Protecting Biodiversity: Empowering Engagement through Interactive Maps

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Abstract: Biodiversity conservation heavily relies on protected areas, with Natura 2000 serving as a network safeguarding Europe's most valuable and threatened species and habitats. Assessment of acceptability for ecological network is integral to Environmental Impact Assessments (EIAs), mandated by the 1998 Aarhus Convention, which advocates for inclusive, accessible, and transparent environmental decision-making. However, the complexity of EIA documents often poses challenges, rendering them inaccessible even to experts. To address this, digital initiatives are emerging to streamline EIAs, with interactive maps playing a key role in enhancing communication and stakeholder engagement. Utilizing the abundant spatial data generated by biological research, increasingly processed using Python or R, we present a dataset collected for an EIA alongside a potential interactive, user-friendly map using open-source options.

Keywords: nature protection; R markdown; environmental impact assessment; open-source tools; mapview.

1 Introduction

Biodiversity is essential for the processes sustaining life on Earth, including humans. To conserve biodiversity, the European Union has made extensive biodiversity conservation efforts establishing the extensive Natura 2000 ecological network of protected areas, one of the largest networks of conservation areas worldwide (Maiorano et al. 2015). When a new plan or project is likely to have a significant negative effect on a Natura 2000 site, to get it approved it must follow a specific procedure (EC 2017). This assessment of acceptability for ecological network is an integral part of Environmental Impact Assessments (EIAs), which ensures that environmental concerns are considered from the very beginning of a project. The procedure also allows the public to actively engage in the EIA procedure, which is mandated by the 1998 Aarhus Convention, advocating for inclusive, accessible, and transparent environmental decision-making. However, these documents are often criticised for being an administrative burden, ending with a bloated, inconsistent and inaccessible report replete with technical jargon that is difficult to navigate and understand (Digital EIA Project Partners 2020). An example is the UK's Environmental Statement for High Speed Two Phase 1 which stood at over 50,000 pages (Digital EIA Project Partners 2020).

With digital technology being promoted to create widely accessible and engaging information sources, it is no surprise that in recent years progressive digital reporting approaches have been adopted by environmental and engineering consultancies to digitalize EIA public-facing reports (Northmore et al. 2022). The main benefits of this approach include (RPS 2024, WSP 2024): (1) transforming a complex and lengthy document into a user-centric format that is easier to digest and navigate for local planning authorities, communities and stakeholders; (2) presenting information in a more clear and user-friendly way, igniting more effective public participation in the planning process; and (3) more clearly representing the key environmental effects of infrastructure and development, thus supporting quicker and more efficient decision making. Digital EIAs are the future, but like any new technology or product, they cannot be integrated into the planning system overnight. Therefore, best practice examples and lessons learned from prototypes should be widely shared to raise standards and promote innovation across the community (WSP 2024).

In addition to more accessible, user-friendly and comprehensible format, digital EIA provides a method to reduce environmental impacts of these projects. A recent wind farm development project in Croatia, which included a comprehensive fieldwork data collection, produced a massive EIA document totalling almost 1,000 pages. Ten copies of this document (in total 10,000 pages) were printed solely for the advisory expert committee, producing the emission of 6 kg of CO_2. This inspired us to make a prototype project using some of the data collected during this project to investigate communication of the main results in a digital environment and with the use of interactive maps.

In this project, we utilized open-source tools commonly used by biologists, to present how the shift towards digital EIA can be made as simple and with as little cost as possible. Our prototype focused on habitats, birds and large carnivores, each representing different data types, to evaluate different approaches for data presentation. With this prototype, we aim to demonstrate a quicker, simpler and more accessible way of assessing environmental effects.

2 Materials and methods

This prototype study entailed the conceptualization of a hypothetical wind farm comprising twelve turbines, devoid of association with any actual wind farm endeavour. Furthermore, for evaluation purposes, this hypothetical wind farm was situated proximate to four Nature 2000 sites, encompassing two Special Areas of Conservation (SAC) and Special Protection Areas (SPA), all of which were also hypothetical in nature. To facilitate comprehension and streamline analysis, only habitat data and data derived from field research on large carnivores and birds were utilized from a real wind farm baseline study (Geonatura's internal database). Utilizing the R programming language

(R Core Team 2024) a digital document in HTML format was generated using the "rmarkdown" package (Allaire et al. 2024) to enable interactive mapping and visualization. Processing of raster and vector data was accomplished by employing various packages including "sf" (Pebesma and Bivand 2023), "sp" (Bivand et al. 2013) and "raster" (Hijmans 2024). Vector data were displayed in the form of points, lines and polygons on which popup views were added. Interactive mapping functionalities were implemented using the "leaflet" (Graul 2016), "leafem" (Appelhans 2023), "mapview" (Appelhans et al. 2023) packages, with "leafpop" (Appelhans and Detsch 2021) utilized for the integration of graph, table, and image popups onto map layers. Graphical representations were generated using the "ggplot2" (Wickham 2016) package, complemented by "plotly" (Sievert 2020) package to integrate interactive features into the generated graphs.

3 Results

A digital document was created in HTML format providing a quicker, simpler and more accessible way of assessing environmental effects. To facilitate better navigation, interactive tabs were organized according to biodiversity groups (habitats, birds, and large carnivores), with the section about large carnivores further subdivided into tabs (Figure 1). Interactive maps featured multiple layers (wind turbine location, SCI and SPA areas, habitat, primary bird heatmap, overflights (Short-toed Snake-Eagle, Western Marsh-harrier and Golden Eagle) and camera traps locations), allowing users to toggle specific layers, zoom, and change base maps. The ability to switch base maps enabled map element inspection with different backgrounds without resetting the zoom or display position. Maps where spatial and non-spatial data were joined through popup windows were created. Table and plot popups allowed a combination of temporal and spatial data (Figure 2). Additionally, a map with raster and vector data on the same display was created, which was especially useful for bird data (Figure 3). However, presenting extensive data in a single interactive map increased computation time, prolonging HTML generation and making error correction and text modifications difficult.

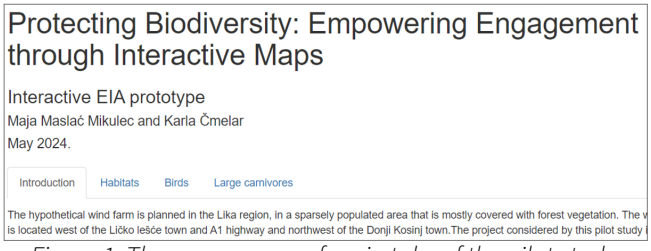

Figure 1. The appearance of main tabs of the pilot study.

4 Discussion

The interactive tab sections were beneficial as they segmented the text into smaller, more manageable sections, enhancing content acquisition and document navigation. Manipulating the basemap provided multiple views of the same data while maintaining zoom stability during basemap changes. Popup features further enhanced the interactive maps by consolidating data that would traditionally be spread across multiple pages into a single display. The mapview and leaflet packages are used for interactive, simple, and quick mapping so they have limitations, particularly regarding performance with large datasets, advanced customization, and in-depth spatial analysis. But this was not considered a significant disadvantage, since when comparing extensive with simpler interactive maps, Vincent et al. (2018) found that better spatial planning decisions were made using the simpler interactive maps. Also, interactive maps with fewer layers were faster to load and easier to compute, thus reducing the HTML production time compared to maps with more layers. To avoid this problem, one approach would be to first create the HTML document with text, ensuring there are no typographical errors, and then generate maps and all map features in a separate script. Once the document's text and maps are finalized, they can be combined into a single file. In this prototype study, the R programming language in the RStudio environment was used due to its simplicity and popularity among biologists, despite its decreased performance with large datasets. Depending on the study and data volume, Python is preferred for handling large datasets and computationally intensive tasks.

With all the benefits of digitalizing EIAs and interactive maps, available literature shows that digital EIA adoption is curtailed by four primary barriers (IEMA 2023): (1) EIA staff's lack of digital competency; (2) lack of standardization of digital EIA approaches, technology, and methods; (3) regulatory challenges; (4) and the increased cost to the proponent. Therefore, we have shown that there is a way of providing EIA information using available open-source tools, in a programming language most used by biologists, to try to tackle at least some of the curtailments.

Consequently, producing this type of digital document containing large amounts of data and maps with multiple layers could demand extended programming skills which could be challenging. However, programming skills are increasing among various disciplines and these challenges could be overcome using other programming languages and tools. On the other hand, at least in some transitional period to a digital EIA, interactive maps alone could be a separate digital document which could be used as a supplement to the main EIA study. Nevertheless, to lower the environmental impact of excess printing, we advocate for a change of regulations, so it is no longer necessary to submit printed copies of EIAs.

Other challenges should also be undertaken to ensure an effective implementation of digital EIAs, such as (IEMA 2020): setting and implementing new data standards (GIS); exploring ways to process the vast amounts of open data; collaborating with specialists in other fields to bring innovation; engaging with creative industries (marketing and communication professionals to explore new ways of presenting information); creating practical guidance on applying digital working throughout the EIA process. Moreover, we should consider ways of presenting important, but sensitive data (e.g. locations of eagle nests,

caves), which should not become completely public during an EIA process.

Hrvoje Peternel, Mirjana Žiljak and Dina Rnjak. This research received no external funding.

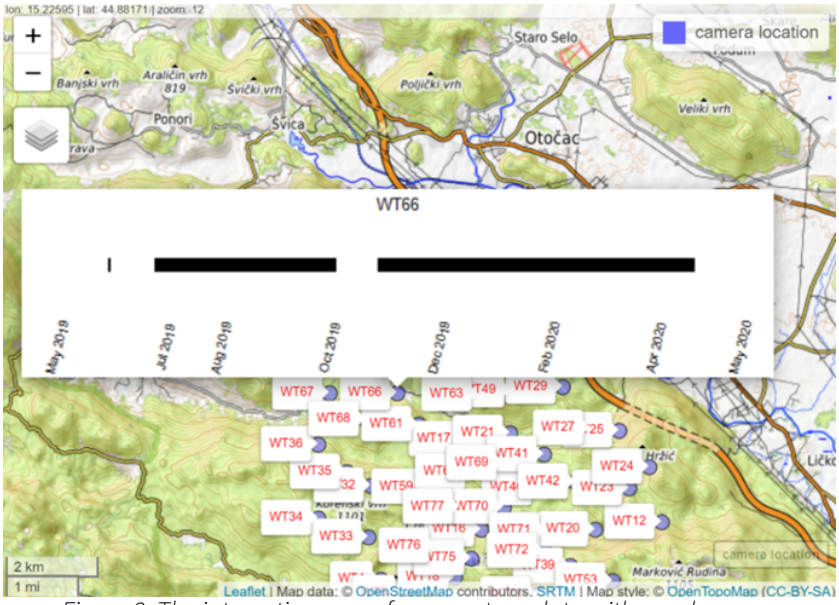

Figure 2. The interactive map of camera trap data with graph popup.

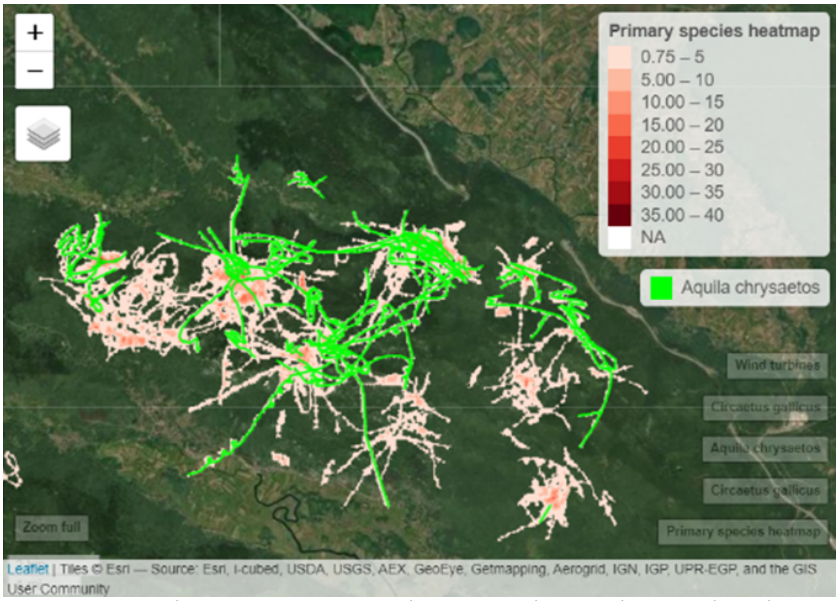

Figure 3. The interactive map with vector and raster data combined.

5 Conclusions

In the climate crisis, making sure the Environmental Impact Assessment process is efficient, effective and accessible is more important than ever (Digital EIA Project Partners 2020). With the growing amount of data, spatial complexity and size of assessment documents they are becoming challenging to truly comprehend, thus disabling the implementation of the 1998 Aarhus Convention. Also, due to regulatory standards, in many countries, like Croatia, it is still necessary to print these huge documents, adding on the environment impact. Here we presented a digital EIA prototype with interactive maps, made with widely used open-source tools, to show how easy (and not necessarily costly) it is to start transferring to the inevitable future of digital EIAs, with all its benefits.

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