Leveraging existing and emerging technologies for biodiversity monitoring in land-use investments

Learnings from the ESKEN webinar

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The Environmental and Social Knowledge Exchange Network (ESKEN) is a workspace for a community of practice involved in the environmental and social (E&S) aspects of financing deforestation-free commodity production, protection of natural ecosystems, forest landscape restoration, and other forms of sustainable land use.

The ESKEN webinar **'Leveraging existing and emerging technologies for biodiversity monitoring in land-use investments'** was held on September 14th, 2023, co-hosted by Raphaele Deau from UNEP-CFU and Joanna Wolstenholme from UNEP-WCMC. The webinar started with an introductory presentation covering the data value chain from data collection to sharing, as well as technological developments across each step. This was delivered by **Boipelo Tshwene-Mauchaza**, Programme Officer at UNEP-WCMC.

A panel discussion followed, focused on how both remote-sensing and novel technologies can be used by financial actors to account for risks and positive impacts in land use projects, in order to improve transparency and efficiency, connect local communities to sources of information, and support claims' credibility. Our panellists were:

- **Anne Rosenbarger**, Global Engagement Manager for Commodities and Finance at WRI
- **Ben Tregenna**, Chief Technology Officer at Pivotal
- **Leo Murphy**, Impact Manager at Climate Asset Management

The event aimed to introduce this topic to investors and other interested stakeholders, and to assist them in understanding which biodiversity monitoring technologies exist, how accessible they are, and how to best factor them into investment strategies.

The recording of the webinar, as well as the introductory slides, can be accessed on the Land Use Finance Impact Hub website.

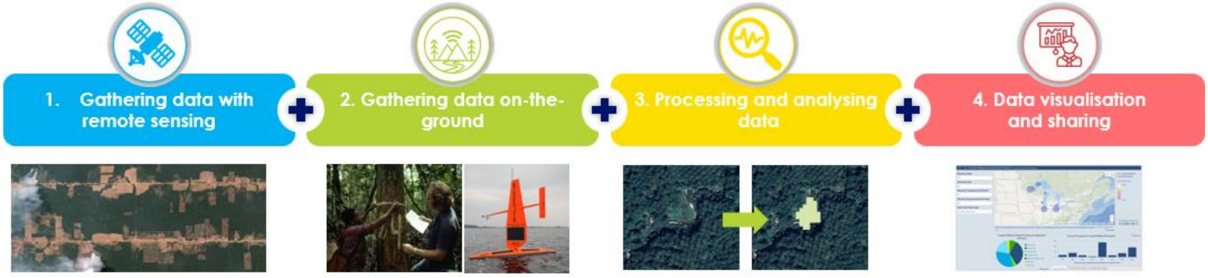
Key takeaways from the webinar

- The availability, scale, resolution, timeliness and accessibility of remote-sensing data and its derived products has seen notable growth in recent years. However, employing remote sensing for biodiversity monitoring still presents technical challenges, and the best performance can be achieved only through a combination of remote and in-situ data collection.
- In-situ technologies are seeing increased availability and accessibility. Effectively engaging with relevant stakeholders on the ground remains fundamental to the success of on-the-ground methods.
- Some of the key learnings when investing in biodiversity monitoring at the project-level include:
    - investors should see remote-sensing and in-situ technologies as being complementary – they capture different sorts of data which together build a bigger picture;
    - understand your needs first and then match data technologies to those needs – a theory of change is a good place to start, and then weave in relevant sensing technologies to capture evidence of the changes you are expecting to see;

- consider capacity, costs and project developers' level of involvement in the monitoring process; and
- collaborate with local communities – they have the best knowledge of local flora and fauna, and shall be involved in your project monitoring from the very start.

Status and trends in biodiversity monitoring technologies

Boipelo Tshwene-Mauchaza, from UNEP-WCMC, provided an overview of the report Tech to Track[1] and touched upon the status and trends in biodiversity monitoring technologies across the data value chain. For each stage of the chain, there have been technological developments that strengthen the case for employing spatial intelligence in the identification and assessment of areas that require protection, restoration and sustainable management of natural resources.



Gathering data with remote sensing is now possible at greater spatial, temporal and spectral resolutions and with more frequency, thus allowing for enhanced impact identification and measurement. For instance, the sensors carried by satellites, airplanes and drones provide high-resolution images of infrastructure, land use and ecosystems and thus simplify the process of detecting where and when land use change takes place (e.g. deforestation). Some of the key developments in remote sensing include Light Detection and Ranging (LiDAR) and Synthetic Aperture Radar (SAR), as well as aircraft and drone sensing.

- LiDAR allows measurement of vegetation structure using lasers in 3D, making it possible to assess forest biomass and carbon storage, important for measuring and possibly quantifying Earth's natural capital.
- SAR collects data on changes in land surface elevation in any weather or light conditions. This quality makes this technology particularly apt for monitoring global forests and deforestation rates, as SAR sensors are able to detect double the changes in often cloudy tropical forests.
- Aircraft and drone sensing happens through metric cameras, hyperspectral scanners and LiDAR mounted on these vehicles. The use of such tools can provide more flexibility to target a specific area compared to satellites and improve accuracy and access to hazardous environments.

Remote sensing technologies can help with monitoring and prioritisation of specific locations. However, they should not be seen as a substitute for on-the-ground information,

[1] Systemiq (2022). Tech to Track: Harnessing the potential of spatial data & digital technologies to prioritise nature and climate action. A product of the SPACES coalition.

which helps with ensuring appropriate biodiversity monitoring and determining location-specific action. *Gathering on-the-ground (or in-situ) data* can happen through population surveys, networks of sensors, sampling of environmental DNA (eDNA), and other field measurements of biodiversity and ecosystem services.

- Sensors include visual, atmospheric and acoustic sensors and can contribute to a more automated, frequent and standardised monitoring of the state of the environment.
- eDNA samples can identify which species are available in a specific location (if the genetic markers are known), without the need for taxonomic experts to carry out field surveys.
- Citizen science is an important on-the-ground practice, with over 80% of biodiversity observation data in Europe estimated to be collected by volunteers. Examples of developments include the global database iNaturalist, which uses a computer vision model to automatically identify species from photographs.

The *processing and analysing of data* are vital to translate it into usable information. As the large volumes of information provided by new technologies often cannot be processed manually, automated tools and platforms are stepping in. Developments include automatic classification through Artificial Intelligence and Machine Learning, as well as edge computing and predictive and prescriptive modelling.

Data visualisation and sharing through storytelling, graphs and dashboards are key mechanisms to engage a diverse and wide range of stakeholders with the nature and biodiversity crisis. For spatial intelligence to be useful, it must also be accessible to its users, with data sharing and integration of data sources among platforms being a critical component (e.g. UN Biodiversity Lab provides free access to around 400 spatial data layers from different datasets).

Remote sensing applications to monitor biodiversity

Anne Rosenbarger, from WRI, provided her insight into the developments characterising remote-sensing data and its derived products. She comments on the increased market availability and accessibility of higher resolution imaging, as well as on the rapidly advancing developments in big data processing and AI that help the researchers take that imagery and other sources and apply it for specific use cases more effectively and innovatively. She adds that remote sensing and spatial data have now moved from a niche field to almost a universal necessity for policymakers and corporate actors who are trying to implement their commitments to nature and sustainability. She also emphasises the resulting shifts in the way products are packaged and delivered – in the forms of tools, platforms, and apps – that are useful to a broad range of stakeholders. As a case in point, Anne mentions that we have very reliable, publicly available, near real-time information on forests and how they change around the world.

However, when it comes specifically to biodiversity monitoring, it is a bit more complicated. To get a full picture of biodiversity, you need to take into consideration a range of variables and different dimensions of genetics, species and ecosystems. Anne comments that remote-sensing data as it currently stands helps on some dimensions more than others. For instance, it can be useful at the ecosystem level, providing support on habitat extent, structure and change through variables such as climate, topography, land cover, fragmentation, degradation, vegetation productivity and health, forest canopy height. Remote sensing is also a really valuable asset in terms of being cost-effective for large-scale monitoring, and also being able to provide repeated measurements and access remote areas. However, species and genetic dimensions are not well covered by remote sensing data alone and still require input from in-situ observations.

Anne finds the combination of remote-sensing data, technological advances in processing and AI, and in-situ data as the most exciting prospect in this space. There are innovations that take site-level species information and couple it with specific environmental indicators to identify where species will be located through species distribution models or habitat suitability models (e.g. Whale Safe). Anne believes that the more we can create these really integrated products, the more we will get a greater coverage over various dimensions of biodiversity, and we will be able to have more information that is useful across scales, applicable to different use cases, and sufficiently dynamic to look at changes over times.

Finally, Anne comments that it is an exciting time for financial actors to be looking into monitoring their impacts on biodiversity. She mentions the adoption of the Global Biodiversity Framework and its relevance for the business and finance sector to help frame their contributions. In addition there are important biodiversity components in the latest private sector-facing frameworks on risks and impacts, e.g. the Taskforce for Nature-related Financial Disclosures (TNFD) and the Science-Based Target Network (SBTN). All of these initiatives trigger this need for increasing alignment around the specific data, indicators and technology that we need to assess, monitor and report.

The importance of on-the-ground monitoring of biodiversity

Ben Tregenna, from Pivotal, shares Anne's view over the importance of combining data measuring methods into a holistic approach rather than looking for a silver bullet. When it comes to designing in-situ measurement technologies, Ben believes that private actors should first aim to understand the risks and impacts of the business before deciding what needs to be further clarified through an in-situ monitoring exercise. Technologies such as passive acoustics, camera and insect trapping, and eDNA are becoming progressively cheaper and more accessible to market actors. However, for in-situ technologies, as opposed to remote sensing, there is also the added dimension of needing to engage on the ground with project managers, communities, and all other relevant stakeholders. Technology has not only increased the quantity of data, but also our ability to process and analyse it. The explosion in open access algorithms developed by large technology companies is increasingly being applied to biodiversity data, accelerating data processing.

Ben comments that whatever your monitoring program is – its biodiversity impact and mitigation claims have to be robust, verifiable, auditable and defensible. Investors should see field visits and surveys carried out by experts as activities that serve to audit the accuracy of data captured digitally. Biodiversity monitoring should also be understood as a long-term action, as positive change happens relatively slowly and investments can look at a 5, 10, 20, 25-year time horizon – and so monitoring plans should consider how technology may advance, and companies come and go – over that time horizon. Ben stresses the importance of transparency and of having a clear and solid methodology that is able to stand the test of time.

Insights from a carbon credit project in Kenya

Leo Murphy, from Climate Asset Management, discusses the impact monitoring technologies that they are deploying on a large-scale carbon credit project in Kenya spanning 1.5 million hectares of land. This project centres around working with Maasai communities to implement more sustainable grazing practices to generate soil carbon benefits but also community and biodiversity benefits. The project is generating carbon credits through the voluntary carbon markets, and it will be certified through the Climate, Community and Biodiversity (CCB) Program. The intention of this project is to ensure high-integrity carbon value by creating a long-term monitoring system that quantitatively demonstrates what is happening in terms of biodiversity as a result of the actions of this project. To do so, a variety of different biodiversity elements are assessed through complementary remote-sensing and on-the-ground approaches.

To begin with, the project team looked at the satellite and remote-sensing imaging to design the project: their intention was to understand which and how many habitats spanned across their focus area, as well as their abundance. Such insights allowed to design baseline surveys that are representative of the actual landscape of operations. Then, they dealt with deploying technologies, such as camera traps and audio recording units, and delivering surveys across 286 different sites. The baseline surveying was recently completed, but as the project is a 15-year long one, the plan was to design it so that it could be repeated across the years to demonstrate what is happening on the ground.

Leo first emphasised that technologies are useful but still have to be complemented by on-the-ground surveys; he also stressed that there is lot of available data nowadays, meaning that what matters is to understand beforehand what your needs are, and which pieces of data should be collected to meet those needs. Designing a theory of change proved useful in this specific project, outlining what they expected to happen through their actions and matching the most appropriate technology to monitor those expectations. For example:

- The project includes implementing a rotational grazing program, expecting that this would lead to increase in vegetation cover. Monitoring vegetation cover increase can be monitored through Normalised Difference Vegetation Index (NDVI), remote sensing and some on-the-ground surveys on species diversity;
- Another expectation links vegetation improvement to more grazing by large mammals and herbivores. In this case, camera traps were deployed to detect that;
- As a combination of large mammals' presence and the increase in vegetation, more invertebrates would feed on grass and dung. To monitor this piece of this theory of change, it is necessary to have people and traps collecting evidence;
- The final piece of this chain of events is that if invertebrates are increasing in diversity and abundance, insectivores such as birds and bats would also increase in abundance, and this is captured through audio recorders.

In general, it is a combination of piecing the right technologies in the right places ensure coverage over expected change over time.

Leo also clarifies that for this project, very little is performed in-house, as he is the only person in the organisation with a biodiversity background. The process is thus carried out by external consultants, project developers, and local communities. Leo underlines that it is important to have a project developer that buys into the project and has in interest in taking an active and long-term role, rather than outsourcing it to someone that might not have as comprehensive a mandate (e.g. in the Kenyan project, one of the project development partners is the Biodiversity Research Institute in Portland, Maine).

Another key learning regards costs, as implementing such a project is neither easy nor cheap. For the baseline surveys and the installation of monitoring technologies, Leo's team needed a mobile camp that supported about twenty people, moving them once a week.

Working with local communities was fundamental, especially in terms of designing and conducting the on-the-ground surveying, as they provided local knowledge on the landscape and its species. Over time, Leo's team is looking to build capacity within those local communities so that they can deploy and manage the technologies. This will be a benefit for the project team in terms of saving up on traveling costs and local communities would also be deriving benefits from the technical skills that they would acquire and that they would be able to use beyond the work on the project. While currently Leo's team is planning to monitor outcomes once a year, this timeline might extend to once every three year as the project develops.

As embarking on this project is not cheap, Leo concludes that it is important to build a convincing internal argument as to why biodiversity monitoring should be implemented. The focus should be on thinking about the data you want to collect and why. What Leo's team is keen to see and why they managed to gather support around the project is that they think there is potential for them to move into the emerging biodiversity credits market. Although they do not think that the biodiversity monitoring component is going to be a real driver of returns on this project (as it is mostly a carbon credit project), Leo's team believes that having a strong data foundation will allow them to generate credits that will help recoup some of the cost and support the data collection moving forward.

Reflections from the Q&A session

It's not that easy to monetise nature-positive investments currently. So why is it in the investors' interest to monitor biodiversity?

Ben states that biodiversity credits are receiving increased attention. Pivotal is collaborating with Plan Vivo to develop their PV Nature standard for biodiversity credits. He then refers back to the SBTN and TNFD frameworks as evidence that there's now increased demand coming from outside companies, as well as inside them, to understand impacts and dependencies on nature. When dealing with biodiversity, a global set of reference metrics can help the private sector understand very broadly what their impact is, but local expertise is essential to get at exactly what is happening and how it is happening on the ground, then allowing for clear and coherent stakeholder reporting.

Anne adds that investors' interest in monitoring biodiversity comes from an increase in standardised commitments including nature-based elements. Such commitments can occur both across trade flows and spanning entire portfolios, but they can also happen at the individual project-level. For instance, in the palm sector investors are looking to conduct biodiversity planning at the site level due to companies' increased awareness to compensate for losses on behalf of their value chains. Demand thus comes from a mix of necessities coming from both overarching frameworks and ground-level projects.

What elements of biodiversity cannot be capture or are struggling to be captured at the moment by the technologies? How can this be overcome?

Leo explains that when thinking about biodiversity monitoring technologies, his team selected those that would best address the various elements of biodiversity that they wanted to capture. For instance, camera traps and audio recordings are best suited to identify mammals, birds and bats. He adds that one of the key learnings during the initial design stage concerned invertebrate monitoring: Leo's team thought that it could be carried out through pitfall traps and on-the-ground surveys; however, when they got to the project's location they realised that there the number of dung beetles was much higher than anticipated, and that there is very little information about which is which. Thus, eDNA might help them, since the element of biodiversity they are interested in is not what each individual species is, but rather how many species there are and how that is changing over time. In general, it is important to think about what's the best overall approach to the project, thinking about how different technologies can complement one another and learning by doing.

Boi comments that while emerging technology have expanded our capacity to monitor biodiversity, we should accept that there are still challenges in capturing certain elements. For instance, technologies fail to capture species abundance and functional diversity without traditional surveys. However, she adds, challenges are being addressed through a combination of innovative developments that have been covered by this webinar. As an example, eDNA is one of the advancements that we are using to minimise the challenges that we still have. Focusing on data integration and disciplinary collaboration is also important to support comprehensive and accurate assessments in the near future.

Are there any frameworks or standards out there to help you harmonise data across different sources? Is there a particular place that people ought to be looking or is it just based on what works best for you?

Boi agrees that standardisation and accessibility do play an important role in the effective use of environmental data. Acknowledging current challenges to data harmonisation, efforts should be taken in ensuring interoperability to integrate multiple sources of data through consistent measuring methods and data structures. Moreover, an architecture putting data sharing first and foremost should be put in place. The central question here is who owns data, and such question must be addressed to ensure credibility, maintain openly accessible datasets, secure funding, and respect data privacy and sensibility.

Leo adds that data harmonisation will also depends on what you are trying to do with such data. For Leo's team, the interest lies in the number of species and abundance of those species. In their case, combining the different technologies is not a big challenge, since they are all measuring the same outcome. If instead you are looking more towards biodiversity credits and wants to have a standardised approach across different projects, that's where it gets more complicated. However, there are different methodologies at the moment trying to get a standardised approach to do that (e.g. talking about a % uplift in biodiversity, quantified across a range of different metrics). Leo also believes that it is important to get as much of this data into the public domain as possible. Since Climate Asset Management's project is collecting more data than actually needed, Leo's team has been in conversation with the Global Biodiversity Information Facility (GBIF) and others to see how some of this data can be made public to other actors.

Anne believes that harmonisation often starts with alignment around metrics. Frameworks such as the TNFD and SBTN can help set agreed-upon metrics, which in turn increases the general understanding around what specific underlying data is useful to gather and creates a space for more collaboration around data harmonisation. Anne concludes by saying that she is sceptical of a single universal data harmonisation effort, but that the goal should at least be harmonisation towards monitoring and reporting against specific metrics, so that impact efforts become more tangible, easier to fundraise around, and more concrete to create the necessary buy-in and alignment.

What is the state of biodiversity monitoring for ocean and coastal areas?

Ben comments that in terms of monitoring there's a number of approaches, with some being very similar to terrestrial. For instance passive acoustic monitoring works well under water, even if there's specific localisation challenges due to noise traveling a lot further underwater). Camera trapping can be implemented for ocean and coastal areas as well. Finally, LiDAR/radar technologies can be used to look at some of the structural aspects of habitats (such as assessing the ruggedness of the terrain, particularly around coral reefs).

Are there any technologies out there that help go through the huge amount of data that can be gathered through camera traps to identify species or maybe even just start classifying those species into different categories?

Ben says that there are such technologies. Classification the way it is done now, with deep learning and neural nets, relies on a whole wealth of training data that's really taxonomic- and geographic-specific. While for species such as leopards, lions and tigers, there's great-quality training data, the same cannot be said for other species. Open-source data repositories such as the GBIF and iNaturalist will overwhelmingly be focused on Europe and North America. Challenges aside, open-source models that are local, regional or taxonomic-specific are definitely the way to go once you know where you're operating, given their level of detail.

Boi adds that there's a platform called Wildlife Insights which uses AI to automatically identify and organize camera trap images, thus offering a very comprehensive solution for managing and analysing wildlife type data (including species identification). Camera trap AI, Deep Learning, and Convolutional Neural Networks (CNNS) offer some great techniques that help with image recognition tasks.

Do you have any examples of how to link financial institutions and local communities in the data collection and monitoring aspect?

Leo comments that the local communities on their project have been critical to what his team is doing. Similarly to dung beetles, Leo mentions that initially they did not have much knowledge over bird calls in the area. Although they had a lot of audio recordings, they had no training data for AI. However, one of the project team's members is part of the local community and is able to recognise birds from their calls. Having such knowledge means being able to create a database of bird calls and explore how AI could be introduced to automate such training dataset later on. By equipping local communities with the technology to effectively carry out data processes, Leo sees the relationship as a mutually beneficial one.

Ben agrees that using computers in the end ultimately requires a quality check coming from experts, especially considering the taxonomic and geographic specificity of biodiversity. These experts can be members of the communities that live in the areas where you are working, and it is through working with them that data processes can work effectively from beginning to end, from initial identification, training, creating computer models, and finally verifying the accuracy of information.