilise the rope corridor we had constructed. After approximately two months, we were delighted to see the first images captured by the infrared cameras showing gibbons using the rope corridor to access the opposite habitat. This made us feel that our efforts were truly worthwhile. Hainan gibbons are highly intelligent creatures.



6.2 CASE STUDY 2

MEXICO

Harnessing the power of AI and community centred approaches to monitor Jaguars in the Yucatan Peninsula



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Summary

Mexico is recognised as a megadiverse country, home to approximately 12% of the world's species. The country safeguards a rich natural and cultural heritage, in part through the efforts of Indigenous communities. The ecologically rich Yucatan Peninsula, in the southeast, is home to rainforests, coral reefs, mangroves, and more. But these ecosystems are rapidly deteriorating, as a result of human activities and climate change. Nearly 80% of the region's rainforests are disturbed, with only 22% covered by mature vegetation, primarily in protected areas.

The Tech4Nature Mexico pilot project employs continuous biodiversity monitoring and artificial intelligence systems for the detection and conservation of priority species in the Dzilam State Reserve. The project aims to strengthen the understanding of the impacts of climate change on the area. This approach has involved the inclusion of the community as main partners and contributors, the application of machine-learning techniques, and the construction of multi-sectoral alliances.

Challenges

Jaguar populations have lost approximately 50% of their habitat across the American continent. The situation is especially disconcerting in Mexico, where the species has lost more than 40% of its territorial range.

The ecosystems of the Yucatan Peninsula (home to nearly half of Mexico's jaguars) are undergoing rapid degradation, with profound implications for jaguar populations, which find themselves increasingly cornered by habitat destruction and human-jaguar conflicts. Furthermore, the Yucatan Peninsula has become a hotspot for illegal jaguar hunting and trafficking. The Dzilam State Reserve faces multiple threats, from land-use alterations and biodiversity loss, to heightened susceptibility to extreme weather phenomena.

Moreover, monitoring jaguars remains a resource-intensive endeavour, given the absence of surveillance mechanisms spanning vast areas, which hinders the gathering of crucial data for their protection.

Beneficiaries

- Local, regional, and national government institutions
- Indigenous Peoples and local communities
- AI and data practitioners and students
- Academic institutions
- Environmental organisations
- Civil society
- Private sector



1. Multi-stakeholder alliance

This project combined the knowledge of different institutions and individuals to create an alliance with local and regional environmental and socioeconomic impact. The project was led by C Minds, the Secretariat of Sustainable Development of Yucatan (SDS), the community of the municipalities of Dzilam de Bravo and Dzilam Gonzalez in Yucatan, the International Union for Conservation of Nature (IUCN), and Huawei, in collaboration with the Polytechnic University of Yucatan (UPY) and Rainforest Connection (RFCx), and with the advice and feedback of biologists with expertise in feline conservation.



Enabling factors

The pilot carefully identified all relevant stakeholders, including non-profit organisations, government, academic institutions, private sector companies, and local communities. Each stakeholder brought their unique expertise and perspective, contributing to the overall success of the project.



Lessons learned

Working toward shared objectives is essential for aligning the efforts of all stakeholders, as is collaborating with stakeholders to establish clear goals and common objectives that address the needs and aspirations of each. This process should translate the goals into a “common language” that is understandable to all, promoting strong understanding and commitment.

2. Community co-design and engagement

From the beginning, the project engaged local leaders, entrusting them with the characterisation and selection of sampling and monitoring sites. Their insights and requirements were actively incorporated into the project’s analysis. Timely presentation of results, widespread dissemination of their work and expertise, and inclusion in working meetings were paramount.



Enabling factors

The Yucatan Ministry of Sustainable Development has been engaging and working with the local communities living in and around the Reserve for several years, ensuring cross-pollination of knowledge, good governance, and justice.

Moreover, the C Minds’ AI for Climate initiative established a robust four-year collaboration with the Yucatan government and essential local

stakeholders representing academia, innovation, and civil society sectors.



Lessons learned

The comprehensive involvement of the local community across all project stages, encompassing design, deployment, data collection, and analysis, emerged as a pivotal and indispensable factor contributing to the project’s successful implementation and the acquisition of valuable biodiversity information within the reserve.

3. Deployment of camera traps and eco-acoustic monitoring devices deployment

The local team strategically placed 15 camera traps and 30 eco-acoustic monitoring devices (audiomoths) within the mangrove and lowland rainforest habitats where jaguars have been previously sighted. This deployment effectively captured the region's biodiversity and generated valuable data for subsequent analysis.



Enabling factors

Field research, in conjunction with active participation from the local community and insights gained from co-design efforts, pinpointed the optimal locations for deploying cameras and audiomoths. These devices were strategically positioned in less-disturbed areas of the mangroves, jungles, and savannahs, ensuring the success of our scientific survey.



Lessons learned

Collaborative site characterisation and mapping with the local community served as a crucial foundation for the successful deployment of these devices. However, we also encountered challenges, including wildfires and extreme events, that temporarily impeded both device placement and data-collection efforts.

4. Algorithm for jaguar detection from camera traps

Images collected by camera traps were used to detect jaguars. The data was divided into three sets: training, validation, and testing. Accuracy, recall, precision, and F1 metrics were calculated. The most relevant metric is F1, which describes how effective the algorithm is in detecting a jaguar in the image (Test accuracy: 0.906, Test recall: 0.863, Test precision: 0.899, F1: 0.87). Likewise, four databases were created within the Huawei Cloud (presence of jaguars during the day, presence of jaguars at night, absence of jaguars during the day, absence of jaguars at night). Finally, three algorithms were tested to compare which one effectively detected the presence and absence of jaguars by day or night.



Enabling factors

Data collected from the devices and strategic alliances with Huawei and the Polytechnic University of Yucatan.



Lessons learned

The algorithm has over 90% accuracy and is trained on photos from camera traps. The identified risks include potential failure on photos that are outside the training spectrum (too blurry, too dark, too light, or images where the jaguar's body is obstructed by some other object).

Mitigation strategies could include:

- Training the model also with types of images other than camera traps or with more images to broaden the spectrum.
- Database and algorithm feedback from peer reviewers and expert collaborators with relevant experience in monitoring felines and their prey added as peer reviewers, providing jaguar images and expert feedback.

5. Acoustic monitoring and analyses

The acoustic component of the project is especially significant, as it played a pivotal role in the automatic detection of over 138 species, with 95 of them integrated into our pattern matching algorithms. This forms a robust foundation for the continuous monitoring of the region over the upcoming years, allowing us to observe how various environmental factors influence species presence.



Enabling factors

Our success in species detection was made possible through the data collected from the devices and the strategic partnerships we established, particularly with Rainforest Connection. Additionally, local experts played a crucial role in validating species presence.



Lessons learned

The integrated passive acoustic monitoring, combined with AI techniques, allowed for the identification of 95 species. There is a positive correlation between species richness and low-canopy forest cover. Furthermore, the soundscape analyses revealed variations tied to different seasons and habitat types. However, the pilot encountered the challenge of limited training data for rare species. To mitigate this, we conducted multiple rounds of sensor deployment across various seasons.

6. Generation of inputs for the strengthening of AI tools and resources for biodiversity protection

Among the strengths of the pilot is the ability to translate learnings into opportunities and recommendations, especially on issues of innovation, digital transformation, and technological ethics for biodiversity protection. For this reason, we closely monitored the implementation of the pilot to develop a public report with a recommendations section, fed by the experiences, inputs, achievements, and learnings of the implementing team.



Enabling factors

Learning from each step and with each partner contributed to strengthening AI tools and methodologies for biodiversity protection.



Lessons learned

Beyond the boundaries of the Reserve, the Tech4Nature Mexico project has sparked a transformative wave in regional conservation efforts. The

fusion of advanced technology with multi-stakeholder collaboration is redefining biodiversity protection. Innovative tracking algorithms have revealed crucial data confirming the presence of threatened species in an unprecedented way. These revelations enrich our understanding of regional ecology and empower local communities, driving lasting commitment to conservation.

How do the Success Factors interact?

The Tech4Nature Mexico pilot's results exemplify holistic synergy among its Success Factors, embracing a human-nature-centric approach with enduring regional impact. By uniting cutting-edge technology with a profound commitment to conservation, local perspectives, and multi-stakeholder collaborations, this pilot has not only transformed the understanding of the Reserve's extraordinary biodiversity but has also fortified local engagement in its protection.

This initiative confirmed the presence of several species at varying risk levels. This rich data underpins targeted conservation and informed decisions, empowering local communities and strengthening conservation efforts, while becoming indispensable tools for strengthening conservation efforts. Furthermore, continuous monitoring efforts and the increased presence of authorities have led to a tangible reduction in human threats, underlining the impact of the community's involvement in the project.

Impacts

The Tech4Nature Mexico project has yielded groundbreaking results within the Dzilam State Reserve. Through advanced monitoring algorithms, the project has confirmed the presence of 146 species, including 38 at risk, reaffirming the significance of their protection. This newfound knowledge has not only enriched local communities' understanding of their environment but also empowered them to actively engage in conservation efforts. The project's automatic jaguar identification model has paved the way to enhancing protection of their habitats. Furthermore, the project's data has international implications, influencing the Reserve's inclusion in the prestigious IUCN Green List and enhancing its management program. Through continuous monitoring and community involvement, the project has reduced human threats to wildlife, ensuring a safer environment.

Some of the technical impacts of the project are:

- Over 80,000 images and videos, and over 600,000 acoustic files collected
- 4,000 hectares covered (mangroves, jungle, and savannah)
- Species richness of 111 birds, 23 mammals (7 jaguars have been identified so far), 6 reptiles, 6 amphibians
- 138 species included in the acoustic Pattern Matching models (CNN)
- 93% precision of the image algorithm capable of detecting and identifying jaguars.



Story

In January 1989, the Dzilam State Reserve earned its designation as a protected natural area. A groundbreaking management plan, an annual operating program, and a vigilant oversight body were established, representing an unprecedented leap forward in Mexican conservation history at that time. Yet, despite these strides, the management program didn't find its way into the Official Gazette of the Government of the State of Yucatan until 2005. From that point on, the reserve's approach centred on the vital notion that preserving nature must harmonise with ensuring the well-being of its inhabitants.

However, the encroachment of agriculture on the reserve has led to the displacement of large mammal species, possibly the primary factor behind the decline in populations of magnificent big cats like the jaguar. Predators often clash with human interests as they target domestic animals, especially livestock.

Juan Castillo grew up in a family of nomads, traversing the jungle long before it gained protected status. Settling near water sources, they thrived through hunting, farming, and cattle-raising. Juan, like his family, once believed that defending cattle against jaguars was paramount, even if it meant killing the big cats.

As years passed, he came to a profound realisation: he and his family were the ones encroaching on the jaguar's habitat, consuming its resources, not the other way around. He took a bold step by removing his cattle from the reserve and relocating to the city.

Now a grandfather, Juan imparts his love for nature to his grandchildren, instilling in them the understanding that these species hold greater value alive than dead, crucial for the survival of the forest, its myriad inhabitants, and, ultimately, the people.

Today, Juan is resolute in his decision to donate his land for conservation, even though it lies within the reserve and is legally his property. Alongside his friend Benjamin, a reformed hunter, they have become eminent guides, explorers, and passionate advocates for jaguar conservation and the preservation of their prey, the rainforest, and the mangroves. They diligently tend to camera traps and acoustic monitoring devices, ensuring everyone's safety within the Teceh4Nature Mexico project. Juan Castillo has emerged as an international champion for conservation, revered for his tireless dedication to this noble cause.



6.3 CASE STUDY 3

MAURITIUS

Using Advance Technology and AI for Reef Restoration: Implications of Active Management to declare a Marine Protected Area in Mauritius



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Summary

Coral reefs, known as the blue rain forests, serve as net carbon sinks, help to fix nitrogen, protect against erosion, and feed a large portion of the world's population. This project focused on active coral reef restoration, to address the rapid and significant loss of corals around the island Mauritius. The restoration site at Pointe-aux-Feuilles covers an area of approximately 2,000 ha (20km²) and is highly visited by tourists and locals. The site is currently not a protected area and requires urgent attention given the amount of biodiversity it contains and its importance in maintaining the ecosystem functions in the area. This solution focuses on technology-based awareness and actions undertaken to restore the reef ecosystems. While education is vital for creating long-term impact, the use of technology to implement a constant flow of information will ensure the participation of multiple stakeholders.

Challenges

Shifts in sociocultural and economic aspects and policies are needed to support the adoption of protected areas to protect and restore the ecological diversity. Since fishing activities will be halted on a voluntary basis in the area, communities that are already at risk could suffer more from the loss of their livelihoods, potentially resulting in lower household income and more food insecurity. Therefore, to address this problem, it was critically important to engage fisher communities in coral reef restoration from the beginning and allow them to take part in ecotourism activities. This not only saved the area from further damage but allowed the fishermen to generate more income through sustainable tourist activities.

Beneficiaries

- Fishing communities, including both men and women
- Children of various age groups
- Local communities
- General public and interested stakeholders
- Tourists of various nationalities



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1. Community engagement and partnerships

This project could not succeed on its own. For the long-term success of coral reef restoration, it was important to develop strong collaboration with locals, fisher communities, and other stakeholders. The Tech4Nature partnership enabled more support and local engagement with relevant stakeholders.

Engaging the fisher communities in coral reef restoration from the beginning of the project and allowing them to take part in ecotourism activities not only saved the area from further damage but allowed the fishermen to generate more income through sustainable tourist activities, while also enjoying the benefits of increased fish abundance in the area.



Enabling factors

- Close-up monitoring by local communities
- Ownership by fishermen communities
- Strong partnership with local companies



Lessons learned

This project has allowed to us to bring the work done underwater to the general public at a global level.

2. Interactive technology for conservation

Using underwater cameras allowed for live viewing and monitoring of areas that were previously inaccessible, allowing the project implementers to better engage with the local fisher community. This new knowledge gave the community a sense of ownership and motivated them to better understand and protect this ecosystem.

The project has also facilitated data sharing on the status of the reef locally and across different channels and has opened the door for more local and international scientific collaboration.



Enabling factors

- Local community buy-in
- Interactive technology
- Data sharing



Lessons learned

Technology provided not only live images but also a completely new level of underwater restoration. The interaction of fish with the coral reef can be securely monitored, allowing scientist to discover more about underwater ecosystems.

How do the Success Factors interact?

The underwater cameras and equipment facilitated the restoration process, allowing the project to capture the current state of the marine ecosystems and share it worldwide, using social media platforms. This facilitated communication between the marine scientists and the stakeholders. The use of underwater pictures and videos has made an impact on the local community, helping them achieve an improved understanding of the state of conservation targets, as well as their vulnerability and resilience.

Impacts

- To date, around 25,000 coral fragments have been grown in the nurseries, with over 15,000 of them planted in deteriorated reefs through the use of support frames.
- An artificial reef was created using concrete blocks to support natural recruitment and marine life.
- Marine biodiversity in the nursery area and restoration sites has increased.

Social impacts

- The local community has an improved understanding of the state of conservation targets (species and ecosystems), as well as their vulnerability and resilience.
- There is increased awareness of the impact of climate change on coral reefs.
- There is increased participation of local fishermen, especially women, in coral farming activities.

Economic impacts

- There are more fish for fishermen to catch and new ecotourism activities to support local communities.



Story

Coral reef restoration is more important than ever to protect our marine resources and the local economies, since coral reefs are increasingly threatened by natural and anthropogenic stressors at the local and global levels. Coral colonies are fragmented by strong wave actions and man-made activities like boat anchoring, destructive fishing practices, and unsustainable sports activities.

The basic principle of coral restoration is to secure broken coral fragments to ensure survival and rejuvenation. Seeing how I could help in coral restoration, this project has allowed me to collect broken coral fragments from the reef, grow them in nurseries until they are mature, and then transplant them in the degraded reef locations. This project has allowed us all to be involved through the use of technology. The development of the mobile app has been challenging but also engaging, in the sense that, when we tested with locals, they were happy to see live underwater images on a daily basis.

This project has allowed fishermen to express their concern about environmental degradation and to establish a close link with them to support coral restoration. The underwater cameras and live viewing allow us to closely monitor coral growth and integrate education alongside. Technology and conservation are vital to help understand what is happening and find a way for Mother Earth to talk to us, to show us the reality underwater and help us understand the importance of active restoration.



6.4 CASE STUDY 4

SPAIN

Enhancing Park Managers' Capacity to Monitor Impacts on Species in Catalonia, Spain



[CLICK HERE](#)

Summary

The Bonelli's eagle (*Aquila fasciata*) is a flagship species in the Mediterranean, although it is vulnerable in several parts of the region. In Catalonia, the Wildlife Service of the Government of Catalonia has estimated 85 breeding pairs, one of them in Sant Llorenç del Munt i l'Obac Natural Park. Park managers have faced challenges in understanding and monitoring the species' reproductive behaviour and its relation to different threats and pressures within and outside the park.

Tech4Nature Spain developed a monitoring programme to understand how visitors and other external factors affect the eagle's breeding and mobility behaviour. A technological architecture using cameras, GPS trackers, and the Axis Station software was put in place, along with metrics and alerts to ensure a better monitoring infrastructure and prevention capabilities. Due to the lack of reproduction during this period, the system was adapted to monitor general behaviour patterns and disturbances. This solution can be replicated in other protected areas, and applied to other species and even other phenomena such as wildfires.

Challenges

The solution tackles the main challenges faced by protected and conserved areas when it comes to the management of the species and their habitats: the lack of technological infrastructure and economic resources allocated to monitoring and research.

The solution also addresses the need to increase the management capacities and skills of the park staff. The implemented solution and parameters were developed in close collaboration with the park management team. This meant that the technological architecture was adapted to the available human resources, both in terms of simplicity of use and the time needed to allocate to the monitoring system, ensuring its long-term success.

Finally, this solution addressed the lack of spatial data about the main disturbances to specific endangered species (in this case the Bonelli's eagle), which is essential to improve their conservation.

Beneficiaries

Park managers and rangers involved in species monitoring and land-use management in Sant Llorenç del Munt i l'Obac Natural Park, in Catalonia (Spain).

Researchers studying the behaviour and evolution of the Bonelli's eagle



1. Installation of the technological infrastructure

The technological infrastructure is composed of two cameras along the nearby trail to monitor visitor flows, and a panoramic camera in front of the nest. All were installed in October 2022. The cameras are powered by solar panels and have integrated mics that detect noise disturbances. Two GPS transmitters, installed in December 2022, are used to track the behaviour of the pair of eagles. Data transmission from the cameras is carried out through point-to-point microwave antennas via a separate internet line. The information is stored on the NAS and on Huawei's cloud. The GPS units include a small solar power plate, and the data is transferred via radio frequency to the Move Bank cloud.



Enabling factors

To enable the success of this building block, it is essential to count on the technical equipment (GPS trackers and cameras), a wireless connection to allow data transmission, and a storage system. Human capacity to know how and where to install the equipment in order to avoid disturbances to the species is also key, ensuring that the reproduction cycle of the species isn't affected.

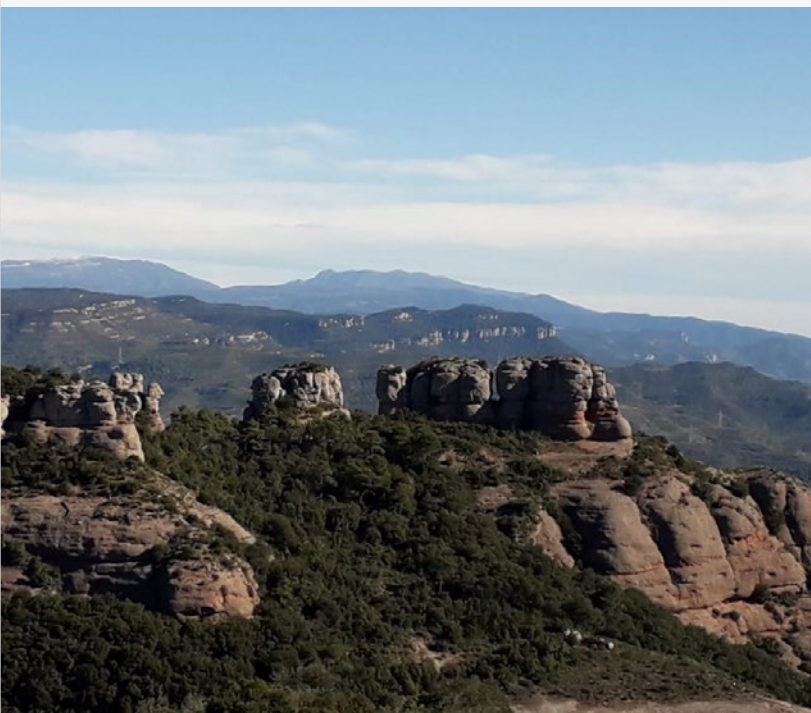


Lessons learned

As in many experimental projects, the monitoring programme encountered technical challenges, mainly due to connectivity issues and the need to coordinate various systems and teams. Legal-administrative considerations, such as data use and installation permissions, are also essential when implementing this building block.

Concerning the GPS trackers, the programming of the transmitters according to different geozones makes it possible to optimise the reception of locations and improve the updating of the data for possible emergency inquiries. In addition, the double solar plate transmitter model placed on the female has proven to be more effective than the single plate model placed on the male during the months of less sun.

The nest camera needs to be installed at the right distance to avoid disturbances while still ensuring a good image resolution. In this case, the need for a higher-resolution device has been identified, to ensure effective interpretation of the behaviour, identify the ringed individuals and their preys, and implement the automation of alarms.



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2. Experimental monitoring system

- The experimental monitoring system consists of a set of parameters to track the behaviour of the species, visitor mobility practices, and risk detection.
- GPS transmitters are programmed for data collection with a scheduled download; there is zoning around the nest.
- Axis Station software: An Axis Loitering Guard tracks moving objects and triggers alerts (e.g., a user is on the trail for x amount of time), sound alerts, and notifications when a threshold is exceeded. An Axis Fend Guard detects interaction events (e.g., the bird leaves the nest, two users leave the trail).
- Alerts for potential mortality, potential territory expulsion, absences at the nest, users near the nest, and noise thresholds.
- Other data related to trail usage by user type and the Bonelli's eagle breeding process.
- Annual reports on raptor spatial mobility, and semi-annual reports on interactions and critical events.



Enabling factors

A simple-to-use software programmed with the desired parameters is essential. It is also important to make the parameters as relevant as possible to the specific monitoring needs, and as concise as possible so that park managers are able to do proper follow-up and respond to any alerts.

It should be noted that certain situations involving wildlife cannot be controlled. For example, in our case, we faced the reproduction failure of the pair of Bonelli's eagles, which partly modified the monitoring objective.



Lessons learned

Although the use of a more sophisticated alert management software based on artificial intelligence is being explored, simple software such as Axis Station can be used to start developing a functioning monitoring programme that notifies critical risk events. Processes and procedures for pre-alert management and data collection and analysis need to be periodically optimised based on the lessons learned during the process.

3. Capacity building and informed decision making for the monitoring of species

The implementation of the technical architecture and monitoring programme has ensured the availability of a big database of information both of the species and its environment. Data availability is key to ensure that park staff (managers, rangers, technicians, etc.) make informed decisions when it comes to territory and species management strategies. In addition, the local design of the monitoring programme and the parameters within it increased the capacity of the park staff not only to manage, but also to improve, the programme and eventually apply it to the monitoring of different species and even other phenomena.



Enabling factors

A co-design process can ensure that park technicians are not only the beneficiaries and end-users of the solution, but are also able to own and self-adapt the monitoring programme. To that end, an initial diagnosis of the capacities of the staff needs to be done, followed by specific training targeting the weaknesses that have been identified.



Lessons learned

Currently, camera data is stored within the cameras themselves and technicians have to access and download the data manually. In order to fully implement this architecture, it is desirable to integrate a dual data storage device using both the device's storage and a cloud service. The goal is to complete this integration to allow for an automatic process that reduces the time allocated to the monitoring process.

4. Building cross-sectoral partnerships

The implementation of this solution has only been possible thanks to a unique cross-sectoral partnership established in the framework of the Tech4Nature initiative in Spain. The partnership was composed of local authorities (Diputació de Barcelona); park technicians, rangers and managers (Sant Llorenç del Munt i l'Obac); nature conservation experts (IUCN Med); an IT company (Huawei); GPS specialists (Parés&Bosch); and camera monitoring specialists (Miranatura). The partnership is continuously expanding, and it is expected that research teams and universities will join the partnership in the near future, bringing in their expertise and experience.



Enabling factors

In order to have a successful cross-sectoral partnership, the scope of involvement of each partner should be clarified from the very beginning. Local ownership of the solution is a fundamental factor to ensure its success in the long run.



Lessons learned

Partners need to be engaged from the very beginning of the solution to ensure a true co-creation process. Nonetheless, the partnership needs to be open to eventual changes in its composition that can lead to further progress and improvements. The local ownership of the solution is what will ensure its long-term sustainability.

How do the Success Factors interact?

The solution consists of four Success Factors. The first one focuses on the implementation of the technological architecture for monitoring and controlling of the species. Ensuring that the correct infrastructure is in place is key to obtain the desirable data.

The second building block takes the technological infrastructure of the first block as a basis for data collection and creates a methodology and monitoring system that tracks the behaviour of the species and park visitors, along with an early warning system for risk detection.

Building on this, the third building block involves park staff using the outcomes of the monitoring system to expand their knowledge and make informed decisions for territory and species management.

Finally, the last building block sustains the correct planning, inception, implementation, monitoring, improvement, and dissemination of the solution. This involves the establishment of a successful partnership willing to maximise the initiative's impact. These four Success Factors are fundamental to ensuring the proper control of the species and addressing the primary impacts affecting it.



Impacts

Since their installation in December 2022, through to April 2023, GPS trackers recorded 5,511 locations for the male Bonelli's eagle, and its vital domain was established at 71 km². As for the female eagle, 21,187 locations were recorded until July 2023, with a vital domain of 68 km².

During the monitoring period when the cameras pointed to the paths near the nest (November 2022 - January 2023), 463 users were observed, including people, bicycles, vehicles, and horses. During this time, an average of nine users per day was registered, although this quantity is expected to vary depending on the time of the year. So far, no noticeable disturbances to the eagle caused by visitors have been detected. Forbidden activities during this time period have been anecdotal, with only two events in January where a motorbike and a 4x4 ignored the chain limiting the trail.

The solution achieved more results than anticipated in monitoring the ecology of Bonelli's eagle. For example, it revealed that the eagles venture beyond the park for hunting, increasing the threats. In addition, the monitoring system is able to detect risks of expulsion or mortality, which made it possible to intervene during these critical events:

- In March, the female spent seven hours upside down on the ground. The technology established the causes: a fight with a neighbouring female, probably due to density dependence, which potentially contributed to the failure in reproduction.
- In April, the death of the male. The GPS locations showed that the male was unusually still next to a communication tower. The body was found before being preyed upon and electrocution was determined as the cause of death. This identified a threat to the species' survival and reporting of the incident for potential mitigation actions.
- Later in April, 17 days after the death of the previous male, the recruitment of another male was detected through the nest camera and confirmed by the rangers



Story

Daniel Pons, Conservation technician and biologist, Sant Llorenç del Munt I l'Obac Natural Park

For decades, a significant group of scientists, technicians, forest rangers, and rural agents have been monitoring the life cycle of a pair of Bonelli's eagles nesting in the Natural Park of Sant Llorenç del Munt I l'Obac, (Catalonia, Spain) belonging to the network of Natural Parks of the Barcelona provincial council (Diputació de Barcelona). The aim was to understand various aspects of their life, such as their behaviour, the areas in which they hunt and nest, their reproductive success, the state of the habitats they frequent, and their prey. As a result of this research, actions have been taken to improve their habitat and adapt power lines to reduce the risk of electrocution and collisions.

In my role as a biodiversity conservation technician in the Natural Park for the past five years, I have greatly appreciated the solution implemented in collaboration with the international initiative Tech4Nature. This solution represents a significant step towards the goal of ensuring the conservation of this pair of raptors by regulating public use in both critical areas and periods for these protected species.

The current initiative provides us with the opportunity to address an outstanding challenge in the management of the park, namely obtaining accurate information on the annual distribution of these birds of prey, the human activities that take place in their nesting area (such as hiking, mountain biking, forest management, and infrastructure maintenance), and the tolerance of the pair towards these activities, according to their intensity, proximity, and time of year.

The results of this monitoring will allow us to establish regulations based on the specific knowledge of this pair of Bonelli's eagles, complementing the broader studies carried out on this species in the Mediterranean basin and following the precautionary principle, which is crucial in the conservation of biodiversity.



To date, this project has achieved several key objectives:

- Recognise and highlight the efforts of various professionals dedicated to biodiversity research and management
- Raise awareness among all stakeholders, including local authorities, environmental organisations, and residents of the municipalities within the park, through communication campaigns carried out by Tech4Nature and the Barcelona Provincial Council's Parks Network
- Underline the importance of public-private partnerships to ensure biodiversity conservation
- Raise awareness of the risk of electrocution caused by poorly designed power lines
- Emphasise the importance of systemic management of the natural environment, both inside and outside protected areas.

From a professional point of view, this initiative has allowed me to become familiar with monitoring technologies, such as images and GPS, and to learn how to use various computer applications to:

- Visualise the presence of eagles in the nest and understand their behaviour
- Monitor the immediate surroundings of the nest and broader areas
- Track the individual movements of these birds within their territory.

One example worth sharing is that I have discovered that these eagles have well-defined routines, spending most of their time together. In the mornings, before egg-laying, they usually fly from the roost to gather at the nest or to watch the locations where they are waiting for their prey, such as partridges, rabbits, and pigeons, as well as to defend their territory from other nearby pairs.



6.5 CASE STUDY 5

SWITZERLAND

T4N: Create CO2 certificates using biodiversity measures



[CLICK HERE](#)

Summary

Biodiversity actions can create carbon sinks which and open up a way to bring these CO2 Certificates onto market. In this Tech4Nature pilot study, we calculated the amount of CO2 sequestered through management activities for Capercaillie (an endangered bird species in Switzerland) in the Schwägalp - Bruggewald forest reserve.

The goal of this pilot study is to test the assumptions made in the newly developed Green List Standard for Carbon (GLS+). GLS+ is an independent Standard but 60% of the indicators are based on the existing IUCN Green List Standard for protected and conserved areas to achieve effective, equitable, and successful conservation outcomes.

The Tech4Nature Pilot is run on real data generated through a biodiversity intervention in the year 2021 to favor the locally endangered Western Capercaillie (*Tetrao urogallus*) but was only testing the potential for CO2 certificates without creating them.

Challenges

- Conservation of the Capercaillie: Creating a suitable habitat for the conservation of the Capercaillie, a locally endangered bird species. This involves
- Biodiversity enhancement through sustainable wood extraction: Opening up the dense forest to create an appropriate ecosystem for the Capercaillie and enhance overall biodiversity within the reserve while benefitting the forester by using the extracted wood in long-term structures. Thus, binding the CO2 over time, necessary for the creation of CO2 certificates.
- Avoiding previous logging and land conversion: The area must meet the additional requirement of not having been previously logged for carbon credit generation or undergone conversion from its original forested state.
- CO2 sequestration and baseline estimation: Accurately calculating CO2 sequestration by establishing a baseline without any intervention and identifying the gap between this baseline and the expected outcomes through the implemented measures.

Beneficiaries

- The forest reserve.
- Foresters
- The key species
- Community of Urnäch and Hundwil
- Potential investors



1. Additionality

In carbon offset projects, additionality is crucial for determining the quality of carbon offset credits. A project is said to be “additional” if its associated greenhouse gas (GHG) reductions would not have occurred without the specific intervention, thereby ensuring the credibility and effectiveness of the carbon credits issued.



Enabling factors

Additionality is achieved if the cut would not have been done without the financial contribution of the issued CO₂ certificates.



Lessons learned

As the cut was already executed and the calculation was done

retrospectively, this condition was not met in the examined pilot project. But if the cut is done for biodiversity reasons and the resulting CO₂ certificates are used to finance the cut or increase the managed surface, then this condition would be met.

2. Avoid double counting

Double counting in carbon projects refers to a situation where a carbon credit is claimed by more than one entity, without producing any additional carbon benefit. In simple terms, it occurs when two parties claim the same carbon removal or emission reduction benefits. Double counting undermines the integrity of carbon offset programs and the fight against climate change, as it distorts the actual emissions reductions or removals achieved. It essentially dilutes the value and effectiveness of carbon credits.



Enabling factors

Double counting can be avoided if all work is done through one entity, using one standard method like the GLS+ methodology tested in this pilot project.



Lessons learned

In the actual setting with one entity and a specific forest, where no measures other than biodiversity measures can be legally undertaken, double counting was not a major concern.

3. Long-term sequestration

Long-term sequestration refers to the practice of capturing, securing, and storing greenhouse gases (GHGs) or other forms of carbon from the atmosphere for an extended period of time, ideally indefinitely.

The goal of long-term sequestration is to mitigate the effects of climate change by reducing the levels of CO₂ and other greenhouse gases in the atmosphere.



Enabling factors

It is important that the used methods are sustainable and secure, to ensure that the carbon does not re-enter the atmosphere. In this pilot, we achieved that goal by using the wood for construction purposes in the area near the forest reserve.



Lessons learned

Long-term sequestration is essential for stabilising global carbon levels and is considered a crucial component in efforts to combat climate change. However, identifying and securing the long-term storage of CO₂ in construction sites is a big task and a costly exercise.

4. Baseline

The baseline refers to the projection of greenhouse gas emissions that would occur in a specific project area if no interventions or changes to current practices are implemented. This serves as a point of comparison to assess the effectiveness of the carbon project in reducing emissions.

Enabling factors

The baseline is essential for calculating the actual carbon reductions attributable to the Capercaillie project and to measure the project's impact on mitigating climate change.

Lessons learned

The baseline sets the benchmark for assessing the carbon reduction achievements of the project and is therefore highly relevant for the issuance of CO₂ certificates. Especially demanding is the forecast of development in a given area over long periods of time, which plays a crucial role in the amount of CO₂ certificates issued. The long-term protection goal in protected and conserved area is therefore an important advantage for the long-term sequestration of CO₂ equivalents.



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How do the Success Factors interact?

To be able to issue CO₂ certificates for a certain project, all Success Factors must be achieved.

Impacts

60% of the requirements for the Green List Standard (GLS) are also necessary for the tested GLS+ Standard. Starting the GLS+ process for carbon could therefore lead the path to the GLS certification and vice versa.

GLS+ is adding the possibility to create high quality carbon credits and the new funds generated can be used to help finance protected and conserved areas to improve their governance and management performance and facilitate their journey towards IUCN Green List certification.

The estimated sequestered amount of 42.08 (tC/ha) and the value represented of approx. 1'000 USD/ ha, does not cover the deficit/ ha for the intervention in our Swiss Pilot project, but the additional funding will allow the extension of the treated area in favour of the Capercaillie.

This model could be attractive to implement in other parts of the world, with lower management cost and where this additional stream could help fill in existing funding gaps.

The managed area has been improved for the Capercaillie and at the same time a part of the costs can be covered through the GLS+ process generating CO₂ certificates.

Story

Swiss managed forests have become overmature, as logging and managing these areas require significant financial inputs. As a result, many forests have become dense and too dark to be suitable habitat for typical species like the Western Capercaillie (*Tetrao urogallus*), which has since become a rare species in the Swiss Alps. Opening up the forests quickly improves the habitat for these species, but logging in these difficult conditions is a costly exercise. In order to increase the surface managed for Capercaillie, we examined the possibilities and conditions to be met in order to co-finance such habitat intervention through CO₂ certificates.

As a part of the Tech4Nature Initiative, a partnership agreement between Huawei and IUCN, we examined an old cut from 2021, where all information is now readily available, to estimate the expected CO₂ equivalents for a new cut. By respecting the necessary conditions like additionality, double-counting, long-term sequestration, and the business-as-usual baseline, we were able to demonstrate that biodiversity measures do generate CO₂ certificates that can be sold on the voluntary carbon market. We used different models and satellite pictures, as well as Lidar and GIS, to calculate different scenarios and estimated a mean equivalent of 42 tons of CO₂ per hectare sequestered through the opening up of the forests. This represents around 1,000 USD/ha which is an important contribution to reducing the costs for biodiversity measures in these steep mountainous areas.

6.6 Additional country initiatives

Asia – Maldives

Merging technology with the IUCN Green List can help in monitoring natural, cultural, and ecosystem values. Specifically in the Maldives, technology can further strengthen marine conservation efforts, ensuring the sustainable conservation and restoration of coral reefs, tuna fish stock, and marine biodiversity, while also promoting effective management of PCAs and marine protected areas (MPAs).

Technology can assist marine ecosystem and coral conservation efforts in the Maldives by providing real-time data, early warning systems, and improved decision making. Satellite imagery and underwater sensors can track environmental factors like water quality and temperature, alerting researchers to coral stress and bleaching events. Aerial and underwater drones enable high-resolution monitoring of reef health and potential threats. Machine learning and AI can process large datasets, identifying trends and anomalies for natural, cultural, and ecosystem values, and contributing towards better-informed conservation strategies.

Tuna fishing is the largest fishing industry in the Maldives, with several species of tuna caught for both local use and export purposes. Advanced satellite tracking and data analytics allow for precise assessment of tuna populations and migration patterns. Deployment of blockchain technology will ensure transparency and traceability, aligning with Green List principles for sustainable fishing. Moreover, the Green List will offer standardised criteria aligned with the Marine Stewardship Council (MSC), certifying sustainable fisheries and enhancing market access. This integrated approach will promote the long-term preservation of tuna stocks, sustain local livelihoods, and safeguard the marine ecosystem in the Maldives.

Central Asia – Western Tien-Shen

The project in Central Asia supported transboundary cooperation between Kazakhstan, Kyrgyzstan, and Uzbekistan for effective conservation of the Western Tien-Shan World Heritage serial site. The framework for transboundary management was developed to enhance conservation efforts of seven protected areas in the three countries, and the IUCN Green List criteria and indicators were used to define components of the framework, especially in building joint monitoring of valuable species and ecosystems. IUCN experts provided introductory workshop on the IUCN Green List of Protected and Conserved Areas Standard for the Regional Committee of the Western Tien-Shan. Protected areas managers and specialists from national ministries and scientific institutions participated, to increase capacity and align the management of beneficiary protected areas with the Green List Standard for the future commitment of the sites to the certification process.

The project supported IUCN's efforts in the region to promote the Western Tien-Shan as a flagship site for joint monitoring and consolidating conservation measures. The discussion was organised around the use of information and communications technologies in conservation in Central Asia and specifically in the Western Tien-Shan. The online workshop attracted participants from Central Asia and other countries outside the region for conversation about application of ICT in monitoring and protection of sites and species and the snow leopard in particular. Two cases on the solutions that use technology for conservation in Central Asia were featured in the Tech4Nature PANORAMA publication – “Solutions in Focus: Tech4Nature”: (1) Using camera traps to restore connectivity for wild cats in Central

Asia (Turkmenistan) and (2) Using monitoring data to create protected areas and wildlife corridors for saiga conservation (Kazakhstan).

The outcomes of the project and IUCN's involvement have supported the establishment of effective management of the site, and facilitated regional dialogue and planning of future activities for the conservation of global values of the Western Tien-Shan World Heritage Site.

Seychelles

In the Seychelles, the project supported digital connectivity in Cousin Island Special Reserve and improved monitoring during Hawksbill turtle laying season, to scale-up conservation of sea turtles, coral reefs, and endemic bird monitoring.

The project also formalised Cousin Island Special Reserve's commitment to the IUCN Green List Standard.

Rwanda

With Tech4Nature support, the Green List programme was officially launched in Rwanda through the signing of a Memorandum of Understanding (MoU) between the Rwanda Development Board (RDB) and IUCN. Through the MoU, Rwanda committed that all four protected areas in Rwanda will undergo Green List evaluation and share best practices in order to promote conservation and biodiversity protection in Africa. Two out of four sites have already started the assessment.

The project facilitated the establishment of the Expert Assessment Group for the Green List (EAGL), training of site managers, and overall advocacy for stakeholders in Rwanda. The Green List has been considered in both the national and regional context (ongoing National Conservation Master Plan, Regional Biodiversity Strategy and Action Plan). This has had a tremendous impact in Rwanda, and IUCN ESARO is keen to expand the Green List programme to other East African countries (Tanzania, Kenya, and Uganda).

Solutions in Focus: Other Tech4Nature case studies

Inspired to learn about more case studies?

In 2021, Tech4Nature sponsored the 'Technology for Nature' category of the 2021 Pathfinder Award. Building on its success, more case studies and best practices were picked and collected to present in a dedicated 'Solutions in Focus' publication.

This publication presents 22 cases of how technology effectively helps conserve nature, from across 19 different countries. Through the examples in that publication, we seek to spark optimism, action, and replication of some of the solutions we're presenting.

You can learn more and [download the publication here](#).



7. FUTURE DIRECTIONS AND OPPORTUNITIES

As we stand at the intersection of technology and conservation, the path forward brims with promise and innovation. In this section, we embark on a journey into the future of conservation, exploring new emerging technologies, fresh approaches, and uncharted directions that hold the potential to revolutionize the way we safeguard our planet's biodiversity and area-based conservation.

From cutting-edge advancements in artificial intelligence and remote sensing to novel collaborative frameworks and community-driven initiatives, the future of conservation technology is marked by exciting opportunities, reshaping the landscape of conservation as we know it.

7.1 Emerging technologies and their potential in conservation:

Acoustic Monitoring in focus (RFCx)

Biodiverse ecosystems are critical to the overall health of our planet, providing numerous essential ecosystem services that underpin human well-being and the global economy. The landmark Global Biodiversity Framework (GBF) lays out a series of powerful targets to combat the current biodiversity loss crisis. However, to track progress towards and ultimately achieve these targets at a global and continuous scale, we need to leverage the power of advanced technologies.

Incorporating artificial intelligence (AI) into passive acoustic monitoring has the potential to revolutionise our understanding of ecosystems, species interactions, and the impacts of environmental changes. By utilising passive acoustic monitoring and AI, researchers can gather data on the presence, distribution, and behavioural trends of a wide range of species, from birds and mammals to insects and frogs. This information can then be used to inform conservation and management decisions, including identifying

key biodiversity areas, establishing protected areas, evaluating wildlife management initiatives, and developing conservation strategies tailored to different species.

Rainforest Connection (RFCx) and the RFCx Arbimon team recently unveiled an innovative new white paper showcasing how ecoacoustics and AI technology can monitor biodiversity and track progress towards conservation targets. The comprehensive report, titled "Harnessing the Power of Sound and AI to Track Global Biodiversity Framework (GBF) Targets," outlines case studies from around the world to showcase the wide range of ecoacoustic applications and align these studies with specific GBF targets. For example, a study to assess and monitor biodiversity in Atlantic Forest restoration areas demonstrated the positive effects of restoration on biodiversity and the need for long-term management (GBF Target 2). Another project evaluated the impact of forest certification on bird communities, highlighting the potential of certified forests to sustain biodiversity and livelihoods (GBF Target 10).

Passive Acoustic Monitoring (PAM) & the Global Biodiversity Framework (GBF)

The GBF outlines 23 action-oriented targets to be achieved by 2030, some of which are highlighted below. PAM provides an efficient and scalable way to monitor biodiversity, track progress towards GBF targets, and guide conservation action.

GBF INDICATORS

Species & Ecosystems

- Red List of Species
- Species Status Index
- Species in restored areas
- Living Planet Index
- Biodiv. Intactness Index
- # of records in global biodiv. databases
- Registry of Invasive Species
- Red List of Ecosystems
- Ecosystem connectivity

Capacity-building & Collaboration

- Local stakeholder involvement
- Increased training & open resources
- Global biodiversity networks
- Multi-dataset integration

TARGET

PAM INSIGHTS

02	Effective restoration of 30% of degraded ecosystems.		Species call detections & soundscapes to assess effectiveness of restoration
03	Effective conservation & management of 30% of land & oceans.		Species call detections & soundscapes to establish baselines, assess change over time
04	Halt human-induced extinctions.		Detecting endangered species to model distribution & occupancy
06	Mitigate impacts of invasive species & reduce spread by 50%.		Detecting invasive species to track spread & serve as early warning system
08	Minimize the impacts of climate change on biodiversity.		Species call detections & soundscapes to determine influential environmental factors
10	Sustainable management of agriculture & forestry.		Species call detections & soundscapes to assess effectiveness of agroforestry, regenerative agriculture
15	Enable businesses to assess & disclose their impacts on biodiversity.		Soundscapes & acoustic-derived biodiversity maps facilitate easy reporting
20	Strengthen capacity-building, knowledge sharing & tech transfer.		Permanent archive of sound, facilitating transparency, information sharing
21	Integrated and participatory management.		Easy to use hardware & software, on-the-ground deployment

RFCx is collaborating to monitor focal species such as the Critically Endangered mangrove finch (GBF Target 4), and, in contrast, to detect the spread of invasive grey squirrels in the UK (GBF Target 6). Further, the white paper emphasises the importance of centring Indigenous communities and their traditional knowledge (GBF Targets 20,21).

The passive acoustic monitoring and AI pipeline is a reliable, scalable, and comprehensive way of quantitatively informing the adopted GBF indicators and tracking progress towards the GBF targets. By leveraging this technology, we can make meaningful progress towards the protection and preservation of our natural world.

7.2 Tech4Nature Initiative

Under Tech4Nature Phase 2 (2023-2026), IUCN and Huawei will be launching the Tech4Nature Initiative. This will catalyse global impact in nature conservation by nurturing collaboration, knowledge-sharing, and the ethical integration and application of cutting-edge digital technology solutions. This initiative is envisioned to bridge the gap between the ICT and the conservation sectors, propelling us closer to achieving effective and equitable PCAs, while contributing significantly to the ambitious T3 under the GBF.

The Tech4Nature Initiative will be a dynamic, global collaboration platform where stakeholders from the ICT and nature conservation sectors converge to collaborate, innovate, and share transformative ideas. This digital ecosystem will transcend geographical boundaries, fostering a collective global effort toward conservation goals. It will actively engage and encourage partnerships between stakeholders from both sectors. By uniting the unique strengths and perspectives of these diverse communities, we aim to ignite innovation and create a force multiplier effect that accelerates the adoption of innovative technology solutions for nature conservation.

By empowering action with knowledge, the Tech4Nature Initiative will provide invaluable resources, best practices, and

tools to empower stakeholders to implement technology solutions responsibly and effectively. This knowledge repository will facilitate informed decision-making, streamline processes, and ensure the ethical and impactful use of technology. It will provide multiple stakeholders with powerful tools that substantially reduce the manual labour required to collect and analyse vital field data. The use of AI will help to provide accurate data on species and threats, often in near real time, to make timely informed decisions to protect ecosystems and species.

A key area of work under the Tech4Nature Initiative is to combine human expertise with AI engines to continue generating powerful tools to support conservationists, Indigenous Peoples and local communities, rangers, local and national governments, and researchers. AI models developed in a multistakeholder participatory manner that are trained on appropriate machine learning datasets can be used to determine the locations of species, to help with detection, poaching management, and research. It can enhance anti-poaching efforts, for instance, by increasing effectiveness by monitoring entry points with around-the-clock surveillance. When a threat is detected, an alert is immediately sent to ranger teams who, thanks to the reduced need for constant manual surveillance, are better able to respond.



8. RECOMMENDATIONS FOR SCALING UP TECH4NATURE EFFORTS GLOBALLY

In our pursuit of a more sustainable and harmonious coexistence with our planet's natural wonders, the Tech4Nature project has illuminated a path of innovation and promise. As we stand on the threshold of the future, this section looks ahead towards scaling up Tech4Nature efforts on a global scale.

Drawing insights from the accomplishments and experiences of phase I of the project, we present a set of recommendations that envision a world where technology and conservation converge to reshape the current landscape of Protected and Conserved Areas (PCAs) and biodiversity worldwide.

8.1 Opportunities to deploy solutions from T4N I to other relevant and appropriate PCAs

It is evident that there is immense potential to scale up these efforts globally and extend the impact of the presented '*tech-4-nature*' cases to a broader array of relevant Protected and Conserved Areas (PCAs). To harness this potential effectively, several key recommendations emerge:

Replication and Adaptation: The successful solutions developed and tested in phase I of Tech4Nature should be looked at for their adaptability to diverse PCA contexts worldwide. This includes not only replicating proven technologies but also tailoring them to suit the specific needs and challenges of different regions and ecosystems.

Capacity Building: To ensure the sustainable deployment of technology in PCAs, capacity-building programs should be prioritized. Training local communities, conservation practitioners, and PCA managers in the effective use of technology will empower them to take ownership of these solutions and integrate them into their management practices.

Multi-stakeholder collaboration: The establishment of collaborative networks and partnerships among conservation organisations, technology providers, governmental bodies, and local communities is pivotal to success. These networks can facilitate the exchange of knowledge, resources, and best practices, fostering a global community committed to conservation through technology. Establishing partnerships can also facilitate funding and investments to scale up local and global efforts.

Community Involvement: Engaging local communities, indigenous peoples, and citizen scientists in the deployment and monitoring of technology is crucial. Their insights and participation can enhance the effectiveness of conservation efforts and promote a sense of stewardship.

Ethical Considerations: As technology becomes increasingly integrated into conservation, ethical considerations related to data privacy, environmental impact,

and community consent should be at the forefront of decision-making processes.

Monitoring and Evaluation: Robust monitoring and evaluation frameworks should be established to assess the impact of technology on nature and people continually. This data-driven approach ensures that resources are directed where they are most needed.

In scaling up Tech4Nature efforts globally, it is essential to recognize that every PCA is unique, with its own set of challenges and opportunities. Therefore, a flexible and adaptive approach, rooted in collaboration and community engagement, will be instrumental in extending the benefits of technology to PCAs worldwide.

8.2 The critical role of youth in the use of technology to support conservation

The active participation and engagement of youth is vital for the future of all societies and the achievement of sustainable development goals (IUCN, 2021; United Nations, 2018). Various organisations offer different definitions of youth, from UNESCO (15-24 years), to the African youth charter (15-35 years). The United Nations considers the youth group as those age between the ages of 15 and 24 and estimates their numbers at 1.2 billion, equivalent to 16% percent of the world's population. In contrast, IUCN (2021) defines youth as all people under the age of 30, who represent an astonishing 52% of the world's population, the majority of them in Asia, Africa and Latin America. Regardless of the definition, youth are undoubtedly a highly innovative and creative group (Bosco Ekka et al., 2022), with tremendous potential to support sustainable development.

The Kunming-Montreal Global Biodiversity Framework (CBD, 2022), adopted by CBD state parties at the 15th Conference of Parties (CoP15) in Montreal, Canada, highlights the importance of embracing technology to achieve the agreed targets and goals in multiple sections. Within this framework, the role of youth is emphasised, recognising the need for all state parties to “foster the

full and effective contribution of youth” in the implementation process. It is therefore imperative that we put youth at the very centre of our dedication of further resources and attention to technology in biodiversity conservation.

The widespread and increasing availability of technology in recent years has given interested youth a platform to collaborate on biodiversity conservation worldwide. Citizen science initiatives involving volunteers in data collection have gained momentum in recent years (Silvertown et al., 2015), offering youth the opportunity to actively participate in conservation by contributing to large-scale monitoring efforts. Additionally, these initiatives create a thriving environment where youth are both learning by doing and exchanging ideas with experts (Silvertown et al., 2015). These sets of conditions will undoubtedly empower youth to mix experience, knowledge, skills, passion, and, most importantly, energy, to help advance the work of humanity towards biodiversity conservation. Ultimately, youth will support advancing the Global Biodiversity Framework for the future we all want, a future where humans live in harmony with nature.

Although the integration of technology into conservation efforts is vital, it is not without its challenges, particularly for the younger generation stepping up to the forefront of environmental conservation. Youth's role is crucial, given their innate familiarity with digital tools and their passion for change. However, several hurdles impede their seamless engagement. Economic disparities often hinder their ability to afford devices and reliable internet connections, creating a digital divide. Educational institutions and job opportunities increasingly require digital skills, leaving those without access at a disadvantage. Bridging this gap is crucial to ensure equitable opportunities for all youth, empowering them to participate fully in today's digital world. Collaborative initiatives can promote digital literacy. By prioritising equitable access to technology, society can ensure that no young person is left behind in the digital era, fostering a more inclusive and empowered future for all.

Tapping into the potential of youth to leverage technology for conservation efforts holds transformative promise in achieving the GBF's ambitious goals. Through the integration of innovative applications, artificial intelligence, and machine learning, young individuals can significantly contribute to species monitoring, data collection, and awareness campaigns. Their adeptness with technology opens avenues for real-time information dissemination and engagement on a global scale. Moreover, the creative energy of youth drives the development of novel solutions, from AI-driven species identification to virtual reality-based environmental education, accelerating progress towards GBF targets. Beyond technological contributions, involving youth nurtures a sense of responsibility and attachment to nature, fostering a generation of dedicated environmental custodians. The synergy between youth, technology, and conservation stands as a formidable force in advancing the GBF's vision of harmonious coexistence between humanity and nature, and the promise of intergenerational collaboration for future conservation success.





9. CALL TO ACTION FOR STAKEHOLDERS TO EMBRACE AND SUPPORT TECH4NATURE

This review of the transformative potential of digital technology to support conservation solutions has illuminated both the pressing challenges we face and the unprecedented opportunities at our disposal. As we stand at this juncture, it is imperative to reflect on our collective responsibility and commitment to the preservation of biodiversity and ecosystems.

Digital technology solutions hold the key to addressing pressing conservation challenges. They offer innovative tools and strategies to empower conservation practitioners and safeguard our natural world.

Looking to the future, we recognise the immense potential of emerging technologies to support conservation goals around the world. Therefore, in the spirit of our shared responsibility and commitment, we issue a resounding call to action to ensure that technology plays a vital role in future conservation efforts:

- **Embrace Technology:** Conservation stakeholders at all levels must embrace technology as an indispensable tool in our arsenal.
- **Empower Youth:** Give young people the opportunities and the tools to lead the charge in integrating technology into conservation efforts. They are the torchbearers of innovation and change.

- **Collaborate:** Foster collaboration among governments, NGOs, local communities, and technology providers. Together, we can amplify our impact and address conservation challenges comprehensively.
- **Ensure the Sustainability of Initiatives:** Commit to long-term plans for maintenance of technology solutions, and continuous learning and capacity development.
- **Act Ethically:** Engage with technology in a responsible, meaningful way, respecting privacy, cultural values, and the rights of Indigenous peoples and local communities.
- **Innovate:** Embrace emerging technologies and innovation, pushing the boundaries of what is possible in conservation.

The choice is clear: We must seize the potential of digital technology solutions to support the Global Biodiversity Framework, advance One Health principles, and drive conservation forward. Through the wise use of technology, we have the opportunity to be stewards of change, protectors of biodiversity, and champions of a sustainable future. Together, we can forge a brighter path for our planet and generations yet unborn.



ANNEXES

1. Additional resources and reading

IUCN Green List Standard:

The IUCN Green List Standard is a framework developed by the International Union for Conservation of Nature (IUCN) to assess and recognize well-managed and effective protected and conserved areas. It provides a set of criteria and indicators that help evaluate the performance of protected and conserved areas in terms of conservation outcomes, governance, and management effectiveness. The Standard aims to encourage the adoption of best practices in area-based conservation and to promote their recognition.

[Read more here.](#)

Tech4Nature Solution in Focus:

The Tech4Nature Solution in Focus is the first flagship publication out of the IUCN-Huawei Tech4Nature partnership aiming to provide guidance on appropriate use of technology in area-based conservation and directly involve the ICT industry in nature conservation outcomes. It features 22 solutions from 19 countries selected from the [PANORAMA | Solutions for A Healthy Planet](#) platform, addressing six key conservation challenges.

[Read more here.](#)

Smart Protected Areas Whitepaper:

Developed by Huawei, IUCN China, and the Ecology and Nature Conservation Institute of Chinese Academy of Forestry, the whitepaper showcases existing use cases and best practices in China. The white paper is designed to serve as a reference point for the conservation industry to plan and develop smart protected areas for specific scenarios using information and communication technologies (ICT).

By analysing the features and challenges of different conservation scenarios, as well as the advantages and limitations of certain ICTs, the paper provides actionable suggestions on solution architecture for smart conservation using technologies such as communications networks, cloud, IoT, big data, sensing technology, and AI analytics.

[Read more here.](#)

STAR Metric (Species Threat Abatement and Restoration):

The Species Threat Abatement and Restoration (STAR) metric measures the contribution that investments can make to reducing species' extinction risk. It helps governments, cities, civil society, the finance industry, investors and companies to target their investments and activities to achieve conservation outcomes and contribute to global policy aims.

[Read more here.](#)

Rainforest Connection (RFCx) “Harnessing The Power of Sound and AI to Track Global Biodiversity Framework (GBF) Targets” Whitepaper:

This white paper, describes the power of passive acoustic monitoring (PAM) and AI (or ecoacoustics) to monitor biodiversity, inform conservation action, and track progress towards GBF targets. It provides a general overview of acoustic monitoring, including its benefits for threat detection and biodiversity monitoring, as well as the technology and infrastructure used. It also highlights several case studies from RFCx collaborative work around the world, to showcase the wide range of ecoacoustic applications.

[Read more here.](#)

Some existing online communities and initiatives:

- [Wildlife Insights](#): streamlines decision-making by providing machine learning models and other tools to manage, analyse and share camera trap data. With access to reliable data, everyone can make better decisions to help wildlife thrive.
- [Wildlife.ai](#): a charitable trust that uses artificial intelligence to accelerate wildlife conservation and works with grassroots wildlife conservation projects and develop open-source solutions using machine learning..
- [Wildlabs.net](#): WILDLABS is the central online hub for conservation technology, connecting 6,000+ conservationists, researchers, field biologists, engineers, developers, makers, and #tech4wildlife experts worldwide! With huge challenges like wildlife crime and poaching, climate change, deforestation, and extinction threatening ecosystems around the world, it's more important than ever for conservationists to have access to the tools, resources, and networks needed to rise to those challenges.
- [Esri](#): Esri is the global market leader in geographic information system (GIS) software, location intelligence, and mapping. Taking a geographic approach to problem-solving, brought to life by modern GIS technology. Esri is committed to using science and technology to build a sustainable world.
- [ConservationXLabs](#): Conservation X Labs focuses on leveraging the best technology, the newest innovation, interdisciplinary genius, and the power of the marketplace to boldly confront the biggest problems facing the planet.

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Green List
Protected / Conserved Areas