



A PROactive approach for COmmunities
to enAble Societal Transformation

D2.2 – Project Research Methodology

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BACKGROUND: ABOUT PRO-COAST PROJECT

The PRO-COAST project was launched to address the issue of biodiversity loss in European coastal ecosystems. Around 40% of Europeans live within 100km of the coast, relying directly on ecosystem services that are threatened by both quantitative and qualitative losses. Groups already facing socioeconomic vulnerabilities are likely to be disproportionately affected. PRO-COAST aims to empower local communities to support the restoration and maintenance of biodiversity and ecosystem services across Europe, integrating local knowledge into practice and policymaking. The project is now underway, coordinating the efforts of 20 partners across 14 countries working on 10 unique case studies. These case studies cover multiple conservation approaches across various coastal ecosystems, testing different governance models and social incentives to engage local actors in adopting technologies and actions for biodiversity conservation.

An important element of PRO-COAST is its holistic, interdisciplinary approach, based on a conceptual framework that treats social-ecological systems as interconnected. By mapping relationships between ecosystem components and uncovering feedback dynamics, the project seeks to identify leverage points for transformative change. PRO-COAST promotes integrated bottom-up decision-making, recognizing that environmental issues cannot be separated from social, economic, and political factors. Through extensive citizen engagement guided by state-of-the-art conservation science, the project aims to build community capacity for biodiversity management, providing scalable solutions that balance conservation needs with local socioeconomic priorities. PRO-COAST hopes to inform adaptive, participatory approaches to governance that avoid biodiversity losses and ensure sustainable, equitable access to coastal resources. It will establish a Community Sustainability Platform to be run until 2033.

EXECUTIVE SUMMARY

The current toolbox consolidates a range of analytical methods and tools to explore the interplay between ecological and social dynamics, offering researchers a structured approach to operationalizing the Social-Ecological Systems Framework (SESF) in coastal areas.

The toolbox is built on a conceptual foundation that integrates ecological, sociological, and governance perspectives. It extends the SESF by incorporating social science theories, such as those addressing inequality, intersectionality, and governance structures, ensuring a comprehensive understanding of socio-ecological systems. These frameworks inform the development of Key Performance Indicators (KPIs), which enable the systematic evaluation of transformative change in coastal ecosystems.

The toolbox employs a multi-method approach, tailored to the diverse contexts of ten case studies across Europe. It includes qualitative methods such as stakeholder mapping, behavioral engagement strategies, and discourse analysis, which provide insights into the subjective experiences and social dynamics relevant to biodiversity conservation. Quantitative methods, including surveys and statistical techniques, are used to capture standardized data for cross-case comparisons and to examine relationships between variables.

Ecological methodologies complement these approaches, with tools like environmental DNA metabarcoding, Local Ecological Knowledge investigations, and camera trap monitoring. These methods facilitate the collection of precise ecological data, which is integrated with social science insights to capture the complexity of socio-ecological systems. The toolbox also incorporates technical tools, such as the EU-Survey platform and Google Earth Engine, which enhance data collection, analysis, and visualization.



This toolbox is designed primarily for the scientific community, offering a coherent framework for conducting interdisciplinary research on biodiversity loss in coastal regions. Its focus is on standardizing methodological approaches while allowing for the necessary flexibility to adapt to local contexts. By bridging ecological and social research, the toolbox provides a robust foundation for understanding and addressing the multifaceted challenges of biodiversity conservation. We are also testing an online tool that offers decision support to citizens participating in data collection and is suitable for massive scale-out. Beyond the scientific community, the practicality of all tools is also tested for non-scientists and local stakeholders, and reflected upon throughout the course of the project.

Through its detailed methodologies and analytical tools, the PRO-COAST Research Toolbox contributes to advancing the integration of interdisciplinary perspectives in environmental research, fostering collaboration, and generating insights that are both academically rigorous and practically applicable. In the long term, it is desirable to develop an analytical framework for coastal areas that can also be used independently of the project to investigate and mitigate biodiversity loss in these regions.

For this reason PRO-COAST Research toolbox is a key deliverable of the Horizon Europe-funded PRO-COAST project, designed to address biodiversity loss in coastal regions by providing a methodological foundation for interdisciplinary research.

LINKS WITH OTHER PROJECT ACTIVITIES

The PRO-COAST project consists of seven interconnected Work Packages (WPs). The research tools and methods compiled in this toolbox are informed by and closely aligned with the broader project activities, particularly those in Work Packages 3, 4, 5 and 6. These WPs are central to implementing the research tools within the case studies, ensuring that the methodologies are adapted to the specific contexts and needs of each study. The collaborative efforts across these WPs form the foundation for the practical application and validation of the tools developed, highlighting the interdisciplinary and transdisciplinary nature of the project.



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1. INTRODUCTION

The Research Toolbox developed in PRO-COAST offers practical methods for understanding and addressing biodiversity loss in coastal regions. To ensure these tools effectively capture the complexity of socio-ecological systems, we first outline the conceptual and theoretical foundations that guide their development.

Before presenting the compilation of research tools in chapter 3, chapter 1 introduces the subject of investigation and the project's key research questions, which bridge ecological and social dimensions, including governance, intersectionality, and inequality. It also describes the selection of case studies, each offering a unique context for applying and refining the tools, and highlights the project's transdisciplinary approach, emphasizing how the Social-Ecological Systems Framework (SESF) and complementary social science theories underpin the toolbox.

Chapter 2 then briefly explains the iterative process by which these frameworks are operationalized through collaboration among work packages, resulting in the identification of variables and indicators. This integration ensures that the tools presented in chapter 3 are firmly grounded in interdisciplinary methods while remaining adaptable to the diverse contexts of coastal regions.

1.1. Subject of Investigation and Key Research Questions of the Project

The PRO-COAST project builds on the pressing need to address biodiversity loss in coastal ecosystems, which are critical for both ecological sustainability and human livelihoods (IPCC 2019 SR, Schuckmann et al. 2024). Coastal areas, hosting approximately 40% of Europe's population within 100km of the coast, face mounting pressures from economic activities, population density, and environmental degradation.

At its core, PRO-COAST investigates the intricate interactions between social and ecological systems, aiming to preserve and restore biodiversity through a socio-ecological systems approach. By integrating ecological, societal, and economic dimensions, the project emphasises resilience and inclusivity in coastal regions. A novel aspect of PRO-COAST is its investigation of these interactions at the micro-level (of individual participants) as well as the meso-level (of communities) and higher, which strengthens its intersectional approach.



Key Research Questions:

- **Ecological Dynamics and Human Interaction:** What are the critical ecological dynamics of coastal systems, and how do human interactions, including cultural practices and socio-economic activities, impact these systems over time?
- **Resilience and Transformative Change:** How can the PRO-COAST framework enhance resilience and adaptive capacity within coastal communities, addressing the technical and social dimensions of transformative change?
- **Social and Cultural Dimensions:** How do diversity factors—such as demographic, social, ethnic, religious, and gender aspects—alongside cognitive and emotional factors, shape perceptions and behaviours regarding coastal biodiversity and ecosystem services?
- **Stakeholder Dynamics:** What roles do various stakeholders play in promoting or hindering biodiversity conservation, and how are these roles influenced by intersectional characteristics like race, class, and religion? How can stakeholders' perspectives be integrated into adaptive management strategies for coastal ecosystems?
- **Challenges and Enablers:** What socio-political, economic, cultural, and environmental barriers and drivers impact biodiversity initiatives in coastal regions? How do these challenges and enablers differ across the five European coastal regions included in the case studies?
- **Innovative Solutions:** How can co-created tools and policies effectively address the diverse needs of coastal communities while promoting sustainable ecosystem management and improving biodiversity outcomes?
- **Policy and Governance:** What innovative governance models can enhance biodiversity conservation and ensure sustainable use of coastal ecosystems across local, regional, and transnational scales?
- **Scientific effects:** Are any new effects that appear during exploration of our unusually detailed socio-environmental data at a statistical significance level deserving of further examination, backed by pre-registration, later in the project?

Importance of These Questions:

These questions reflect PRO-COAST's commitment to integrating the "human side" into biodiversity research, moving beyond traditional ecological frameworks. By addressing the socio-ecological complexities outlined in these research questions, the project seeks to ensure that conservation efforts are scientifically robust, socially equitable, and sustainable. Through participatory methodologies like the



Bristol Approach and Extreme Citizen Science, PRO-COAST aims to foster local engagement and align global ecological goals with local realities.

This section provides a foundation for understanding the project's broader methodological and conceptual framework, as further elaborated in the following chapters.

1.2. Selection of Case Studies

PRO-COAST employs a case study approach to investigate biodiversity challenges in coastal ecosystems, spanning nine diverse locations across Europe. These case studies were chosen to reflect the project's commitment to exploring socio-ecological systems under varying geographical, cultural, and ecological conditions.

Criteria for Selection:

The case studies were selected based on:

- **Geographical Diversity:** Covering Europe's coastal regions, including the Mediterranean, North Sea, Atlantic, and Baltic areas, to capture the broad range of ecological and societal dynamics.
- **Socio-Ecological Complexity:** Cases were chosen to represent the interaction between ecological degradation, economic activities, and societal factors, such as tourism, fishing, and urbanisation.
- **Stakeholder Engagement:** Each location features a network of stakeholders (e.g., policymakers, NGOs, local communities) who are actively involved in biodiversity conservation efforts.
- **Scalability and Transferability:** The selected cases offer insights that are not only locally relevant but also applicable across other coastal regions facing similar challenges.

Overview of Case Studies:

The ten case studies encompass EU and non-EU territories, providing a comprehensive lens on biodiversity loss in coastal ecosystems. Key examples include:

- Mediterranean regions, where urbanization, agriculture, and tourism pose significant threats to biodiversity hotspots.
- North Sea and Atlantic coasts, where agriculture, fishing, introduced species, and industrial activities intersect with conservation efforts.
- Baltic regions, which face unique socio-ecological challenges, including eutrophication and biodiversity loss due to intensive agriculture.



Each case study is supported by local stakeholders and tailored to address specific challenges and opportunities. For instance, eDNA techniques are employed to map biodiversity in data-poor regions, while participatory approaches like the Bristol Approach facilitate stakeholder collaboration.

Importance of Case Study Selection:

The selection ensures that PRO-COAST can:

- Examine diverse socio-ecological contexts.
- Develop scalable tools and policies informed by local insights.
- Foster stakeholder engagement tailored to each region's unique needs.

This targeted approach underpins the project's broader goal of aligning biodiversity conservation with social and economic resilience, ultimately contributing to sustainable coastal ecosystem management.

1.3. Transdisciplinary Approach

A cornerstone of PRO-COAST is its transdisciplinary approach, which integrates expertise across disciplines to address the complex socio-ecological challenges of coastal biodiversity loss. Recognizing that no single discipline can fully address these interconnected issues (Pohl/Hirsch Hadorn 2007, Angelstam et al. 2013, Zerbe 2023), the project blends ecological, social, and economic perspectives to develop actionable solutions.

Bridging Disciplines

The transdisciplinary approach involves collaboration among natural scientists, social scientists, and local stakeholders to:

1. Understand Socio-Ecological Dynamics: Explore the interplay between ecological changes (e.g., habitat loss, species decline) and societal factors (e.g., stakeholder attitudes, economic pressures).
2. Incorporate Local Knowledge: Combine formal scientific methods with local insights to capture the nuanced realities of coastal regions.
3. Develop Comprehensive Solutions: Design tools and policies that balance ecological conservation with social and economic sustainability.

Participatory Methodologies

- In addition to scientific trans-disciplinarity, the project also focuses on the practical applicability and implement-ability of scientific findings in the case studies. In order to initiate and accompany transformation processes, three different concepts are used. The Bristol Approach: A participatory



framework that co-develops solutions with stakeholders, ensuring that local priorities and perspectives are central to biodiversity conservation efforts.

- Extreme Citizen Science (ECS): Involving non-experts in data collection and analysis, ECS bridges gaps between formal science and community engagement, fostering inclusive decision-making in what is increasingly also called a 'participatory approach'.
- Behavioural change approach: The Behavioural Change Approach is a concept from change management, which assumes that transformation processes cannot only be initiated through technical and strategic adjustments but must also focus on a deep change in the thinking and behavior of the people involved.

The participatory concepts primarily aim to tailor and shape the transformation process according to the specific needs of the case at hand. In doing so, they address the focal action situation within the SESF.

Operational Framework

The Social-Ecological Systems Framework (SESF), based on the concept of Elinor Ostrom (Ostrom 2009, McGinnis/Ostrom 2014) serves as the foundational model, enriched with sociological theories and social indicators to capture the human dimensions of coastal biodiversity. This is further detailed in subsequent sections, highlighting the integration of ecological and sociological perspectives.

Importance of Trans-disciplinarity

By uniting diverse perspectives, the trans-disciplinary approach ensures that:

- Complex Interdependencies are understood, enabling targeted interventions.
- Stakeholder Engagement is meaningful, enhancing the social acceptability of conservation measures.
- Innovative Solutions are developed, tailored to the unique challenges and opportunities of each case study.

This approach not only addresses biodiversity loss but also fosters resilience and capacity building in coastal communities, aligning ecological goals with broader societal needs.

1.3.1. The SES Framework as a Basis for Operationalization

The Social-Ecological Systems Framework (SESF), grounded in the seminal work of Elinor Ostrom (Ostrom 2009, McGinnis/Ostrom 2014), serves as the foundational model for PRO-COAST. This framework is pivotal for understanding the intricate interactions between ecological, societal, and economic subsystems, particularly in coastal regions where these interdependencies are most



pronounced. The SES Framework provides a structured approach to dissecting the drivers and pressures that influence biodiversity loss, enabling a comprehensive analysis of these dynamics.

In operationalizing the framework, PRO-COAST integrates methodologies to extend its applicability, ensuring that social, economic, and cultural dimensions are adequately captured. This includes addressing cognitive, emotional, and societal factors such as inequality, intersectionality, and gender dynamics, which are critical to fostering resilience and transformative change within communities (Hancock 2016, Collins/Bilge 2016, Ergas/McKinney/Bell 2021, Erwin et al. 2021, Hamann et al. 2018, Castañeda Camey et al. 2021, Echavarren 2023).

To enhance stakeholder engagement and participatory practices, PRO-COAST also adopts citizen science (Serrano et al., 2014, Fraisl et al., 2022), including elements from the Bristol Approach (Balestrini et al., 2017) and the Extreme Citizen Science Framework (Chiaravalloti et al., 2022; Pocock et al., 2018), and the Behavioural Change Approach (Nienaber et al. 2023). The Bristol Approach complements the SES Framework by offering a participatory methodology tailored to local contexts, empowering communities to identify and address environmental challenges collaboratively. These methodologies ensure that the SES Framework remains dynamic and adaptable, facilitating its application in the ten diverse case studies of the project.

This integrated model not only strengthens the project's analytical rigor but also ensures that social-ecological systems are understood in a way that drives actionable solutions for biodiversity conservation in coastal areas.

1.3.2. Enriching the Socio-Ecological Systems Model through Sociological Theories

The Social-Ecological Systems (SES) Framework forms a central component of the PRO-COAST project, offering a robust tool to map interactions between ecological systems and societal structures. However, gaps in addressing key sociological dimensions, such as social inequalities, emotional, and cognitive factors, intersectionality, and gender dynamics, necessitate methodological enhancement to fully capture the complexity of coastal socio-ecological systems.

To address these gaps, the project integrates additional sociological theories that provide a deeper understanding of the human dimensions of biodiversity conservation. For instance, theories of intersectionality illuminate how overlapping social categories influence individuals' vulnerabilities to biodiversity loss (Ergas et al. 2021, Erwin et al. 2021), while concepts from emotional sociology and cognitive sciences explore how perceptions and emotional engagement drive participation in ecological restoration (Badri 2024, Kalwak/Weihgold 2022, Neckel/Hasenfratz 2021, Qiu/Qiu 2024).



Insights from the Research Design Workshop (Task 2.2 in WP2) further informed this enrichment process. During the workshop, participants identified critical deficiencies in existing theoretical models and deliberated on strategies to integrate sociological perspectives. These discussions underscored the importance of addressing the interconnectedness of ecological resilience with social dynamics, such as community trust, governance systems, and the role of social capital in enabling transformative change.

Moreover, the State-of-the-Art Report on Transformative Change and Biodiversity (Deliverable D2.1) highlighted the necessity of blending ecological indicators with social dimensions to create a truly interdisciplinary framework. For instance, the report emphasised that demographic diversity and social norms directly influence the effectiveness of participatory conservation efforts (Bronfan et al. 2015, Bravo-Monroy et al. 2016, Thaller et al. 2020, Dörge et al. 2022, Davison et al. 2023).

1.3.3. The Ecological Perspective on Biodiversity Loss in Coastal Regions and the Importance of Integrating Social Indicators

Biodiversity loss in coastal regions represents a critical challenge for ecosystems and human communities alike. Coastal ecosystems, such as wetlands, coral reefs, and estuaries, are among the most biologically productive areas on Earth, providing essential services including flood regulation, water purification, and support for fisheries. However, these ecosystems face increasing pressures from climate change, habitat destruction, pollution, and overexploitation, which threaten their stability and resilience.

Ecological Perspective

The ecological dimension of the PRO-COAST project focuses on understanding these drivers of biodiversity loss and their cascading effects on ecosystem services. Central to this perspective is the need to develop adaptive management strategies that respond to the dynamic interactions between ecological processes and human activities (Kenward et al., 2011). Conceptual tools like the Social-Ecological Systems framework (SESF) help operationalize this understanding by connecting biodiversity loss with socio-economic and cultural dynamics. Methodical and practical tools help to collect the data that is important for the analysis and transformation process.

Importance of Integrating Social Indicators

While ecological indicators (e.g., species richness, habitat coverage) are well-established in biodiversity research, they provide only a partial picture of the challenges at hand. Social indicators, such as perceptions of environmental justice, community resilience, and stakeholder attitudes toward conservation, are crucial for a comprehensive analysis. These indicators may help identify barriers to biodiversity protection, such as social inequalities or conflicting interests, and provide insights into how conservation measures can be better tailored to local contexts.



Integrating social indicators allows researchers to uncover how socio-economic structures and cultural values influence ecological outcomes. For instance, stakeholder willingness to engage in conservation efforts often depends on perceived fairness, access to resources, and trust in governance structures. By addressing these factors, PRO-COAST not only aims to mitigate biodiversity loss but also to create equitable and sustainable pathways for coastal ecosystem management.

2. RESEARCH PLAN – ANALYZING TRANSFORMATIVE COMMUNITIES BASED ON THE SESF MODEL

Operationalizing the Social-Ecological Systems Framework (SESF) in PRO-COAST involves a targeted, interdisciplinary process that adapts the framework to the project's diverse methodologies and tools. The process ensures that while not all variables are used in every tool, they are strategically selected based on the tool's specific focus and application, reflecting the project's diverse priorities. It also offers the possibility to work at both the case-specific level and across cases.

Indicator Identification:

Indicators are derived from the SESF and tailored to address the project's key research questions, such as the socio-economic and ecological interactions in coastal systems. The process draws on prior research, such as the State-of-the-Art Review (Task 2.1), and insights into ecological, social, and governance dynamics. Certain indicators focus on intersectionality, gender, and social inequities, while others emphasize ecological or economic factors.

Variable Development in Collaboration with WPs:

Selected indicators are refined into variables in collaboration with leaders and experts across the relevant Work Packages (WPs). For example, in the Stakeholder Survey, variables incorporate intersectionality to explore demographic, cognitive, and affective factors influencing biodiversity attitudes. Conversely, in tools with a stronger ecological emphasis, such as those for eDNA or local ecological knowledge, variables mainly focus on environmental data. This highlights how tool-specific priorities guide variable selection and operationalization.



Standardization

In order to work in a comparative case-study manner, the aim is to standardize the application of certain methods across all cases. For example, parts of the stakeholder survey are used in a standardized way across all case studies, while other parts of the survey are tailored to the specific case. It is not always possible to implement the principles of standardization in every case. Due to the case-specific implementation of the project, priority must also be given to the specific case situations. This iterative and transdisciplinary research process thus also involves the adaptation of case-specific modifications to standardized methodology, which can then be further developed through confrontation with real cases (Krohn 2008).

For a more detailed reflection on the current research process with regard to standardization in transdisciplinary, case-based projects, see section 3.7.

KPI Derivation and Validation:

Key Performance Indicators (KPIs) are identified during the analysis phase. KPIs aim to evaluate the impact of interventions and capture the socio-ecological transformations occurring within the case studies. The iterative development process ensures that KPIs are both context-sensitive and aligned with broader project goals. The KPIs are also used both case-specific and cross-case in their analysis. They consist of different variables primarily from three areas. For example, in the economic sector, indicators such as the increase in eco-tourism-related jobs or the number of sustainable buildings following biodiversity guidelines can be selected. In the ecological sector, depending on the case, indicators such as the reduction of marine pollution or the decrease in invasive species are applied. The socio-cultural sector analyzes indicators such as the number of local awareness campaigns or the number of biodiversity policies implemented.

Iterative Collaboration and the Role of Task 2.2:

Task 2.2 anchors this collaborative effort, involving multiple partners, including FredU, UoC, CAR, CU, UniSal, UiB, CN, and IBE. These partners contribute their expertise to refine indicators and validate their relevance across the case studies. Coordination is achieved through workshops and structured consultations, ensuring that the SESF is effectively operationalized while remaining adaptable to varying local conditions.

Tool-Specific Applications:

Not all variables are applied across all tools, as their focus and scope vary significantly. For example, the Stakeholder Survey integrates intersectionality and inequality as a core component, reflecting the influence of gender, education and economic situation on biodiversity perceptions. In contrast, tools like eDNA sampling or local ecological knowledge mapping prioritize ecological and environmental data, with minimal



overlap into socio-cultural dimensions. This differentiation ensures that each tool maximizes its effectiveness in addressing its specific research objectives.

Research Design Workshop and Methodological Refinements:

The Research Design Workshop under Task 2.2 played a pivotal role in aligning methodologies across partners. It addressed gaps in the SESF's application to the project's tools and fostered a shared understanding of priorities. This collaborative effort ensures that the operationalized framework balances ecological and social perspectives while maintaining scalability.

By incorporating diverse disciplinary insights and focusing on the specific needs of each tool, PRO-COAST ensures that the SESF is operationalized to capture the complexities of coastal socio-ecological systems. The resulting KPIs provide actionable insights into managing and restoring biodiversity while addressing social and economic challenges in coastal regions.

3. MULTI-METHOD AND CASE-SPECIFIC APPROACH – CONCEPTS, METHODS, TOOLS AND APPLICATIONS

A multi-method approach in a transdisciplinary project refers to the integration of different research methods and techniques aimed at addressing complex, real-world problems that extend beyond traditional disciplinary boundaries (Angelstam et al., 2013; Giugliani, 2023; Breda et al., 2016). Transdisciplinary research is characterized by the combination of academic and non-academic knowledge, the active involvement of diverse stakeholders, and the collaborative creation of solutions (Archibald et al., 2023; Giugliani, 2023; O'Donovan et al., 2020).

One of the central elements of a multi-method approach in such projects is the integration of various disciplinary perspectives. Transdisciplinary research brings together researchers from a range of academic fields, as well as practitioners and stakeholders outside academia, to tackle a shared problem (Angelstam et al., 2013; Giugliani, 2023; O'Donovan et al., 2020). This integration is essential for forming a comprehensive understanding of the issue and for generating innovative solutions (Breda et al., 2016;



O'Donovan et al., 2020). Another key feature is the use of a variety of research methods, which may include both qualitative and quantitative approaches such as interviews, focus groups, surveys, modeling, and experiments (Archibald et al., 2023; Koier & Horlings, 2014; Giugliani, 2023). By combining these methods, researchers can gain a more holistic and nuanced understanding of the problem (Koier & Horlings, 2014; Giugliani, 2023; Breda et al., 2016). Furthermore, transdisciplinary research emphasizes the continuous engagement of stakeholders throughout the research process. These stakeholders - ranging from policymakers to community members and industry representatives - are involved in defining the problem, collecting data, and developing and implementing solutions (Breda et al., 2016; O'Donovan et al., 2020; Elder et al., 2014). This active participation ensures that the research remains relevant and responsive to the needs of the target population (Giugliani, 2023; O'Donovan et al., 2020; Hoffmann et al., 2019). A multi-method approach also promotes the integration and co-creation of knowledge. It facilitates the combination of academic and non-academic knowledge, fostering the creation of new knowledge and solutions that transcend traditional disciplinary boundaries (Archibald et al., 2023; Giugliani, 2023; Gustafsson et al., 2016). This process is crucial for addressing the complex challenges of real-world problems (Breda et al., 2016; O'Donovan et al., 2020; Klein, 2020). Finally, transdisciplinary research requires a reflexive and adaptive approach, as researchers and stakeholders must navigate the challenges of working across multiple disciplines and sectors (Breda et al., 2016; Elder et al., 2014; Klein, 2020). The multi-method approach supports this reflexivity by enabling continuous evaluation and adjustments to the research process (Scholz & Steiner, 2015; Hoffmann et al., 2019).

In summary, a multi-method approach in transdisciplinary projects combines diverse disciplinary perspectives, utilizes a range of research methods, ensures active stakeholder engagement, fosters co-creation of knowledge, and supports a reflective and adaptive process. This holistic, collaborative approach is essential for addressing complex, real-world problems that cannot be solved by a single discipline or sector alone. In addition to applying various methods and methodically linking the different disciplinary perspectives, both case-specific and case-comparative approaches are used. Some of the methods are specifically tailored to the circumstances of the respective case under investigation, while other methods aim to establish comparability between the cases.

Below, we will briefly present the concepts, methods, tools and applications we have used so far. Methodologically, the project is unified both through common concepts and standardizations across the various cases and through continuous measurements at multiple time points, which are intended to track changes over time.

The following chapter is further subdivided. The first section covers communication, focusing both on internal project communication and communication within and with the case studies. A second section addresses conceptual methodology, which is closely tied to the SESF base model. In the third section, we discuss the methods and tools predominantly used in the social sciences. The fourth section focuses on the ecological methods, tools, and applications used in the case studies. The final section presents an



interdisciplinary application that is developed and tested during the course of the project. An appendix also contains a synthesis of all the tools used, with a reference to how these can be utilized by both scientists and non-scientists (table A1 in the appendix).

We only describe the tools that we use within the project and that go beyond standard software. The description follows a consistent format. In addition to the name and category of the tool, there is a detailed description and the goal of the respective method or application. There are also details about the time required, the number of study objects, the data format, and the foundational literature. Furthermore, additional links are provided, along with a contact person who is available for further questions within the Pro-Coast project.

3.1. Communication

In a project consisting of 10 case studies and 7 working groups at various European universities and institutions, communication is essential. For joint communication, there are both regular online meetings and in-person meetings, as well as joint site visits to the case studies. Shared storage space and content exchange primarily take place through standard programs in everyday research activities. The main focus is on availability and accessibility in all countries involved in the project.

The standard programs we use include:

1. Microsoft Word, Powerpoint
2. Google communication tools (e.g. GoogleGroups)
3. Doodlepoll
4. Mail chimp
5. Zoom
6. Wikipedia (editing)

Additionally, two other tools are used for both communication of the project contents and for communication with the case studies in the form of forums.

3.1.1. MORPHmaster (Multilingual Online Restoration Project Hosting)

CATEGORY:

Socio-cultural

PURPOSE OF THE METHOD:

MORPHmaster is proprietary software developed by Anatrack Ltd for ease of translating multilingual content by volunteers with minimal training



DESCRIPTION:

A back-office for administrators handles users and translation (currently 54 languages) of objects which can be text, language-specific images or culture-specific links to as many single-language sites (in the System for Community Liaison) as required for language-regions that a user can select to reflect their geographic location. The system is constrained to non-commercial use by a license with not-for-profit third parties who manage the networks. The first instance, a stand-alone site, <https://www.naturalliance.eu>, is described in Chapter 20 of Kenward et al. 2013).

EFFORT IN TIME:

A 1-page tutorial (mostly an image of the translation screen). Ease of use is 4-5/5.

NUMBER OF OBJECTS INVESTIGATED:

Each of the current 5 multilingual networks has its own internet domain.

DATA FORMAT:

HTML, also proprietary code, in SQL databases.

BASIC LITERATURE:

Kenward, R.E., Papathanasiou, J., Arampatzis, E. & Manos, B.A. (eds) (2013). Transactional Environmental Support System Design: Global Solutions. IGI-Global, Hershey, Pennsylvania, USA. <https://doi.org/10.4018/978-1-4666-2824-3>

CONTACT PERSON WITHIN PRO-COAST:

Robert Kenward, reke@ceh.ac.uk, Pro-Coast Coordination

Nick Casey, nick@anatrack.com, software engineer

LINKED MATERIAL:

The current networks are:

<https://www.sakernet.org> (2015)

<https://www.perdixnet.org> (2017)

<https://www.falconet.org> (2018)

<https://www.naturalliance.org> (2019)

<https://www.pro-coast.eu> (2024) this instance is the hub for the Community Sustainability Platform

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<https://doi.org/10.5281/zenodo.14771321>



3.1.2. System for Community Liaison

CATEGORY:

Socio-cultural

PURPOSE OF THE METHOD:

System for Community Liaison (SYCL) is a proprietary software developed by Anatrack Ltd, used by administrators to create and manage networks of inter-linked websites, on which content creation is simplified for volunteers with minimal training.

EFFORT IN TIME:

Can be used within an hour of tutorial use and competently with a 1-day course. Ease of use is 3-4/5.

NUMBER OF OBJECTS INVESTIGATED:

No limits – currently 114 instances are operative.

DATA FORMAT:

HTML, also proprietary code, in SQL databases

DESCRIPTION:

A back-office for administrators handles users, translation (currently 15 languages), websites and pages which can occur in one language across many sites. Individual sites can support registration, forums, image galleries, maps with routes, and a variety of page and site formats. Content is written by site editors, who may also have publisher rights, on WYSIWYG editors that convert to HTML. The system is constrained to non-commercial use by a licence with not-for-profit third parties who manage the networks.

BASIC LITERATURE:

There is a tutorial site at: <https://sycl-uk.sycl.net/1/getting-started-with-sycl>

CONTACT PERSON WITHIN PRO-COAST:

Robert Kenward, reke@ceh.ac.uk, Pro-Coast Coordination

Nick Casey, nick@anatrack.com, software engineer

LINKED MATERIAL:

The system links to Morphmaster to create networks at, e.g.,



<https://www.pro-coast.eu> on which many instances host the Community Sustainability Platform
<https://www.naturalliance.org> which hosts >50 global instances in >40 languages for IUCN
but also runs many stand-alone websites, e.g.,
<https://esug.sycl.net>
<https://arne-parish-council.sycl.net/1/arne-parish>

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<https://doi.org/10.5281/zenodo.14771502>

Within the case studies, there is an additional tool used for communication with the local population, primarily for knowledge transfer and participation.

3.1.3. Instorier

CATEGORY:

Socio-cultural

PURPOSE OF THE METHOD:

It is a storytelling tool, which allows an engaging dissemination of the background and aims of the case study for the public.

DESCRIPTION:

Instorier is a digital storytelling tool which can be used by people without graphical or coding background. It is a user-friendly tool which creates powerful visual outputs. It is possible to include maps and interactive formats within the stories.

EFFORT IN TIME:

Depending on the complexity of the story it requires between 4- 15 hours of work to create a story.

NUMBER OF OBJECTS INVESTIGATED:

n/a

DATA FORMAT:

textual, images, videos, maps



BASIC LITERATURE:

Time to learn. Instorier. <https://instorier.com/learn>

CONTACT PERSON WITHIN PRO-COAST:

David Herbert, David.herbert@uib.no , Leader Case Study Bergen

Instorier is currently being developed for collaborative education and scientific communication use through a pilot project at the University of Bergen. If you join the pilot by 30 June 2025, you will be eligible for free lifetime basic use of the tool. Please contact David at the mail above if you wish to participate or for further information.

LINKED MATERIAL:

Most helpful resources:

<https://www.youtube.com/watch?v=jVU3sv-Pzw4> (this is a really short (1 minute) introduction to making a story)

<https://www.youtube.com/watch?v=Zdly83F7VbI> (this is a 6-minute introduction to the editing tools)

<https://www.youtube.com/watch?v=WUWnBPViPt8> (this is an 8-minute guide to creating 3D scenes)

Comprehensive list of tutorials provided by Instorier: <https://instorier.com/learn>

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<https://doi.org/10.5281/zenodo.14771580>

3.2. Conceptual methodology

Closely linked to communication is the fundamental conceptual methodology, which focuses on the focal action situation of each case study and works on the development of communication and collaboration.

3.2.1. Three-Fold Engagement Strategy for Behavioural Change in Biodiversity Conservation

CATEGORY OF DATA:

Economic/Socio-cultural/Environmental/Spatial



PURPOSE OF THE METHOD:

The Three-Fold Engagement Strategy for Behavioural Change in Biodiversity Conservation is designed to facilitate effective communication and collaboration between change agents and stakeholders in biodiversity conservation initiatives. Its primary goal is to foster transformative behavioural change in communities to address biodiversity loss, particularly in coastal ecosystems.

The tool measures and analyses the following key aspects:

1. *Stakeholder Engagement: It tracks the level of involvement and collaboration among stakeholders, ensuring inclusivity and addressing barriers to effective participation.*
2. *Behavioural Change: It assesses progress towards fostering sustainable practices and addressing resistance within communities.*
3. *Knowledge Exchange: It evaluates the effectiveness of workshops and interactions in sharing best practices and empowering change agents.*
4. *Governance and Management: It provides insights into the effectiveness of biodiversity management practices, governance structures, and the implementation of local biodiversity programs.*

The tool is applied in the context of biodiversity conservation projects, particularly those targeting coastal ecosystems, aiming to integrate a wide range of stakeholders, foster engagement, and promote long-term behavioural change. The strategy is implemented through structured communication, workshops, and training sessions.

DESCRIPTION:

The Three-Fold Engagement Strategy is a comprehensive tool designed to support and measure the effectiveness of behavioral change processes aimed at reducing biodiversity loss within coastal ecosystems. It works through a structured framework that includes monthly meetings, regular email communications, and a series of workshops to engage local change agents, stakeholders, and communities. The tool focuses on fostering collaboration, knowledge exchange, and the development of trust among all parties involved in biodiversity conservation efforts.

How It Works:

1. *Monthly or bi-monthly Meetings: These meetings involve potential key stakeholders and change agents of each case study individually (WP 6 plus change agents) who discuss themes related to governance, stakeholder awareness, barriers to change, and specific biodiversity issues. The goal is to align strategies and ensure continuous progress.*
2. *Open forums: Regular communication through emails and hosting on SYCL sites facilitates ongoing support, problem-solving, and the sharing of updates between the change agents and the project team. And the use of an online platform to create a space for community learning to build long-term capacity (can last over the duration of the project).*
3. *Workshops: Four workshops are planned throughout the project to focus on key themes such as building change champions, implementing local biodiversity programs, fostering knowledge*



exchange, and refining strategies. These workshops are designed to build skills, share best practices, and address challenges.

EFFORT IN TIME:

The Three-Fold Engagement Strategy for Behavioural Change in Biodiversity Conservation is designed for long-term implementation, with results becoming visible over an extended period of time. Based on the outlined activities, here is an estimated timeline:

1. Short-Term (0-18 months):

- Initial engagement and collaboration efforts, including monthly meetings, workshops, and training sessions for change agents, will focus on building awareness, developing partnerships, and addressing resistance.*
- Results Available: Initial results, such as stakeholder involvement, awareness levels, and early signs of behavioural change, may be observed within the first 18 months. However, these will likely be preliminary.*

2. Mid-Term (18-24 months):

- Workshops and knowledge exchange activities will continue, with a focus on local biodiversity programs and the refinement of strategies based on initial feedback.*
- Results Available: By the 24-month mark, more concrete results such as successful implementation of biodiversity programs and deeper collaboration among stakeholders should become evident. The effectiveness of the strategies in reducing resistance and fostering positive behaviours can be better measured. By this stage a Community Sustainability Platform will have been constructed for use in case studies.*

3. Long-Term (24-36 months):

- Ongoing activities will aim to reinforce the changes and address any remaining barriers, ensuring that the transformation is sustained over time. Continuous evaluations and adjustments will be made to ensure long-term success.*
- Results Available: By the end of the project (around 36 months), substantial and measurable results should be achieved in terms of sustainable practices adopted by the community, the successful implementation of biodiversity conservation programs, and the establishment of a long-lasting impact on the local ecosystem. By this stage the Community Sustainability Platform should have started testing for scale-out.*

In summary, the method will take around 3 years for results to be available, with incremental progress visible at various stages throughout the timeline. However long-term results are only available after a significant period of time. i.e., that exceeds 3 years, through continued monitoring via the Community Sustainability Platform.

NUMBER OF OBJECTS INVESTIGATED:

For the Three-Fold Engagement Strategy for Behavioral Change in Biodiversity Conservation, the number of objects or measurements will depend on the specific activities being monitored and evaluated throughout the process. Here's an estimation:

Monthly Meetings and Communication



- *Objects/Measurements: Number of meetings held, number of participants, topics discussed, and feedback from change agents and stakeholders.*
- *Estimated Count:*
 - *Meetings: regular meetings over 3 years around 20 in total*
 - *Topics: 8-10 main themes covered throughout the project.*
- *Workshops (4 in total)*
- *Objects/Measurements: Number of workshops, attendees, feedback on the effectiveness of the workshops, and knowledge exchange.*
- *Estimated Count:*
 - *Workshops: 4 workshops (at months 18, 21, 24, and 27)*
 - *Feedback: Evaluation forms and participation surveys from attendees after each workshop.*

Behavioural Change and Biodiversity Impact

Objects/Measurements: Changes in behaviour of community members, adoption of sustainability practices, and environmental impacts (e.g., biodiversity conservation efforts).

Estimated Count:

Behavioural Metrics: 5-10 measurable behaviours related to biodiversity conservation and sustainability. e.g. positive emotions (scale 1-5) or trustworthiness of a stakeholder partner (1-5)

Impact Metrics: 3-5 key indicators (such as biodiversity index, community participation, etc.) assessed at baseline and during follow-ups.

Training Sessions for Change Agents

- *Objects/Measurements: Number of training sessions, participant feedback, and skills acquired.*
- *Estimated Count:*
 - *Training Sessions: 1 training session (pre-workshop)*
 - *Feedback: Post-training evaluations from each participant.*

Total Estimated Objects/Measurements:

- *Meetings: 24 meetings, approximately 2-5 participants per meeting, 8-10 themes.*
- *Workshops: 4 workshops, approximately 10-15 participants per workshop, and feedback collected.*
- *Behavioural Change Metrics: 5-10 behaviour-related measurements (e.g. identified behaviours of each stakeholder group (that the change agents engage with to drive change) of a scale from 1-5 to see whether behaviours changed over the duration of the project or trustworthiness of the stakeholder partner (scale 1-5) that will be hopefully increase over the time of the project, 3-5 impact metrics assessed at different stages.*
- *Training: 1 session with 10-20 participants and feedback collected.*

This leads to an estimated 100+ data points based on participant numbers, feedback, and measurable outcomes across the three years of the project.

DATA FORMAT:

All, textual as protocols, focus groups in the workshops, interviews during the workshops, co-creative methodologies lead to workshop material; visual materials: Used for the workshops, training, or community events, Action plans and progress reports: Documentation of strategies, adjustments, and evaluations throughout the project.



BASIC LITERATURE:

Nienaber, A. M., Spundflasch, S., & Soares, A. E. (2023). Behavioural Change in Local Authorities to Increase Organisational Capacity. In *Capacity Building in Local Authorities for Sustainable Transport Planning* (pp. 81-98). Singapore: Springer Nature Singapore.

CONTACT PERSON WITHIN PRO-COAST:

Prof. Dr. Ann-Marie Nienaber, ann-marie.nienaber@coventry.ac.uk

LINKED MATERIAL:

D 6.1 in PRO-COAST

Nienaber, A. M., Spundflasch, S., & Soares, A. E. (2023). Behavioural Change in Local Authorities to Increase Organisational Capacity. In *Capacity Building in Local Authorities for Sustainable Transport Planning* (pp. 81-98). Singapore: Springer Nature Singapore.

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3.2.2. Eight-Step Framework for Sustainable Change: A Behavioural Transformation Approach

Behavioural change approach: In line with PRO-COAST's overall objective to increase capacity and resilience within the transformative communities a change process has to be initiated, taking into account technical and social capacity. While the technical side of the change comprises new technologies and services regarding biodiversity, the social side of the change focuses on the human's openness and readiness for change.

Our design of the behavioural change approach is built on the work of Nienaber and colleagues (2019; 2020; 2023) during the EU-Horizon project SUITS. This model is very transparent, clearly structured and practically oriented. Above all, it can be easily communicated to different change actors, facilitating the creation of shared meaning and ultimately contributing to the effectiveness of the change programme. The eight steps of the model are outlined below before discussing how this was used in the project.

- Step One: Create urgency. First of all, a sense of urgency has to be created amongst humans within the transformative communities. This step creates the 'need' for change, as opposed to a 'want' for change. This might differ across case studies, as in some cases, the sense of urgency already exists within communities.



- Step Two: Form a powerful coalition (team). A strong, proactive and influential coalition needs to be built from humans with a range of skills and experiences, across the different areas and departments involved in biodiversity/conservation planning to drive and support the change process. The team itself needs to be a role model for others, helping to spread messages throughout the transformative community, delegating tasks and ensuring support for the change community-wide. Key to this is the appointment of an influential and widely respected change agent, who has the backing of, and ability to influence, senior managers.
- Step Three: Create a vision for change. An inspirational, far reaching and comprehensible vision should be jointly developed by those immediately concerned with the change. It should be supported by the whole transformative network.
- Step Four: Communicate the vision. A vision that is developed but not communicated will not be known. Thus, the vision should be communicated throughout the whole transformative network and understood by its humans. It should be continuously communicated in different ways in order to rise above competing messages in the whole community.
- Step Five: Empowering broad-based action. Empowering humans requires active listening, investing in them through training, and making them responsible for major accomplishments. Empowerment contributes to increased levels of human engagement, and more specifically in their engagement in the change process, which is important in guaranteeing success. To increase human empowerment existing obstacles such as organisational structures, skills deficits, systems and stakeholders must be addressed.
- Step Six: Create short-term wins. Behavioural change needs time, and few rewards may be visible at the start of the process. Therefore, it is most important to create opportunities for quick wins and the celebration of these to keep partners motivated to support ongoing processes. Shorter-term targets are useful tools for motivation and direction. Using these wins to justify investment and effort can help to re-motivate people to continue backing the change.
- Step Seven: Build on the change. Many change programs fail because they lack an end point, continuation plans, or are not self-reflective. Change is a continual process in which, in this case, transformative communities should keep setting goals and analyzing what could be done better for continued improvement.
- Step Eight: Anchor the changes in corporate culture. For a change to be sustainable and successful it needs to be anchored in the transformative communities' culture. The changes, and the need to evolve, must become part of the core way of behaviour to have a lasting effect



CATEGORY:

Economic/Socio-cultural/Environmental/Spatial

PURPOSE OF THE METHOD:

The tool is designed to guide and measure the process of behavioral change, specifically focusing on shifts within local communities to promote actions that reduce the risk of biodiversity loss. It analyzes the steps required to create and sustain long-term change in behaviors that support biodiversity conservation. The tool applies to communities involved in biodiversity protection, providing a structured framework to assess and manage the implementation of conservation measures, from creating urgency to anchoring changes in corporate culture. It measures progress at each stage of the behavioral change process, ensuring that the transition is effective, inclusive, and sustainable.

DESCRIPTION:

This tool is designed to track and evaluate the behavioral change process aimed at reducing biodiversity loss within communities. It operates by gathering both qualitative and quantitative data from community members, stakeholders, and activities implemented to foster sustainable practices. The tool works through a structured framework that spans several stages of the behavioral change process, including creating urgency, forming coalitions, developing and communicating a vision, and assessing ongoing efforts.

Variables Measured:

- *Awareness and Understanding: Measures how well the community understands the importance of biodiversity and the need for change.*
- *Values: We measure values to understand the guiding principles and priorities that shape how the community approaches sustainability and biodiversity conservation.*
- *Emotions: We assess emotions to gauge the community's feelings and emotional responses, which influence their motivation and engagement with sustainable practices.*
- *Community Engagement: Tracks the level of community participation in activities aimed at reducing biodiversity loss.*
- *Behavioural Change: Quantifies the adoption of new, sustainable behaviours within the community.*
- *Barriers and Enablers: Identifies obstacles that hinder or factors that facilitate change (e.g., cultural, economic, or institutional).*
- *Satisfaction and Motivation: Assesses how motivated and satisfied the community is with the ongoing change process.*
- *Impact on Biodiversity: Measures changes in local biodiversity, such as improvement in species diversity, habitat restoration, or reduced harmful practices.*

How the Results Are Interpreted:

- *Quantitative Data: Results from surveys, participation rates, and behavioural changes are analysed to identify trends over time. Increases in sustainable behaviours or positive environmental outcomes indicate progress.*



- *Qualitative Data: Feedback and insights gathered from interviews or focus groups provide context for understanding barriers, motivations, and the overall experience of change. This data can highlight areas needing improvement or successful strategies that can be scaled.*
- *Impact Assessment: The tool combines community-level data with biodiversity indicators to gauge the overall success of the intervention in reducing biodiversity loss.*

By comparing initial baselines to results over time, the tool provides insights into the effectiveness of the change process and helps identify adjustments needed to achieve long-term sustainability goals.

EFFORT IN TIME:

The overall time frame for this method is typically 3 years. While the initial stages of planning, vision creation, and identifying barriers can be completed within the first 12 months, it usually takes around 2 further years for the community to reach a point where short-term wins and deeper changes begin to take hold (Nienaber et al., 2019; 2020; 2023). While change requires time, the three-year period is crucial for laying the groundwork to establish long-lasting behavioral shifts, ultimately leading to a significant and sustained impact in the future. Sustainable change and social transformation inherently mean creating something enduring for the future, ensuring progress that benefits generations to come.

After three years, communities should have successfully navigated through the key stages, such as creating urgency, empowering action, and celebrating short-term wins. By this time, the focus will shift to anchoring the changes and ensuring they become part of the community's culture for lasting impact. Therefore, the entire process, including long-term sustainability, may take up to 3 years or longer, with continuous monitoring and adjustments beyond this period to maintain progress. This is a normal and necessary aspect of achieving lasting change, as initiatives designed to endure must be revisited and institutionalized over time. While change requires time, the three-year period is crucial for laying the groundwork to establish long-lasting behavioural shifts, ultimately leading to a significant and sustained impact in the future.

NUMBER OF OBJECTS INVESTIGATED:

In relation to the change process, the number of objects or measurements will depend on the specific stages of the process being implemented and the scope of the change being measured. For instance:

- *Number of communities involved: If multiple communities are part of the process, this could range from a few to several hundred depending on the size of the program.*
- *Measurements of change: This would involve quantifying various aspects of the change process, such as:*
 - *The number of initiatives launched (e.g., community projects to reduce biodiversity loss)*
 - *The number of individuals or community members actively participating in these initiatives*
 - *Short-term wins measured (e.g., successful pilot programs or positive feedback from community members)*
- *Number of barriers identified and removed (e.g., physical, social, or policy-related obstacles)*



- *Changes in community knowledge, attitudes, and behaviours regarding biodiversity conservation (measured through surveys or interviews)*

Timepoints of measurement: Assessments could take place at several stages throughout the process (e.g., baseline, mid-point, end-point), which would result in multiple rounds of data collection for tracking progress.

Data points per measurement: Each community could provide multiple data points depending on the variables measured, such as behavioral changes, participation levels, and feedback on interventions.

So, the number of objects or measurements would likely be in the range of several hundred to thousands, depending on the number of communities and individuals involved, and the specific metrics being tracked at each stage.

DATA FORMAT:

The data collected in relation to the behavioral change process will be in the following formats:

Numerical: Quantitative data on participation rates, number of initiatives launched, and measurements of behavioral change (e.g., reduction in activities harmful to biodiversity).

Ratings or scores from surveys measuring attitudes or satisfaction with the process or changes implemented.

Qualitative: Feedback and insights from community members, stakeholders, or experts through interviews, focus groups, and open-ended survey responses. Descriptions of barriers encountered and strategies for overcoming them, as well as detailed feedback on what has worked or not worked in the process.

Textual: Written reports, logs, or documentation of activities and initiatives. Narrative data from case studies, success stories, or challenges in the change process.

Images: Photographs or videos documenting the change process, community involvement, or changes in the environment as a result of the interventions (e.g., habitat restoration efforts, community activities).

This mixed-methods approach will allow for a comprehensive understanding of both the quantitative impact and qualitative experiences within the behavioural change process.

BASIC LITERATURE:

John P. Kotter: *Leading Change: Why Transformation Efforts Fail*. In: *Harvard Business Review*. Band 2, Reprint 95204, 1995, S. 59–67

Nienaber, A. M., Spundflasch, S., & Soares, A. E. (2023). Behavioural Change in Local Authorities to Increase Organisational Capacity. In *Capacity Building in Local Authorities for Sustainable Transport Planning* (pp. 81-98). Singapore: Springer Nature Singapore.

Nienaber, A. M., Soares, A., & Woodcock, A. (2020, July). Implementation of organisational change: Design of an 8-step organizational change process for local authorities. In DIS 2020 workshop 'Making Civic Initiatives Last'.



Nienaber, A., Spundflasch, S., & Soares, A. (2019). Sustainable Urban Mobility in Europe: Implementation needs behavioural change. SUITS Policy brief 3. [SUITS funded from the European Union's Horizon 2020 research and innovation programme under grant agreement no 690650. Mobility and Transport Research Centre, Coventry University]

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3.3. Social Science methods and tools

The aim of the methods used in the social sciences is to gain a comprehensive understanding of human behavior, social interactions, and the complex dynamics of social systems. Social science research employs a multi-method approach to address the inherent complexities and contextual factors that influence social phenomena (Angelstam et al., 2013; Giugliani, 2023; Breda et al., 2016).

As described above social science research utilizes a combination of qualitative methods, such as interviews, focus groups, and ethnographic observations, as well as quantitative methods, such as surveys, experiments, and statistical analyses, to capture the nuances and complexities of human behavior and social interactions (Giugliani, 2023; Breda et al., 2016; Elder et al., 2014).

3.3.1. Qualitative and quantitative methods and evaluation procedures

Qualitative Methods

Qualitative methods aim to achieve a deep understanding of phenomena and social processes, particularly within their specific context. They focus on the subjective experiences and meanings of individuals or groups and are especially useful for capturing complex, multi-dimensional issues. In contrast to quantitative methods, qualitative approaches work with non-numerical data, such as interviews, observations, or texts. These data are typically collected through open and flexible methods, allowing researchers to respond to new discoveries and emerging themes during the research process. The analysis of qualitative data is inductive, meaning that patterns and themes are derived from the collected data to gain deeper insights into the social phenomena being studied. Qualitative methods are particularly suited for answering questions related to the "how" and "why" of events and experiences, providing a detailed and contextualized view of the topics under investigation. Qualitative methods, however, entirely reflect the interpretation of the observer and lack comparability as well as estimates of probability (uncertainty), which is why they are primarily used for in-depth interpretation of quantitative results or as exploratory pilot studies.



Integration in Case Studies:

In the case studies, qualitative methods play a central role in identifying stakeholder dynamics and relationships. Participatory approaches, through interviews, workshops, and focus groups, ensure the inclusion of diverse perspectives, and network analysis is applied to visualize connections and the intensity of relationships among stakeholders. The choice of analysis method is determined by the research question, and the results provide critical insights into the structures and processes within social and ecological systems.

Common Qualitative Analysis Methods:

- Content Analysis: Identifies and interprets patterns or themes within the data, useful for structuring large textual datasets (Mahl/Guenther 2023, Knott et al. 2019, Okoko et al. 2023).
- Thematic Analysis: Focuses on recurring themes, emphasizing subjective meanings and contextual understanding (Taylor 2015, Okoko et al. 2023).
- Grounded Theory: Develops theories inductively from the data without pre-existing assumptions (Ge et al. 2024, Okoko et al. 2023).
- Discourse Analysis: Examines language to uncover how it constructs social realities and power dynamics (Gee 2014, Okoko et al. 2023).
- Narrative Analysis: Explores stories and narratives to understand how individuals structure and make sense of their experiences (Kutsyuruba/Stasel 2023).
- Case Study Analysis: Provides detailed insights into a single case or small set of cases, often used for exploring specific phenomena (Ndame 2023).
- Field Note and Visual Analysis: Analyses observational notes or visual data such as photographs and videos to uncover non-verbal dimensions (Phillippi/Lauderdale 2018).
- Conversation Analysis: Investigates the structure and flow of conversations, focusing on interactional dynamics (Schegloff 2017).

Analytical Processes:

- Coding and Categorization: A core step in qualitative analysis, where data are segmented into themes, categories, or theoretical constructs, such as selective or axial codes (Flick, 2018). This step aims to reveal structures and relationships within the data and, done objectively, can permit quantitative analyses where sample sizes are adequate.
- Qualitative Content Analysis (Mayring, 2022): Structures material based on existing theoretical frameworks, refining, or expanding them through iterative analysis.
- Discourse or Media Analysis: Analyses media content or conversations to explore societal influences or power relationships.
- Network Analysis: Examines relationships between actors (individuals or groups) to identify strong or weak ties and patterns of interaction within stakeholder networks. Stakeholder maps are often



created through participatory discussions. Both qualitative and quantitative methods can be employed here.

Software Tools for Qualitative Analysis:

Qualitative data analysis is often supported by specialized software tools, which streamline the organization, coding, and interpretation of data. Commonly used software includes:

- Atlas.ti (<https://atlasti.com/>): A versatile tool for qualitative data analysis, allowing for advanced coding, visualizations, and network mapping (Archer et al. 2017).
- MAXQDA (<https://www.maxqda.com/>): Widely used for organizing and analyzing qualitative and mixed-methods data, with features for coding, text analysis, and visual representation (Kuckartz/Rädiker 2019).
- NVivo (<https://lumivero.com/>): Offers robust functionalities for managing and analyzing text, audio, and visual data, with tools for thematic analysis and data visualization (Bazeley 2007).
- Dedoose (<https://www.dedoose.com/>): Designed for qualitative and mixed-methods research, emphasizing collaborative work and accessibility (Salmona et al. 2019).

These tools enhance the efficiency and accuracy of qualitative analysis by providing structured workflows and visualization capabilities, enabling researchers to uncover deeper insights.

Recommended Literature:

- Flick, U. (2018). *An introduction to qualitative research* (6th edition). SAGE. <https://us.sagepub.com/en-us/nam/an-introduction-to-qualitative-research/book278983>
- Ge, W., Du, J., & Ali, K. (2024). An Exploratory Grounded Theory Approach: Unveiling the Impact Mechanism Model of Collaborative Dynamics between Green Production and Living. *Sustainability*, 16(8), 3352. <https://doi.org/10.3390/su16083352>
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Analysis in Communication Research. Springer VS, Wiesbaden. https://doi.org/10.1007/978-3-658-36179-2_18

Mayring, P. (2022). *Qualitative Inhaltsanalyse: Grundlagen und Techniken* (13. Neuausgabe). Julius Beltz GmbH & Co. KG. <http://nbn-resolving.org/urn:nbn:de:bsz:31-epflicht-2019387>

Ndame, T. (2023). Case Study. In: Okoko, J.M., Tunison, S., Walker, K.D. (eds) *Varieties of Qualitative Research Methods*. Springer Texts in Education. Springer, Cham. https://doi.org/10.1007/978-3-031-04394-9_11

Okoko, J. M., Tunison, S., & Walker, K. D. (Eds.). (2023). *Varieties of qualitative research methods: Selected contextual perspectives*. Springer Cham. <https://doi.org/10.1007/978-3-031-04394-9>

Phillippi, J., & Lauderdale, J. (2018). A guide to field notes for qualitative research: Context and conversation. *Qualitative Health Research*, 28(3), 381–388. <https://doi.org/10.1177/1049732317697102>

Schegloff, E. A. (2017). Conversation analysis. In Y. Huang (Ed.), *The Oxford handbook of pragmatics* (online edn). Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780199697960.013.26>

Software References:

Archer, E., Janse van Vuuren, H. H., & Van der Walt, H. D. (2017). Basic operations, tips and tricks for coding: Introduction to ATLAS.ti (6th ed.). Research Rescue. <https://uir.unisa.ac.za/bitstream/handle/10500/23000/Atlas%20manual%206th%20Edition%20PDF.pdf?sequence=1>

Bazeley, P. (2007). *Qualitative data analysis with NVivo*. SAGE. <http://www.loc.gov/catdir/enhancements/fy0728/2006936346-d.html>

Kuckartz, U., & Rädiker, S. (2019). *Analyzing qualitative data with MAXQDA: Text, audio, and video*. Springer Cham. <https://doi.org/10.1007/978-3-030-15671-8>

Lewins, A., & Silver, C. (2014). *Using software in qualitative research: A step-by-step guide* (2. ed.). SAGE.

Salmona, M., Lieber, E., & Kaczynski, D. (2019). *Qualitative and mixed methods data analysis using Dedoose: A practical approach for research across the social sciences*. SAGE Publications, Inc.

Quantitative methods

In the social sciences, various quantitative analysis methods are used depending on the research question and data type. The following methods represent essential techniques for analysing social phenomena:

- Descriptive Statistics: Summarizes and describes the basic features of a dataset (e.g., mean, median, standard deviation).
Software: SPSS, R, Stata.
- Correlation Analysis: Measures the strength and direction of relationships between variables.
Software: Python (NumPy, SciPy), R.
- Regression Analysis: Examines how independent variables influence a dependent variable (e.g., linear regression, logistic regression).
Software: Stata, R, Python (statsmodels, sklearn).



- Analysis of Variance (ANOVA): Tests for differences between group means.
Software: SPSS, SAS, R.
- Chi-Square Test: Investigates associations between categorical variables.
Software: SPSS, Excel, R.
- Factor Analysis: Reduces a large number of variables into underlying latent dimensions.
Software: Mplus, R (psych package), SPSS.
- Structural Equation Modelling (SEM): Tests relationships between observed and latent variables using simultaneous regression models.
Software: Mplus, AMOS, R (lavaan package).
- Cluster Analysis: Groups data points based on shared characteristics.
Software: Python (scikit-learn), R, SPSS.
- Discriminant Analysis: Differentiates groups based on predictor variables.
Software: SPSS, Stata, R.
- Time Series Analysis: Studies data over time to identify patterns and trends.
Software: Python (statsmodels), R (forecast package).
- Bayesian Statistics: uses Bayes' theorem to update the probability of a hypothesis based on new data (Koch 2007, Bolstad/Curran 2016)

By standardizing questions and data collection methods across all case studies, the survey facilitates the comparative analysis of social science research questions.

Recommended Literature for Quantitative Methods:

- Bolstad, W. M., & Curran, J. M. (2016). Introduction to Bayesian statistics (3rd ed.). Wiley.
<https://doi.org/10.1002/9781118593165>
- Hancock, G. R., Stapleton, L. M., & Mueller, R. O. (Eds.). (2019). *The reviewer's guide to quantitative methods in the social sciences* (2nd ed.). Routledge. <https://doi.org/10.4324/9781315755649>
- Imai, K. (2017). *Quantitative social science: An introduction*. Princeton University Press.
<https://doi.org/10.23943/9781400885251>
- Koch, K.-R. (2007). Introduction to Bayesian statistics. Springer-Verlag Berlin Heidelberg.
<https://doi.org/10.1007/978-3-540-72726-2>
- Stockemer, D., & Bordeleau, J.-N. (2023). Quantitative methods for the social sciences: A practical introduction with examples in R (2nd ed.). Springer International Publishing.
<https://doi.org/10.1007/978-3-319-63186-6>

Software References:

- Albert, Jim (2025). Package 'LearnBayes'. Functions for Learning Bayesian Inference. R-package version 2.15.1. <https://cran.r-project.org/web/packages/LearnBayes/LearnBayes.pdf>



- Cutler, J., & Dickenson, M. (2020). Computational Frameworks for Political and Social Research with Python (1st ed. 2020.). Springer Nature Switzerland AG.
- Dinu, J. (2018). Foundations of Data Science: A Practical Introduction to Data Science with Python. Addison-Wesley Educational Publishers Inc.
- Field, A. (2018). Discovering statistics using IBM SPSS statistics (5th ed.). Sage.
- James, G., Witten, D., Hastie, T., & Tibshirani, R. (2021). *An introduction to statistical learning: With applications in R* (2nd ed.). Springer. <https://doi.org/10.1007/978-1-0716-1418-1>
- Wickham, H., & Grolemund, G. (2017). *R for data science: Import, tidy, transform, visualize, and model data*. O'Reilly Media. <https://r4ds.had.co.nz>

3.3.2. Social Science methodological tools

The social science data collection in the ongoing project currently includes four different methods, which are presented below.

3.3.2.1. Stakeholder mapping

CATEGORY OF DATA:

socio-cultural/environmental/spatial

PURPOSE OF THE METHOD:

To evaluate the socio-ecological baseline of diverse coastal systems, analyze challenges such as biodiversity loss, habitat degradation, governance gaps, and design strategies that promote sustainable management, integrating stakeholder perspectives.

This serves as a starting point for easing further research and engagement activities, such as defining Key Performance Indicators (KPIs), developing engagement and governance models, and determining focal actions. By framing the initial scenario, it highlights the relevance of key aspects and identifies critical scenarios that must be considered to ensure effective participatory research and decision-making.

DESCRIPTION:

The method involves a structured approach to collecting and integrating socio-ecological data using tools like field surveys, remote sensing, and stakeholder consultations. This process establishes baselines for ecological conditions, economic activities, and governance frameworks, identifying key drivers of change. The analysis employs the Social-Ecological Systems Framework (SESF) to diagnose challenges and guide targeted conservation strategies, ensuring community engagement through participatory workshops and iterative stakeholder feedback.



EFFORT IN TIME:

Approximately 6 to 10 months from initial data collection to the completion of baseline analysis and stakeholder consultations.

NUMBER OF OBJECTS INVESTIGATED WITHIN THE PROJECT:

Ten distinct case study areas, each featuring unique ecosystems, governance structures, and socio-economic conditions.

DATA FORMAT:

Mixed formats including numerical/quantitative data (e.g., biodiversity indices, habitat quality measures, statistics, indicators), qualitative textual data (e.g., stakeholder interviews, textual responses, stakeholder narratives), geospatial data (e.g., habitat mapping, maps, GIS layers), and visual data (e.g., photos of habitats or biodiversity conditions). Also, textual and multimedia data from non-scientific sources such as blogs and social media analysis.

BASIC LITERATURE:

Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. *Science*, 325(5939), 419-422. <https://doi.org/10.1126/science.1172133>

Bio Innovation Service, Directorate-General for Environment (European Commission), Fundación Ibercivis and The Natural History Museum (2018). Citizen science for environmental policy: Development of an EU-wide inventory and analysis of selected practices. Final report for the Directorate-General for Environment (European Commission), EU Publications <https://doi.org/10.2779/961304>

Partelow, S. (2018). A review of the social-ecological systems framework: Applications, methods, modifications, and challenges. *Ecology and Society*, 23(4). <https://doi.org/10.5751/ES-10591-2304>

Fraisl, D., Hager, G., Bedessem, B., et al. (2022). Citizen science in environmental and ecological sciences. *Nature Reviews Methods Primers*, 2, 64. <https://doi.org/10.1038/s41592-022-00677-9>

PRO-COAST Consortium. (2024). Definition of Case Studies, Including Baseline Status, Assessment Criteria, and Socio-Ecological Goals. D5.1. Horizon Europe.

CONTACT PERSON WITHIN PRO-COAST:

Judith Bielsa Millán

Email: bielsa@ibercivis.es

Role: Researcher, Ibercivis Foundation

LINKED MATERIAL:

PRO-COAST Deliverable D5.1:



https://docs.google.com/document/d/1BNnC9_ierRGuhznYyQxcsmKu62IIH4x/edit?usp=drive_link&oid=101739054819718562908&rtpof=true&sd=true

Questionnaires responses from Case Studies:

https://drive.google.com/drive/folders/1As_OeUs6SmPMZxE65RbD83trBLImp7Qk?usp=drive_link

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<https://doi.org/10.5281/zenodo.14771694>

3.3.2.2. Stakeholder identification and analysis

CATEGORY OF DATA:

Socio-cultural

PURPOSE OF THE METHOD:

Analyzing stakeholder relevance and capacities is essential as this provides a foundation for understanding adaptation processes. It is important to combine top-down knowledge, such as information from official documents, with bottom-up insights from local experiences. This process should be systematic and done carefully. By integrating these types of knowledge, we can better understand the stakeholder landscape and identify who should be involved in, for example, climate adaptation processes or biodiversity conservation processes. It also helps address issues like unclear responsibilities and differing expectations about regional adaptation efforts.

DESCRIPTION:

This method is a systematic approach to identifying and analyzing stakeholders involved in the case study area preventing or promoting biodiversity loss in the specific coastal region. It aims to map the stakeholder landscape, clarify roles and responsibilities, and evaluate their influence and interests. The analysis of stakeholder profiles is based on the Q-helix model (Carayannis/Campbell, 2009).

How It Works

1. Specify Stakeholder Types
2. Specify Stakeholder Roles
3. Select and Classify Stakeholders
4. & 5. Associate Stakeholders with Roles and Analyse Their Influence and Interests

Variables Measured

Relevance: The stakeholder's connection to adaptation issues.



Influence: Their capacity to impact decisions or processes.

Interests: Their motivations and priorities in adaptation efforts.

Roles: Their formal or informal responsibilities.

Interpreting Results

The method produces a detailed map of stakeholders, highlighting their relevance, roles, and relationships. This analysis helps in understanding power structures, uncovering gaps or overlaps in responsibilities, and designing strategies for effective collaboration in adaptation initiatives.

EFFORT IN TIME:

The method includes several steps. Besides the collection of available information, it also entails a participatory process which, however, can be done simultaneously with the stakeholder classification. The analysis can also be time-consuming especially if it includes a stage of validation of initial results. A rough estimate of the time it takes is 2 months per case.

DATA FORMAT:

numerical, qualitative, stakeholder maps, textual, images

BASIC LITERATURE:

Carayannis, E. G., & Campbell, D. F. J. (2009). 'Mode 3' and 'quadruple helix': Toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management*, 46(3/4), 201–234. <https://doi.org/10.1504/IJTM.2009.023374>

Karin André, Louise Simonsson, Åsa Gerger Swartling & Björn-ola Linnér(2012) Method Development for Identifying and Analysing Stakeholders in Climate Change Adaptation Processes, *Journal of Environmental Policy & Planning*, 14:3, 243-261, DOI:10.1080/1523908X.2012.702562

Ronald K. Mitchell, Bradley R. Agle and Donna J. Wood (1997) Toward a Theory of Stakeholder Identification and Salience: Defining the Principle of Who and What Really Counts. *The Academy of Management Review*, Oct., 1997, Vol. 22, No. 4 (Oct., 1997), pp. 853-886

Sova CA, Helfgott A, Chaudhury AS. 2013. Multilevel stakeholder influence mapping in climate change adaptation regimes. Working Paper No. 46. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at: www.ccafs.cgiar.org

CONTACT PERSON WITHIN PRO-COAST:

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Irini Theodorakopoulou theodorakopoulou@agreri.gr (member of UoC—WP4leader)

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3.3.2.3. Activity template

CATEGORY:

Economic/Socio-cultural/Environmental/Spatial

PURPOSE OF THE METHOD:

A template for collecting evidence of activities by change agents is essential for several reasons:

1. *Consistency: It ensures uniform data collection across case studies, allowing for reliable comparisons and analysis.*
2. *Clear Documentation: It helps clearly record activities, objectives, and outcomes, providing a solid basis for assessing behavioural changes. (good governance)*
3. *Tracking Progress: The template allows for monitoring changes over time, identifying patterns, and determining which strategies are most effective.*
4. *Facilitating Analysis: With standardized data, it's easier to compare results and draw meaningful conclusions across case studies.*
5. *Reflection and Adaptation: It helps change agents assess their approaches and adjust strategies based on evidence.*
6. *Accountability and Transparency: A standardized template supports clear documentation, ensuring accountability and transparency to stakeholders. (good governance)*
7. *Measuring Behavioural Change: It provides concrete evidence of behavioural changes, crucial for evaluating the impact of interventions.*

In short, a template helps organize, track, and analyze change agent activities, providing valuable insights into the effectiveness of behavioural change efforts.

DESCRIPTION:

The tool is a template designed for change agents to document and track the activities they implement in their case studies. It collects data related to the specific behavioural change interventions they are carrying out. The template is structured to capture key information, such as the type of activity, its objectives, the target audience, and the observed outcomes.

The tool measures several variables, including the frequency of activities, the nature of behavioural changes observed, and the engagement level of participants. It also allows change agents to record qualitative data, such as feedback from participants and reflections on the effectiveness of each activity. The results can be interpreted by analysing patterns in the types of activities being carried out and their alignment with the desired behavioural changes. It helps to evaluate which interventions are more effective and identify areas for improvement. By tracking these variables over time, the tool provides insights into the progress of the behavioural change process within the specific case studies.



EFFORT IN TIME:

The template is being used and filled in throughout the entire duration of the project, ensuring consistent and thorough documentation of activities and progress.

NUMBER OF OBJECTS INVESTIGATED:

Regarding the template for activities, the number of objects or measurements will vary depending on the specific activities and case study. As each change agent documents their activities, the number of entries recorded throughout the project could range from a few key actions to multiple instances per activity, depending on the frequency and complexity of the behavioral changes being tracked. Therefore, it is difficult to estimate a precise number without knowing the full scope and depth of each case study's activities. However, we anticipate a consistent recording process that will capture relevant data throughout the project.

DATA FORMAT:

The data collected through the template for activities will be primarily qualitative and textual, as change agents will document the specific actions, observations, and reflections related to the behavioral changes they are working on. In some cases, numerical data may be included if there are measurable outcomes tied to certain activities (e.g., number of participants, frequency of behavior change). Additionally, images could be included to visually document key activities or milestones.

CONTACT PERSON:

Prof. Dr. Ann-Marie Nienaber, ann-marie.nienaber@coventry.ac.uk

LINKED MATERIAL:

Use of the template as to be cited as

Nienaber, A.M., Celestina, M., Imrie-Kuzu, D. (2024). Template of Activities

<https://doi.org/10.5281/zenodo.14772023>

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<https://doi.org/10.5281/zenodo.14771740>

3.3.2.4. Stakeholder-Survey

CATEGORY:

Socio-Cultural / Economic



PURPOSE OF THE METHOD:

The stakeholder survey across all case studies designed for a variety of stakeholders aims to explore the attitudes, values, and emotions that influence human behaviours in relation to driving behavioural changes for biodiversity conservation.

DESCRIPTION:

The survey is structured into three main sections to comprehensively explore the factors influencing behavioral changes for biodiversity conservation while allowing for both case-specific insights and cross-case comparisons. Below is an overview of the survey design:

Section 1: Attitudes, Values, and Emotions

This section is uniform across all case studies and focuses on identifying the attitudes, values, and emotions that influence human behaviors related to biodiversity conservation. The aim is to uncover the psychological and emotional drivers that shape individuals' engagement with conservation efforts.

Section 2: Behaviors

This section has a dual purpose:

The first part is tailored to the unique requirements and contexts of each case study, allowing for an in-depth exploration of specific behaviors relevant to the individual case study's goals and circumstances.

The second part focuses on four standardized behaviors that are consistent across all case studies ("I would be willing to accept cuts in my standard of living to protect the environment"; "Taking environmentally-friendly actions is an important part of who I am" Both questions are asked twice related to two different tasks: a) "We are now moving to the stakeholder groups in your community and are interested in how you perceive them. Please indicate how much you agree with the following statements regarding the group of "XX." and b) "Imagine ten of those people answering the survey. How many of those ten do you guess would agree with the following statements?". This consistency enables comparative analysis across case studies to identify common patterns and trends in behaviors related to biodiversity conservation.

Section 3: Socio-Demographics and Stakeholder Relationships

This section gathers important socio-demographic information, including age, gender, religion, sexual orientation, and other relevant characteristics. The socio-demographic data are uniform across all case studies to support broad comparisons and ensure consistency in analysis.

Additionally, this section assesses the trust levels within and between stakeholder groups. By examining trust relationships on a collective level, the survey aims to provide a clearer understanding of the dynamics



between stakeholders in each case study and how these relationships influence collective actions for biodiversity conservation.

Overall, the survey is designed to balance case-specific insights with broader comparative analyses, offering a detailed exploration of individual and collective behaviors while considering key psychological, demographic, and relational factors.

EFFORT IN TIME:

Depending of the survey timeline – app. 6 weeks

NUMBER OF OBJECTS INVESTIGATED:

12 values, 8 emotions, trustworthiness, behaviours, and socio-demographics, - app. 35 variables

DATA FORMAT:

Numerical

BASIC LITERATURE:

Nienaber et al. 2024 (reference for this survey)

Acknowledgement: We would like to express our sincere gratitude to the following individuals for their valuable support in the development and design of this survey: Ben Kenward, Alexander Yendell, Irini Theodorakopoulou, Duru Imrie-Kuzu, and Mateja Celestina.

The survey is based on:

Schwarz ([https://zis.gesis.org/skala/Schwartz-Breyer-Danner-Human-Values-Scale-\(ESS\)](https://zis.gesis.org/skala/Schwartz-Breyer-Danner-Human-Values-Scale-(ESS)));

The Positive and Negative Affect Schedule (PANAS): Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, 54(6), 1063–1070. <https://doi.org/10.1037/0022-3514.54.6.1063>.

Trustworthiness scale:

Mayer, R. C., Davis, J. H., & Schoorman, F. D. (1995). An integrative model of organizational trust. *Academy of Management Review*, 20(3), 709–734.



Social identity scale:

Brown, R., Condor, S., Matthews, A., Wade, G., & Williams, J. (1986) Explaining intergroup differentiation in an industrial organization. *Journal of Occupational Psychology*, 59, 273-286

Pro-environmental behaviour scale

Stern, Paul C., Thomas Dietz, Troy Abel, Gregory Guagnano, and Linda Kalof. (1999). A Value-Belief-Norm Theory of Support for Social Movements: The Case of Environmentalism. *Human Ecology Review* 6 (2): 81–97.

CONTACT PERSON:

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LINKED MATERIAL:

Survey template

<https://doi.org/10.5281/zenodo.14772038>

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<https://doi.org/10.5281/zenodo.14771760>

3.3.2.5. Padlet

CATEGORY:

Socio-cultural

PURPOSE OF THE METHOD:

Padlet is an interactive community tool. We will use it as a public/shared gallery. People who take walks on Eidsvika (case study area in Norway) will find QR codes on small signs where they can access the gallery and upload a picture from their trip. The purpose is to create a stronger sense of community, low-threshold engagement and to collect data by “counting” the recreational use of it.

DESCRIPTION:

Padlet is a low-threshold, interactive community tool working with creative pin-walls, that is widely used in education settings. It does not require downloading an app or creating a user-account. People who receive the link (though a QR code on signs in the nature area in our case) are able to contribute. Our pin-wall is a gallery. The setting of the gallery only allows the upload of pictures taken by the camera immediately



(not from a camera roll). This will help to create a clearer picture of “reported” recreational use by the community. It is also possible to give the pictures a title. Posts can be made anonymously.

We established the tool because we observed that many community members upload pictures from their hikes in the area in the large Facebook group. However, this is a politically loaded place and members usually post with their actual name and they must have a Facebook account. By making the gallery we hope to establish a distinct space for impressions of the area and make it even easier to upload pictures for everyone. This will help the community to feel ownership of the area and the research team to have data in the form of numbers and images about the recreational use. The gallery will be monitored until the end of the project, to measure impact on the socio-cultural level.

EFFORT IN TIME:

The padlet was created within 5 hours and so was the design of the signs.

NUMBER OF OBJECTS INVESTIGATED:

n/a

DATA FORMAT:

textual, images, numerical

BASIC LITERATURE:

What is Padlet? Padlet.Help.

<https://padlet.help//en/article/cpfiutfzxb-what-is-padlet>

CONTACT PERSON WITHIN PRO-COAST:

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LINKED MATERIAL:

<https://padlet.com/>

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3.3.3. Digital applications

Digital applications were mainly used for programming the stakeholder surveys. Some of the case studies used standard programs such as Google Forms or Microsoft Forms.

3.3.3.1. EU-Survey

CATEGORY:

Socio-cultural/Environmental/Economic

PURPOSE OF THE METHOD:

EUSurvey is an online survey tool developed by the European Commission to help create, distribute, and analyze surveys. It is specifically designed for creating surveys related to European Union (EU) policies, research, and projects.

We have utilized the EUSurvey tool to create Stakeholder Surveys in multiple languages for the Pro-Coast Project. This has allowed us to efficiently collect data, analyze the results, and generate comprehensive reports.

More specifically, the key features of this tool are:

- **Survey Creation:** EUSurvey allows users to create customized surveys, including various types of questions (e.g., multiple choice, open text, ranking, etc.).
- **Distribution:** The surveys can be distributed via a public or private link, allowing for both open and targeted responses.
- **Data Collection:** It supports the collection of responses from individuals across the EU, making it useful for gathering data from a diverse population.
- **Analysis:** EUSurvey provides built-in tools to analyze the survey results, including reports and visualizations, which help users interpret the data.
- **Multi-Language Support:** Since the tool is EU-focused, it allows surveys to be created in multiple languages, ensuring accessibility to people across the EU.
- **Privacy & Compliance:** It ensures compliance with EU regulations on data protection (such as GDPR) when collecting and processing responses.

DESCRIPTION:

EUSurvey is an online survey tool developed by the European Commission, designed to help create, distribute, and analyze surveys. For the Pro-Coast Project, we use EUSurvey to gather valuable data from stakeholders, including participants in different regions and languages. The tool supports both qualitative



and quantitative data collection, making it ideal for gathering feedback on coastal management, conservation, and other related topics.

How It Works:

The tool allows us to design customizable surveys with a wide variety of question types (e.g., multiple-choice, Likert scales, open-ended questions). Once created, the surveys are distributed via a web link to participants, and responses are collected in real-time. After submission, the data is stored securely and can be easily accessed for analysis.

Variables Measured:

- Demographic information: such as age, location, and profession (if we give an age range).
- Opinions and attitudes: measured through Likert scales or rating questions related to coastal management, sustainability, and the environment.
- Behavioral data: responses related to participants' actions, knowledge, and practices concerning coastal conservation and policies.
- Open-ended responses: allowing participants to share detailed feedback and insights.

Interpretation of Results:

The results are processed and analyzed using EUSurvey's built-in reporting tools, which provide both visual and statistical representations of the data. This allows us to identify key trends, patterns, and insights relevant to the Pro-Coast Project. The data can be aggregated by specific categories (e.g., demographics) and reports are generated in multiple formats for further review and dissemination.

EFFORT IN TIME:

The estimated time required for the creation of the surveys depends on the complexity and length of the questionnaire.

On average, it takes a few days to finalize the survey content and make it ready for distribution.

Once the questionnaires are distributed to participants and they submit their responses, the results are typically available within 24 hours, allowing for quick data analysis and reporting.

NUMBER OF OBJECTS INVESTIGATED:

1. If you are referring to respondents:
The number of objects would refer to the number of survey participants. Through the results, we can see how many participants have answered the Survey.
2. If you are referring to the questions or variables being measured:
The number of objects refers to the survey questions or data points being measured. In our surveys, there are approximately 40 to 50 questions in each staggered category. While the



categories might be 4 to 5. Each question collects data on various aspects related to the category the participant chooses.

So, for each survey, we gather data on key topics or aspects, with each aspect having multiple questions for analysis.

DATA FORMAT:

Our survey collects both numerical and qualitative data. Numerical data includes ratings and scaled responses, while qualitative data is gathered from open-ended questions, where participants provide descriptive feedback. No geospatial or image data is collected.

The EU survey stores all required data in an Excel (.xlsx) and/or csv format.

BASIC LITERATURE:

Official Documentation:

European Commission. (n.d.). EUSurvey – Create, publish and manage surveys. Retrieved from <https://ec.europa.eu/eusurvey>

CONTACT PERSON WITHIN PRO-COAST:

Giota Michailidou, Administrative officer, pm@tero.gr

LINKED MATERIAL:

- PRO-COAST Spørreundersøkelse
- PRO-COAST Sondajul grupului de persoane interesate pentru măsurarea impactului
- PRO-COAST Stakeholder Group Survey for Measuring Impact_Romania_EN
- PRO-COAST Stħarrig ġħall-Gruppi tal-Partijiet Interessati ġħall-Kejl tal-Impatt
- PRO-COAST Stakeholder Group Survey for Measuring Impact_Malta_EN
- PRO-COAST Sidusrühmade uuring mõju mõõtmiseks_Eesti
- PRO-COAST Stakeholder Group Survey for Measuring Impact_Estonia_EN
- PRO-COAST Arne Parish Survey

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3.3.3.2. 1KA online survey application

CATEGORY:

Socio-cultural



PURPOSE OF THE METHOD:

1KA is an open-source application that enables services for online surveys. It allows users to make different surveys, forms, or voting questionnaires with many options for question types, IF conditions, loops, statistical analyses etc. It allows collection and analysis of survey answers.

DESCRIPTION:

1KA is an open-source application for online surveys developed at the Centre for Social Informatics, Faculty of Social Sciences, University of Ljubljana. The application provides functionalities for questionnaire creation (design and technical setup), survey implementation (invitations, publishing, and data collection), and data analysis (including paradata).

1KA emphasizes simplicity by minimizing clicks, as reflected in its name "EnKlikAnketa" (translated as "One Click Survey"). It supports unlimited free use for online surveys, while additional services such as training, custom installations, or data analysis are available for a non-profit fee. The application can be installed on any server, linked via API, or used offline for personal interviews (CAPI) on Windows devices. It is completely in accordance with the legal standards for data protection.

EFFORT IN TIME:

A few months.

NUMBER OF OBJECTS INVESTIGATED:

=Number of participants; approximately 100

DATA FORMAT:

numerical

BASIC LITERATURE:

n/a

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LINKED MATERIAL:

<https://www.1ka.si/d/en/about/general-description>

<https://1ka.arnes.si/a/442cc376&preview=on&testdata=on>

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3.4. Ecological methods, analytical tools and applications

3.4.1. Ecological methods in general

In projects that work with case studies on biodiversity loss in a coastal regions, various approaches and methods could be combined to assess both species diversity and their ecological functions. Initially, a species inventory is often created through systematic observations or sampling of flora and fauna. These determinations allow the use of biodiversity indices, such as the Shannon-Wiener Index or the Simpson Index, which quantify species diversity and distribution. But in order for these to be comparable between different localities similar levels of taxonomic identification and methods of sampling are necessary. This is not always the case in applied research situations. Often decisions have to be made on imperfect data and the reliance on information gathered on species of conservation concern or on the status of "umbrella species" or "keystone" species - whose conservation will also aid other species that share its ecosystem.

In addition, ecological indicators such as bioindicators or trophic indices can be used to assess changes in biodiversity due to environmental factors or human activities. Habitat quality is also examined to understand the impacts of fragmentation and destruction on species diversity. Remote sensing technologies like satellite imagery and drone photography, as well as GIS-based modeling, offer a way to monitor large-scale changes in coastal protection areas and analyze species distribution.

For a detailed assessment of ecological health, ecophysiological measurements are carried out, such as examining water quality and genetic diversity. Long-term monitoring programs are essential for capturing trends in biodiversity over extended periods and documenting changes. In this context, local stakeholders and citizen scientists must be absolutely involved, providing valuable data through their observations and



knowledge. Finally, models for predicting changes in biodiversity due to environmental shifts or human activities help anticipate and understand future developments.

By combining these methods, a comprehensive and precise assessment of biodiversity in coastal regions can be achieved. The choice of method and tools for analyzing the collected data depends on the ecological research subject. Standard analysis software includes, among others:

- Spreadsheets (Excel, GoogleDocs)
- SPSS Statistics
- R coding language
- Python

Basic Literature in the field of biodiversity research:

Dandois, J.P. and Ellis, E.C. (2010) Remote Sensing of Vegetation Structure using Computer Vision. Remote Sensing, 2, 1157-1176. <https://doi.org/10.3390/rs2041157>

Gaston, K. J. (2000). Global patterns in biodiversity. Nature, 405(6783), 220-227. <https://doi.org/10.1038/35012228>

Tilman, D., May, R. M., Lehman, C. L., & Nowak, M. A. (1994). Habitat destruction and the extinction debt. Nature, 371(6492), 65-66. <https://doi.org/10.1038/371065a0>

Sala, O. E., et al. (2000). Global biodiversity scenarios for the year 2100. Science, 287(5459), 1770-1774. <https://doi.org/10.1126/science.287.5459.1770>

Elith, J., & Leathwick, J. R. (2009). Species distribution models: Ecological explanation and prediction across space and time. Annual Review of Ecology, Evolution, and Systematics, 40, 677-697. <https://doi.org/10.1146/annurev.ecolsys.110308.120159>

Phillips, S. J., Anderson, R. P., & Schapire, R. E. (2006). Maximum entropy modeling of species geographic distributions. Ecological Modelling, 190(3-4), 231-259. <https://doi.org/10.1016/j.ecolmodel.2005.03.026>

Software References:

Oksanen, J., Blanchet, F. G., Friendly, M., et al. (2019). Vegan: Community ecology package (R package version 2.5-6). <https://cran.r-project.org/web/packages/vegan/vegan.pdf>

Not all methods can be applied simultaneously across all case studies. The following section outlines the methods that have been used in the project so far and provides information on the specific tools that have been utilized.



3.4.2. Methodological tools

3.4.2.1. Citizen science (CS) initiatives

CATEGORY:

Environmental / Socio-cultural

PURPOSE OF THE METHOD:

Citizen science initiatives aim to engage the public in environmental research, focusing on monitoring biodiversity, pollution, and climate change impacts. The ability to foster engagement is as important as the ability to gain useful monitoring habitat or biodiversity monitoring information. The scientific value of the data collected through citizen science can be improved through careful planning at the outset to collect data that accounts for covariates and to address issues of coverage and spatial bias. Training of citizen scientists at the outset of data collection is key. Statistical techniques can help to address issues of observer variation and spatial bias and benchmarking citizen science datasets with those collected by professional surveyors will help to address issues of identification errors.

DESCRIPTION:

Citizen Science refers to the scientific work undertaken by members of the general public, in collaboration with or under the direction of professional scientists and scientific institutions. At the same time, a Citizen Scientist refers to a member of the general public who engages in scientific work, in collaboration with or under the direction of professional scientists and scientific institutions.

Data is obtained from Citizen Science through standardised questionnaires and in-person interviews with the stakeholders involved in the initiatives.

Data is analysed through tabulation (e.g., in Microsoft Excel ®). Qualitative, quantitative and temporal tabulated data are processed with statistical software (e.g., R for statistics). When spatial information is available, data is processed in Geo-spatial Information System (GIS) environments.

DATA FORMAT:

Qualitative, quantitative, spatial, temporal, images, and textual data.

BASIC LITERATURE:

Backstrom, L. J., Callaghan, C. T., Leseberg, N. P., Sanderson, C., Fuller, R. A., & Watson, J. E. M. (2024). Assessing adequacy of citizen science datasets for biodiversity monitoring. *Ecology and Evolution*, 14, e10857. <https://doi.org/10.1002/ece3.10857>



Barańczuk, K., & Barańczuk, J. (2021). Smart control of the climate resilience of European Coastal City (SCORE) HORIZON 2020-Coastal City Living Lab-Case of Gdańsk. Doctoral School of Natural Sciences. <https://doi.org/10.3030/101003534>

Binley, A. D., & Bennett, J. R. (2023). The data double standard. *Methods in Ecology and Evolution*, 14, 1389–1397. <https://doi.org/10.1111/2041-210X.14110>

Bio Innovation Service, Directorate-General for Environment (European Commission), Fundación Ibercivis and The Natural History Museum (2018). Citizen science for environmental policy: Development of an EU-wide inventory and analysis of selected practices. Final report for the Directorate-General for Environment (European Commission), EU Publications <https://doi.org/10.2779/961304>

Fraisl, D., Hager, G., Bedessem, B., et al. (2022). Citizen science in environmental and ecological sciences. *Nature Reviews Methods Primers*, 2, 64. <https://doi.org/10.1038/s41592-022-00677-9>

Harley, M. D., & Kinsela, M. A. (2022). CoastSnap: A global citizen science program to monitor changing coastlines. *Continental Shelf Research*, 245, 104796. <https://doi.org/10.1016/j.csr.2022.104796>

Marrocco, V., Zangaro, F., Sicuro, A., & Pinna, M. (2019). A scaling down mapping of *Pinna nobilis* (Linnaeus, 1758) through the combination of scientific literature, NATURA 2000, grey literature and citizen science data. *Nature Conservation*, 33, 21-31. <https://doi.org/10.3897/natureconservation.33.30397>

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3.4.2.2. Local Ecological Knowledge (LEK) investigations

CATEGORY:

Environmental/Socio-cultural

PURPOSE OF THE METHOD:

Gathering ecological information about biodiversity, ecosystem benefits, socio-cultural environmental resources, etc. thanks to the knowledge owned and shared by the residents and/or specific target groups.



DESCRIPTION:

Local Ecological Knowledge (LEK) represents the accumulation, which has been going on for some time, of knowledge, practices, and beliefs regarding the relationships between living beings in a specific ecosystem. This knowledge is acquired by indigenous human populations over hundreds or thousands of years through direct contact with the environment, passed down from generation to generation, and used for subsistence. LEK encompasses the links between people, plants, animals, natural phenomena, and landscapes, and the timing of events for activities such as hunting, fishing, trapping, agriculture, and forestry. It also encompasses a people's worldview, including ecology, spirituality, human-animal relationships, and more.

Data from Local Ecological Knowledge is obtained by standardised questionnaires and in-person interviews with the locals involved.

Results are tabulated (e.g., in Microsoft Excel®). Qualitative, quantitative and temporal tabulated data are processed with statistical software (e.g., R for statistics). When spatial information is available, data is processed in Geo-spatial Information System (GIS) environments.

EFFORT IN TIME:

Usually, the time required for one interview is limited to half hour.

NUMBER OF OBJECTS INVESTIGATED:

Usually, the minimum number of interviews is defined depending on the topic.

DATA FORMAT:

Qualitative, quantitative, geospatial, and temporal data.

BASIC LITERATURE:

IPBES. (2022). Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Zenodo. <https://doi.org/10.5281/zenodo.6417333>

Newman, R. (2021). Human Dimensions: Traditional Ecological Knowledge—Finding a Home in the Ecological Society of America. *The Bulletin of the Ecological Society of America*, 102(3). <https://doi.org/10.1002/bes2.1892>

Pascual, U., Balvanere Levy, P., Christie, M., & Baptiste, B. (2022). Summary for policymakers of the methodological assessment of the diverse values and valuation of nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). IPBES Secretariat. <https://doi.org/10.5281/zenodo.6522392>



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3.4.2.3. Environmental DNA (eDNA) metabarcoding for biodiversity assessments and biomonitoring

CATEGORY:

Environmental

PURPOSE OF THE METHOD:

eDNA metabarcoding allows for a fast and reliable description of the biological communities' composition, as well as their genetic and spatial variation, in different ecosystems, opening for more rapid and reliable biodiversity assessment and monitoring programs.

DESCRIPTION:

eDNA metabarcoding refers to the analysis of DNA molecules present in an environmental sample, such as water or sediment, through the PCR amplification of specific gene markers, high-throughput sequencing of amplicons, and taxonomic classification of DNA sequences comparing them with DNA barcodes deposited in the barcode reference databases.

The high-throughput sequencing results are processed through bioinformatic pipelines developed in different programming languages (e.g., R, Python, etc.). The biodiversity results are tabulated (e.g., in Microsoft Excel ®) and processed with the use of statistical software (e.g., R for statistics).

EFFORT IN TIME:

Usually, the time required for one investigation depends on the experimental design defined

NUMBERS OF OBJECTS INVESTIGATED:

Usually, the minimum number of samples is identified depending on the experimental design defined.



DATA FORMAT:

Qualitative, quantitative

BASIC LITERATURE:

Pawlowski, J., Kelly-Quinn, M., Altermatt, F., Apothéloz-Perret-Gentil, L., Beja, P., Boggero, A., ... & Kahlert, M. (2018). The future of biotic indices in the ecogenomic era: Integrating (e) DNA metabarcoding in biological assessment of aquatic ecosystems. *Science of the Total Environment*, 637, 1295-1310. <https://doi.org/10.1016/j.scitotenv.2018.05.002>

Pinna, M., Zangaro, F., & Specchia, V. (2024). Assessing benthic macroinvertebrate communities' spatial heterogeneity in Mediterranean transitional waters through eDNA metabarcoding. *Scientific Reports*, 14(1), 17890. <https://doi.org/10.1038/s41598-024-69043-w>

Shea, M. M., & Boehm, A. B. (2024). Environmental DNA metabarcoding differentiates between micro-habitats within the rocky intertidal. *Environmental DNA*, 6, e521. <https://doi.org/10.1002/edn3.521>

Specchia, V., Zangaro, F., Tzafesta, E., Saccomanno, B., Vadrucchi, M. R., & Pinna, M. (2023). Environmental DNA detects biodiversity and ecological features of phytoplankton communities in Mediterranean transitional waters. *Scientific Reports*, 13(1), 15192. <https://doi.org/10.1038/s41598-023-42389-3>

Specchia, V., Saccomanno, B., Zangaro, F., Tzafesta, E., & Pinna, M. (2022). Exploring the biodiversity of a European Natura 2000 Mediterranean lagoon through eDNA metabarcoding. *Diversity*, 14(11), 991. <https://doi.org/10.3390/d14110991>

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3.4.2.4. Camera traps and species observations

CATEGORY:

Environmental / Spatial

PURPOSE OF THE METHOD:

Camera traps are motion-sensitive cameras used to monitor animal activity in an area without human intervention. Camera traps are non-invasive, long-term, and cost-effective data collection tools.



Applications are: wildlife monitoring, biodiversity assessment, ecological studies, and health status of animal.

Camera traps can measure/analyse: species presence, population sizes and/or densities of species, behaviour, habitat use, human impact.

DESCRIPTION:

Camera traps are secured on a stable surface (usually a tree or a pole) to record wildlife passing in front of it, which trigger an infra-red sensor and the camera takes pictures or videos. Camera traps record date and time of the event but can also record temperature and atmospheric pressure. AI advancements have enabled automatic species recognition. Using the recorded data (images, videos) we can measure:

- Species presence (species richness)
- Activity patterns
- Population estimates
- Density
- Behavioural data (on/off nests)
- Human impact

EFFORT IN TIME:

Camera traps are usually deployed for a few months or longer. Results can be analysed once the camera traps (or SD cards) are collected from the field and analysed by eye with the help of AI (using Agouti) depending on the number of camera traps deployed, the specifics of how the cameras are set (how easily they are triggered), and the duration of the deployments (e.g., 12 cameras deployed for 3 months, should take 2 weeks for data analysis in Slovenia).

NUMBERS OF OBJECTS INVESTIGATED:

Camera traps are active all hours of the day and can record hundreds or thousands of events over a few months, depending on animal activity and presence. Furthermore, multiple camera traps can be deployed in an area at the same time. E.g., in one study in Slovenia, with 12 cameras in a period of 3 months (1208 camera days) we recorded over 2700 events. The methodology for estimation of wildlife species (European roe deer, red deer and wild boar) density are described in details in the EFSA report provided by Enetwild project (Enetwild consortium 2023).

DATA FORMAT:

Images and/or videos, numerical (number of observations), qualitative (behaviour, interactions).



BASIC LITERATURE:

Burton, A.C., Neilson, E., Moreira, D., Ladle, A., Steenweg, R., Fisher, J.T., Bayne, E. and Boutin, S. (2015), REVIEW: Wildlife camera trapping: a review and recommendations for linking surveys to ecological processes. J Appl Ecol, 52: 675-685. <https://doi.org/10.1111/1365-2664.12432>

Ceasar, J., Milotic, T., Liefing, Y., Desmet, P., Jansen, P. (2019), Agouti: A platform for processing and archiving of camera trap images. Biodiversity Information Science and Standards. <https://doi.org/10.3897/biss.3.46690>

Enetwild consortium et al. (2023) Wild ungulate density data generated by camera trapping in 37 European areas: first output of the European Observatory of Wildlife (EOW), EFSA supporting publication, 20(3): EN-7892. 90 pp. <https://doi.org/10.2903/sp.efsa.2023.EN-7892>

Sollmann, R. (2018), A gentle introduction to camera-trap data analysis. Afr J Ecol, 56: 740-749. <https://doi.org/10.1111/aje.12557>

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LINKED MATERIAL:

<https://wildlifeobservatory.org/>

<https://www.agouti.eu/>

<https://www.wildlifeinsights.org/>

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3.4.3. Digital applications

For data collection and the analysis of the data gathered in the individual case studies, different tools and applications were used, which will be introduced in more detail below.

3.4.3.1. Google Earth Engine (GEE)

CATEGORY:

Environmental/Spatial

PURPOSE OF THE METHOD:

We applied GEE in mapping baseline land use cover of Streedagh Beach, Ireland (CS 5).



DESCRIPTION:

Google Earth Engine (GEE) hosts a multitude of geospatial data, including regularly updated satellite and climate datasets. It facilitates processing datasets through user written scripts to analyze and visualize data directly on the platform and output results stored in the Google cloud and downloadable for further analysis and visualization in other geospatial tools. In our context we have used the Machine Learning land use cover classification of Streedagh Special Area of Conservation with Sentinel 2 satellite image for 09/2024. GEE makes available several variables that can be measured including land/habitat cover and their changes (e.g. marram grass cover), water (e.g. ocean water extent) and climate. The interpretation of the results is guided by the objective of the analysis. In our context temporal cover changes from baseline to future i.e., the changes in marram grass cover at the start of behavioral change campaigns to a future time in order to assess our ability to influence beach users to reduce grass degradation and, by extension, dunes erosion. This will then be fed into policy covering ecosystem and biodiversity conservation.

EFFORT IN TIME:

2 weeks

NUMBER OF OBJECTS INVESTIGATED:

1. Maram grass cover
2. Sand dunes cover
3. Other covers

BASIC LITERATURE:

Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., & Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. *Remote Sensing of Environment*. <https://doi.org/10.1016/j.rse.2017.06.031>

Parracciani, C., Gigante, D., Mutanga, O., Bonafoni, S., & Vizzari, M. (2024). Land cover changes in grassland landscapes: Combining enhanced Landsat data composition, LandTrendr, and machine learning classification in google earth engine with MLP-ANN scenario forecasting. *GIScience & Remote Sensing*, 61(1), 2302221.

Sunde, M., Diamond, D., & Elliott, L. (2024). Ecological Systems Classification: Integrating Machine Learning, Ancillary Modeling, and Sentinel-2 Satellite Imagery. *Remote Sensing*, 16(23), 4440.

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Fredrick Otieno



LINKED MATERIAL:

<https://code.earthengine.google.com/>

<https://code.earthengine.google.com/b619d460d55f2f0c4ccdad2ff01e8b6>

[https://drive.google.com/drive/folders/1UDVYfPGKiVn0T9HV2VbALkgRzJVwvbUN?usp=drive link](https://drive.google.com/drive/folders/1UDVYfPGKiVn0T9HV2VbALkgRzJVwvbUN?usp=drive_link)

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3.4.3.2. Quantum Geographic Information System (QGIS)

CATEGORY:

Environmental/ Spatial

PURPOSE OF THE METHOD:

QGIS was used to visualize and produce the final Streedagh land use cover map using the data that resulted from the Google Earth Engine (GEE) image analysis.

DESCRIPTION:

QGIS is an open-source GIS application that enables creation, editing, analysis, visualization, and publishing of geospatial data. In our context we input image output from GEE to produce a detailed map of the Streedagh beach land use cover after several geospatial analyses including georeferencing, removing scattered random pixels, generalization of cover classes, conversion of image to vector, and cover area calculations.

EFFORT IN TIME:

1 week

NUMBER OF OBJECTS INVESTIGATED:

1. Maram grass cover areas
2. Sand dunes cover areas
3. Other covers areas

DATA FORMAT:

Geospatial / images



BASIC LITERATURE:

GIS Development Team. (2009). QGIS Geographic Information System.

<http://qgis.org> Kurt Menke, G. I. S. P., Smith Jr, R., Pirelli, L., & John Van Hoesen, G. I. S. P. (2016). Mastering QGIS. Packt Publishing Ltd.

Graser, A. (2016). Learning Qgis. Packt Publishing Ltd.

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LINKED MATERIAL:

[https://drive.google.com/drive/folders/1UDVYfPGKiVn0T9HV2VbALkgRzJVwvbUN?usp=drive link](https://drive.google.com/drive/folders/1UDVYfPGKiVn0T9HV2VbALkgRzJVwvbUN?usp=drive_link)

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3.4.3.3. ArcGisPro

CATEGORY:

Environmental/ Spatial

PURPOSE OF THE METHOD:

ArcGIS is a geographic information system (GIS) used for mapping, analyzing, and visualizing spatial data. It measures and analyzes geographic patterns, relationships, and trends, supporting applications in urban planning, environmental management, resource allocation, disaster response, and more. It enables data-driven decision-making across diverse industries.

DESCRIPTION:

ArcGIS is a powerful GIS tool used to collect, manage, analyze, and visualize spatial and geographic data. It integrates various data types —geospatial, numerical, textual, and imagery—into layered maps. ArcGIS measures variables such as location, elevation, population density, land use, and environmental conditions. Users apply its tools for mapping patterns, identifying spatial relationships, and modeling predictions. Results are interpreted through interactive maps, charts, or reports, aiding in decision-making across fields like urban planning, resource management, and environmental conservation. Its versatility makes it essential for understanding and solving location-based challenges.



EFFORT IN TIME:

The time required to work with ArcGIS and obtain results depends on factors like the complexity of the project, data availability, user expertise, and the analysis scope. For basic mapping tasks, results may be ready in hours. However, advanced analyses (e.g., geostatistical modeling or multi-layered studies) can take days to weeks.

NUMBER OF OBJECTS INVESTIGATED:

Anything that involves maps or spatial data/relations.

DATA FORMAT:

ArcGIS collects and works with various data formats, including:

Geospatial data: Shapefiles, GeoJSON, KML, raster layers.

Numerical data: Attribute tables, statistical datasets.

Qualitative data: Survey responses or categorizations linked to spatial features.

Textual data: Metadata, annotations, descriptions.

Images: Satellite imagery, aerial photography, and scanned maps.

BASIC LITERATURE:

ArcGIS is a comprehensive geographic information system (GIS) developed by Environmental Systems Research Institute, Inc. (Esri) for creating, managing, analyzing, and mapping spatial data. It enables users to visualize geographic information, perform spatial analysis, and share insights through maps and reports. ArcGIS supports various data formats, including geospatial, numerical, textual, and imagery, facilitating diverse applications such as urban planning, environmental management, and resource allocation. By integrating and analyzing spatial and non-spatial data, ArcGIS helps users identify patterns, relationships, and trends, supporting informed decision-making across multiple disciplines.

Allen, D. W., & Gerike, M. J. (2021). Focus on Geodatabases in ArcGIS Pro. *Photogrammetric Engineering & Remote Sensing*, 87(7), 468–469. <https://doi.org/10.14358/pers.87.7.468>

Barsai, G. (2018). Getting to know ArcGIS Pro. *Photogrammetric Engineering & Remote Sensing*, 84(4), 181–182. <https://doi.org/10.14358/pers.84.4.181>

Koch, T. (2018). Review of GIS Tutorial 1 for ArcGIS Pro. *Cartographic Perspectives* (89), 61–65. <https://doi.org/10.14714/cp89.1457>

LaLonde, T. L. (2017). Review of Getting to Know ArcGIS Pro. *Cartographic Perspectives* (86), 45–47. <https://doi.org/10.14714/cp86.1370>



Macdonald, O. (2017). Getting to know ArcGIS Pro. Cartographic Journal, 54(3), 284–285.
<https://doi.org/10.1080/00087041.2017.1371449>

Molter, A. (2020). XLUR: A land use regression wizard for ArcGIS Pro. Journal of Open Source Software, 5(50), 2177. <https://doi.org/10.21105/joss.02177>

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3.4.3.4. SRNA CS application ("Spremljanje in Raziskovanje Narave z Aplikacijo", literally "An Application for Monitoring and Exploring Nature")

CATEGORY:

Environmental/ Spatial

PURPOSE OF THE METHOD:

The application records wildlife sightings of citizen scientists. It allows researchers to determine presence and distribution of selected species with many important metadata: location, time, species, number of individuals, sex, age, reproductive potential, and health status. Collected data can then be used in ecological research.

DESCRIPTION:

SRNA is a citizen science app for recording sightings of wildlife observed during outdoor activities. It collects data on 31 species of mammals and 8 species of birds. Additionally, as well as number of individuals, sex and age, SRNA can collect data on reproductive potential and health status. The application also includes a guide for identifying wildlife and a quiz where users can assess their proficiency to distinguish random pictures of similar wildlife species. SRNA was developed by the University of Primorska and the Hunters Association of Slovenia, within the Step Change project. The data collected will help to improve the knowledge and, consequently, the management and conservation of wildlife in Slovenia.



EFFORT IN TIME:

Several months

NUMBER OF OBJECTS INVESTIGATED:

n/a

DATA FORMAT:

Numerical, qualitative, geospatial, textual and images

BASIC LITERATURE:

Fakulteta za matematiko, naravoslovje in informacijske tehnologije. (2022). SRNA: Nova aplikacija za monitoring prostoživečih živali / SRNA: New app for monitoring wildlife. Retrieved from: https://www.famnit.upr.si/sl/novice_studenti/srna-nova-aplikacij-1

VELKAVRH, Žiga, DUNIŠ, Luka. (2024). Aplikacija SRNA: nekaj spoznanj iz opažanj lovcev. Lovec: glasilo Slovenskega lovskega društva. [Tiskana izd.], letn. 107, št. 6, str. 265-266, ilustr. ISSN 0024-7014. <https://clan.lovska-zveza.si/userfiles/Lovec/pdf/Lovec-2024-06.pdf>

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LINKED MATERIAL:

<https://srna.lovska-zveza.si/login>

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3.4.3.5. eBird

CATEGORY:

Environmental/ Spatial



PURPOSE OF THE METHOD:

eBird is a citizen science platform that collects and analyzes bird observation data globally. Its purpose is to document bird distribution, abundance, habitat use, and trends over time. eBird allows users to report sightings, contributing to a vast database used in ornithology, conservation planning, and ecological research. Researchers and conservationists use the data to monitor species populations, assess biodiversity, and guide habitat preservation efforts. It is widely applied in environmental education, birdwatching, and global conservation initiatives.

DESCRIPTION:

eBird is a global citizen science platform that allows birdwatchers and researchers to record, share, and analyze bird observations. Users submit data on bird species they observe, including information about the species, location, date, number of individuals, and environmental conditions. eBird also tracks bird behavior and habitat details. The platform generates real-time data, helping to monitor bird populations, migration patterns, and biodiversity trends. Researchers, conservationists, and policy-makers use eBird data to inform conservation efforts, track changes in bird distributions, and guide land use and habitat management decisions. Results can be interpreted to assess species trends, habitat preferences, and environmental health.

EFFORT IN TIME:

The time required for using eBird depends on the type of observation and analysis being conducted:

Data Collection: Entering a single bird observation into eBird can take a few minutes. Users simply report species, location, and time of the sighting. Larger surveys may take longer, depending on the number of species recorded and the complexity of the habitat.

Results Availability: Once data is submitted, it is typically available for analysis immediately. However, aggregating data into meaningful trends or reports (such as species distribution or migration patterns) may take a few days to weeks, depending on the scope and the need for advanced data processing.

In general, results from individual observations are available in real-time, but more comprehensive analyses may take longer depending on the scale of the project.

NUMBER OF OBJECTS INVESTIGATED:

For eBird, the number of objects or measurements can vary greatly depending on the specific observation or analysis being conducted. Here's an estimate based on typical use:



Individual Observation (Object): Each bird species observed is considered an object. For example, if you observe 10 different species during a birdwatching session, that would be 10 objects.

Measurements: For each observation, the following measurements are typically recorded:

Species name (1 measurement per species)

Location (coordinates, 1 measurement)

Date and time (1 measurement)

Number of individuals observed (1 measurement per species)

Behavior (e.g., feeding, flying, etc., if noted, 1 measurement)

Environmental conditions (weather, habitat type, etc., may include 2-5 measurements)

Thus, a single observation can generate 5-10 measurements, and the total number of objects/measurements depends on the number of species observed and the level of detail recorded. For large-scale datasets or regional surveys, the number of measurements can reach thousands or millions.

DATA FORMAT:

The data collected through eBird includes the following formats:

Numerical:

Number of individuals observed for each species.

Time of observation (usually in hours or minutes).

Geographic coordinates (latitude and longitude) of the observation site.

Qualitative:

Behavior of the birds (e.g., feeding, flying, resting).

Descriptions of the habitat or environmental conditions.

Geospatial:

GPS coordinates (latitude and longitude) for precise location of observations.

Textual:

Notes and additional details entered by observers about the sighting, including observations of unusual behaviors or rare species.

Images:

Occasionally, observers upload photos of species, which can provide visual verification of sightings.

This combination of data formats allows eBird to track bird distributions, behaviors, and trends effectively.



BASIC LITERATURE:

<https://support.ebird.org/en/support/solutions/articles/48001158707-get-started-with-ebird>

CONTACT PERSON WITHIN PRO-COAST:

Ana.cirjan@totalpr.ro

LINKED MATERIAL:

<https://ebird.org/home>

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3.4.3.6. Anatrack mapper

CATEGORY:

Environmental / Spatial

PURPOSE OF THE METHOD:

Intuitive mapping of areas (e.g. habitats), lines (e.g. routes) and point locations on desktops, laptops, tablets and smartphones by local people, in multiple languages and simple enough to be used by children.

DESCRIPTION:

Anatrack Mapper is a software tool used in animal movement research to collect, visualize, and analyze GPS data from animals. It helps study movement patterns, migrations, and habitat use by displaying tracking data, gathered through GPS collars or tags, on maps. Researchers can identify movement patterns and preferred areas of animals. The software also enables the creation of movement models and the analysis of the impact of environmental factors on animal behavior. Additionally, the data can be integrated with other geographical information to better understand animal movements in the context of their environment. Anatrack Mapper thus provides valuable insights into ecological processes and the needs of wildlife.

Coordinates are plotted freehand, or with snap to previous vertices, over maps (e.g. Google Earth) to align them with map coordinates or using walk-round with GPS. Original enabled mapping in 14 EU languages (plus Japanese, Russian, Turkish & Ukrainian) (using CSV upload of translation on Excel sheets). A version is incorporated in the Reciprocal Environmental Decision Support (REDS) system being tested for



the Community Sustainability Platform of Pro-Coast. This tool was used for most projects in Chapters 9-19 of Kenward et al. (2013).

EFFORT IN TIME:

Proficient use in minutes.

Original tool was rated 4-5/5 for ease of use.

NUMBER OF OBJECTS INVESTIGATED:

No Limit.

DATA FORMAT:

Inputs: own images, tiles from GoogleEarth or OpenStreetmap). Outputs: geospatial data as shapefiles, GeoJSON, KML and CSV but can also create images for presentations and publications.

BASIC LITERATURE:

Kenward, R.E., Papathanasiou, J., Arampatzis, E. & Manos, B.A. (eds) (2013). Transactional Environmental Support System Design: Global Solutions. IGI-Global, Hershey, Pennsylvania, USA. <https://doi.org/10.4018/978-1-4666-2824-3>

CONTACT PERSON WITHIN PRO-COAST:

Nick Casey, nick@anatrack.com , software engineer.

LINKED MATERIAL:

To be applied in Arne Parish (CS6) as described now at:

<https://pro-coast.sycl.net/10/pro-coast-case-studies>

and (to be developed) at:

<https://pro-coast-uk.sycl.net/>

and for sites in at least 11 other languages as part of the Pro-Coast Community Sustainability Platform.

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<https://doi.org/10.5281/zenodo.14772175>

3.4.3.7. Fritidsfiskeappen

CATEGORY:

Environmental / Socio-cultural (for Ghostfishing)



PURPOSE OF THE METHOD:

This is an app by the Directorate of Fisheries. Users can report on the exact location and type of equipment that they have lost in the sea. If the lost gear has been removed from the seabed, the removal can be reported as well. The data for these reports is visualized and accessible for previous years as well. We will use it to monitor the number of reports.

DESCRIPTION:

The app allows users to report their lost fishing gear and for under-water cleaners to report when they have removed this gear from the seabed. It is visualized in a map but also in tables and other numerical and textual formats. It is created and run by the Norwegian Directorate of Fisheries and accessible by the public.

EFFORT IN TIME:

The app exists already. Retrieving the information from it, will require minimum amount of time.

NUMBER OF OBJECTS INVESTIGATED:

n/a.

DATA FORMAT:

Numerical

BASIC LITERATURE:

Fritidsfiskeappen. Fiskeridirektoratet.

<https://www.fiskeridir.no/Fritidsfiske/Meld-tapt-og-funnen-reiskap>

CONTACT PERSON WITHIN PRO-COAST:

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3.5. Transdisciplinary and participatory applications

As already described, standardized data collection is a major challenge, especially in the ecological field. Pro-Coast is also exploring new approaches to make data collection and data utilization more attractive and efficient for both scientists and local communities.

3.5.1. Reciprocal Environmental Decision Support (REDS)

CATEGORY:

Socio-cultural/Environmental/Spatial

PURPOSE OF THE METHOD:

REDS is software to improve land-use decisions at central levels (authorities and scientists) and local levels (communities and individual land managers) by improving the quality of and access to models of the effects of land-use change. This is achieved by Citizen Science and Environmental Decision Support being combined in a novel way (see Kenward et al., 2024).

EFFORT IN TIME:

A user can report data to scientists and reciprocally receive automated advice within minutes; but the process of the user-inputted data leading to better support could take months or longer.

NUMBER OF OBJECTS INVESTIGATED:

Potentially limitless. In the example of the Arne Case Study, we might expect a few hundred reports from the public.

DATA FORMAT:

Spatial data is collected from users, for example, locations of local micro-habitats and species sightings.

DESCRIPTION:

Consider two traditional forms of one-way data flow. Citizen Science is primarily from citizens to scientists. Environmental Decision Support (EDS) is primarily from scientists to citizens. So that EDS can be tailored to the specific needs of citizens with specific local circumstances, they typically describe their local circumstances, but this information is not retained in the system. REDS closes this loop: citizens provide data (species, detailed habitat, habitat management) to scientists, which is useful to the scientists and allows them to update their models, but in return, the citizens receive tailored EDS.



An example of how this will be used is from the Arne Case Study, which aims to re-establish native red squirrels. Control of non-native grey squirrels will be facilitated by citizen reports of sighting locations for grey squirrels, as well as citizens mapping the habitats in their gardens. In return, citizens will receive tailored advice about how their gardens could be improved to better support red squirrels, for example by maximizing native tree species corridors.

BASIC LITERATURE:

Kenward, B., Ewald, J., Casey, C., & Kenward, R. (2024) Reciprocal Environmental Decision Support (REDS): tailored support in return for data. Working paper. Available at [https://esug.sycl.net/file_link/00064/Reciprocal Environmental Decision Support \(REDS\) 6386 28676574933256.pdf](https://esug.sycl.net/file_link/00064/Reciprocal%20Environmental%20Decision%20Support%20(REDS)%20638628676574933256.pdf)

CONTACT PERSON WITHIN PRO-COAST:

First contact: Ben Kenward, ESUG. Other contacts: Robert Kenward, ESUG; Nick Casey, Anatrack.

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3.6. Reflection on Standardization in Interdisciplinary Case-Based Projects

Standardization is a cornerstone of scientific research, particularly in interdisciplinary and international projects. It ensures that data are collected, processed, and analyzed consistently, enabling comparability, transparency, and reproducibility. Given the complexity of our project, which integrates diverse methodologies such as surveys, environmental monitoring, and data from digital tools, a lack of standardization can lead to significant challenges in data integration and analysis.

To address these issues, a workshop was organized during the project, where participants explored the barriers to effective standardization and discussed practical solutions. The insights gained from this workshop have been synthesized into this chapter to provide a comprehensive framework for implementing standardization in research.

3.6.1. Principles of Standardization

Effective standardization is guided by three fundamental principles:

1. Consistency – Standardizing methods for data collection, processing, and analysis ensures that the same procedures are applied across different research units, creating a reliable foundation for scientific inquiry.



2. Comparability – Standardized data formats and methodologies enable meaningful cross-study analyses and meta-analyses, allowing researchers to uncover patterns and trends across diverse contexts.
3. Transparency – Clear documentation of methods, variables, and any deviations from protocols ensures that datasets are interpretable, reproducible, and usable for future studies.

These principles form the backbone of any effort to align methodologies across disciplines, ensuring that data from varying sources can be effectively harmonized.

3.6.2. Challenges in Standardization

Achieving standardization is not without its obstacles. Several challenges commonly arise in interdisciplinary projects:

a) Variability in Data Collection Methods

Research teams often employ different methods for collecting data, reflecting the diversity of disciplines and case study contexts. For example:

- Stakeholder surveys may use varying question formats, response scales, and sampling techniques, making it difficult to merge datasets into a unified framework.
- Environmental monitoring involves different tools, calibration procedures, and spatial scales, complicating efforts to compare findings.
- Digital tools may use distinct data structures and metadata standards, creating barriers to seamless integration.

b) Inconsistent Measurement Scales and Categories

Even when studying similar phenomena, discrepancies in scales and categorizations can hinder analysis. Common issues include:

- Different Likert scales (e.g., 5-point vs. 10-point scales) used in surveys.
- Demographic variables such as age groups or educational levels categorized inconsistently.
- Qualitative data coding varies significantly between researchers, limiting the ability to conduct aggregated analyses.

c) Lack of Metadata and Documentation

Comprehensive metadata are essential for understanding and integrating datasets, yet they are often incomplete or inconsistent. This can result in:

- Unclear data provenance, making it difficult to trace the origins and context of datasets.



- Insufficient documentation of methods, leading to challenges in replicating or interpreting results.

These challenges emphasize the need for clear guidelines and structured processes to standardize research workflows.

3.6.3. Strategies for Effective Standardization

To overcome these challenges, standardization can be implemented at two key levels:

a) Pre-Standardization: Aligning Methods Before Data Collection

The most effective way to ensure consistency is to establish standardized protocols before data collection begins. Key actions include:

- Developing standardized survey instruments with core questions and consistent variable definitions across case studies.
- Implementing uniform environmental measurement protocols, such as using calibrated tools and consistent field procedures.
- Defining shared data structures for digital tools, including metadata templates and unique identifiers to facilitate integration.

b) Post-Standardization: Harmonizing Data After Collection

When pre-standardization is not fully feasible, harmonization can align datasets retrospectively:

- Re-coding variables to standardize formats across different datasets.
- Normalizing data scales to allow for robust statistical comparisons.
- Enhancing metadata practices to document data attributes comprehensively, improving usability and reproducibility.

Both approaches are essential to ensure that datasets, whether newly collected or pre-existing, meet the standards needed for high-quality research outputs.

3.6.4. Best Practices for Sustainable Standardization

Building on the principles and strategies discussed, the following best practices can further enhance standardization efforts:

- Comprehensive Documentation: Ensure that all data collection methods, variable definitions, and deviations are fully documented.
- Use of Templates: Standardized templates for surveys, metadata, and environmental protocols help maintain uniformity across teams.



- **Iterative Refinement:** Continuously review and adjust standardization protocols to address emerging challenges or changes in research design.
- **Cross-Disciplinary Collaboration:** Engage researchers from diverse fields to align methodologies and address inconsistencies collectively.
- **Clear Communication:** Maintain open lines of communication among all project participants to ensure shared understanding of standardization goals.

Additionally, capacity building is critical to support sustainable standardization efforts. This includes investing in the development of skills, such as metadata management and harmonization techniques, and establishing robust infrastructures, such as shared databases and digital tools, to facilitate alignment. Supporting these efforts within the research community ensures that standardization becomes a collaborative and scalable practice.

3.6.5. Conclusion

Standardization is a dynamic and collaborative process that underpins the success of interdisciplinary research. By aligning methods and ensuring consistent documentation, researchers can overcome challenges related to data variability, inconsistent scales, and incomplete metadata. The principles, strategies, and best practices outlined in this chapter provide a roadmap for achieving robust and reproducible research outputs.

Through thoughtful standardization, projects can enhance data quality, facilitate cross-study comparisons, and maximize the impact of their findings on the broader scientific community.

3.7. Pre-registration in PRO-COAST – why and how?

3.7.1. Introduction

There are appreciable cross-disciplinary differences in the extent to which quantitative researchers engage in pre-registration - for example this practice is relatively common in psychology, but less so in sociology or political science (Ferguson et al., 2023). However, the advantages that pre-registration confers can apply across a wide variety of types of quantitative research, including in areas where it is not yet common (Dal-Ré et al., 2014; Simmons et al., 2021). The purposes of this chapter are therefore to (1) explain to PRO-COAST colleagues and other interested readers who are less familiar with pre-registration why it could be beneficial to engage in this practice in the project, and (2) suggest how a valid pre-registration could be made for the stake-holder questionnaire.



3.7.2. Why preregister?

There are multiple reasons for pre-registration, generally relating to ensuring that published results are more reliable. Within experimental psychology, it is well known that there is a problem with reliability of published results (Open Science, 2015), but the reasons for why some questionable practices might lead to poorer reliability of results generalise in ways that apply to other disciplines (Cova et al., 2021). Other disciplines might therefore be expected to have issues, even if they have not yet updated practices or subjected studies to replication attempts.

Two of the major problems which can occur in the absence of pre-registration, but are mainly avoided when pre-registration is used, are hypothesising after the results are known (HARKING; Kerr, 1998) and switching between different analyses in order to find one that provides a significant p-value (p-hacking; Stefan & Schönbrodt, 2023). In the remainder of this section, we first provide a reminder of how p-values relate to rejection of the null hypothesis and how this inevitably means that sometimes the null hypothesis will be rejected even though it is true (false discovery). This involves explaining how the selection of an α -value of 0.05 means that the false discovery rate should in theory be kept at 0.05, but also how the false discovery rate can be inflated through HARKING or p-hacking. We then explain how pre-registration minimises both of these problems.

Null hypothesis significance testing (NHST) is a common approach to statistical inference (Cohen, 1994). In NHST, a null hypothesis is posited which states that there is no effect or relationship between variables. An alternative hypothesis states that an effect or relationship does exist. A statistical test is then conducted, yielding a p-value. The p-value represents the probability of obtaining the observed data or more extreme data assuming the null hypothesis is true. If the p-value falls below a pre-determined significance level (α), typically set at 0.05, the null hypothesis is rejected and the finding is deemed "statistically significant." What this means is that the obtained data would be unlikely if the null hypothesis is true, so the researchers assume it is not true.

However, using an α of 0.05 means that even if the null hypothesis is true, it will be incorrectly rejected 5% of the time. This represents the false discovery rate - the expected proportion of statistically significant findings that are actually false positives. Importantly, the false discovery rate is tied to the α level, but only if certain conditions are met, namely that the statistical test was chosen ahead of time and conducted only once.

We now describe how the false discovery rate can become inflated above the nominal α level through questionable research practices like HARKING and p-hacking. It should be emphasised that such practices are not necessarily dishonest. They have been (and still are in some quarters) normal practices, carried out because of lack of knowledge of their consequences.



HARKing involves Hypothesizing After the Results are Known. This might be because a hypothesis is changed retrospectively to fit observed results – obviously problematic – but this also covers more common and less obviously incorrect practices such as beginning with a large list of hypotheses, and omitting in publication those for which significant results are not obtained. This common practice may feel more forgivable but will also inflate the false discovery rate.

As a related but different practice, p-hacking refers to conducting multiple alternative analyses on the same data and selectively reporting only those with statistically significant results. Both HARKing and p-hacking capitalize on chance, exploiting the fact that even if the null hypothesis is true, some analyses will yield significant p-values by chance alone. Whereas HARKing involves modifying the focal hypotheses, p-hacking involves modifying the analyses used to test them. Engaging in either of these practices therefore increases the likelihood of obtaining and publishing false positive results.

Pre-registration effectively eliminates the opportunity for both HARKing and p-hacking (Nosek et al., 2018). In pre-registration, the research hypotheses and planned analyses are specified ahead of time, prior to observing the data. Deviations from the pre-registered plan are not forbidden, but are discouraged, engaged in only for specific reasons, and highlighted when reporting the results. Since the analyses are pre-specified, there is no opportunity to cherry-pick an analysis that yields a significant p-value by chance. Moreover, since the hypotheses are stated up front, they cannot be reframed to fit the observed results. In this way, pre-registration constrains researcher degrees of freedom and greatly reduces the risk of false positive results.

Researchers can find that there are additional benefits to pre-registration beyond the controlling of the false discovery rate. It can be easier to specify details of analysis in the absence of data, because one is not subject to the types of dilemmas that can lead to p-hacking (experiencing different results with different variations of the analysis). In the context of our large multidisciplinary consortium, agreeing an analysis plan in advance has further obvious benefits. Then, when it is time to analyse the data, there is already a script to follow so the process is more straightforward.

Pre-registration does not disallow complementary exploratory analysis of a dataset. Indeed, new effects that may appear during exploration of our unusually detailed socio-environmental data should be adequately explored, with robust approaches to the setting of α levels to minimize misinterpretation based on false-positives. However, in a publication presenting both confirmatory (preregistered) and exploratory analyses, preregistered results are typically regarded as “privileged”, because the false discovery rate is controlled for those results, so they are considered more reliable.



3.7.3. How to pre-register hypotheses and analyses for the stakeholder survey

The primary PRO-COAST data-set that might be subject to a large variety of quantitative analyses is the stakeholder questionnaire. This chapter therefore now focuses on how pre-registration can in practice be implemented for this data-set. This approach might also be applicable for other analyses within PRO-COAST.

A pre-registration represents a record of intent to test certain hypotheses in a certain way that is time-stamped and hosted by an organisation independent of the researcher, so that it is independently verifiable that the registration is made prior to analysis of data. It is often regarded as acceptable to pre-register although data is already accessible to the researcher, as long as they have not in fact examined aspects of the data that pertain to the hypotheses. Trust is important, as in other areas of scientific practice. A pre-registration made by a PRO-COAST researcher, that provides a useful example for PRO-COAST as it concerns environmental attitudes in local communities, is available (Anon, 2022). Pre-registrations are often initially anonymous because this facilitates anonymous peer-review – they can be de-anonymised following acceptance of a publication.

Two commonly used pre-registration services are provided by aspredicted.org (Wharton Credibility Lab, n.d.) and osf.io (OSF, n.d.). Both of these services are operated by academic labs or consortia and are widely used and trusted. The first provides a more streamlined and simple experience, the second allows for more complex forms of registration. It is suggested that one of these services be chosen once the following process has been completed, which will determine whether a longer or shorter pre-registration is appropriate.

Preregistration Process Step 1: PRO-COAST researchers with an interest in the stakeholder questionnaire data contribute proposed hypotheses to a shared editable document.

Preregistration Process Step 2: Those researchers hold a discussion meeting focussed on deciding which of the hypotheses to pre-register. If there are many hypotheses, it may be necessary to exclude some hypotheses from pre-registration in order not to intend to test very many p-values (those hypotheses can still be examined exploratorily). This is because simultaneous testing of very many hypotheses is typically regarded as requiring correction of the α -value, otherwise the false discovery frequency is increased simply because many p-values are being examined (Benjamini, 2010).

Preregistration Process Step 3: Having decided which hypotheses to pre-register, the researchers responsible for each hypothesis write an analysis plan for that hypothesis, in coordination with each other



so that stages common to all analyses (e.g., data pre-processing) can also be pre-registered. An example issue to be resolved at this stage is that participant age data has been collected slightly differently in different case studies. There are different ways it could be harmonised, which might have different consequences for the analysis. Agreeing a harmonisation method in advance means that any given arbitrary choice is more defensible, as the impact on analysis results is not considered while making the choice, as is appropriate to avoid p-hacking.

Preregistration Process Step 4: The collaboratively created material is compiled together as a pre-registration on either aspredicted.org or osf.io.



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5. APPENDIX

Table A1: Overview of the tools based on their utility and applicability

Tool name	user group		Purpose (used for):				Supported other than in English			Usability in local communities				Ownership		
	scientists	non-scientists	Communication	Analysis	Social science	Ecology	No	1-10 languages	>10 languages	<1 h training	1-4 h training	>4h training	Used already	State	Private	Civic (non-profit)
Communication & Social Science																
Microsoft Word, Powerpoint	X	X	X						X	X			X		X	
Google communication tools (e.g. GoogleGroups)	X	X	X						X	X			X		X	
Doodlepoll	X	X	X	X	X				X	X			X		X	
Mail chimp	X	X	X					X		X			X		X	
MORPHmaster (Multilingual Online Restoration Project Hosting)	X	X	X				X			X			X			X
System for Community Liaison (inc. editing & forums)	X	X	X						X		X		X			X
Wikipedia (editing)	X	X	X						X		X		X			X
Three-Fold-Engagement Strategy for Behavioural Change in Biodiversity Conservation	X		X		X	X	X					X				
Eight-Step Framework for Sustainable Change	X		X		X	X	X					X				
Stakeholder mapping	X			X	X	X	X					X				
Stakeholder identification	X			X	X	X	X					X				
Activity template	X		X	X	X		X			X						
Stakeholder Survey	X			X	X	X	X				X					
EU-Survey	X	X	X	X	X				X		X		X	X		
Microsoft Forms	X	X	X		X				X		X		X		X	
1KA (one-klick-survey)	X		X	X	X				X			X	X			X
Instorier (storytelling tool for dissemination)	X	X	X		X	X		X			X		X		X	

Continuation of table A1 from the previous page: Overview of the tools based on their utility and applicability

Tool name	user group		Purpose (used for):				Supported other than in English			Usability in local communities				Ownership		
	scientists	non-scientists	Communication	Analysis	Social science	Ecology	No	1-10 languages	>10 languages	<1 h training	1-4 h training	>4h training	Used already	State	Private	Civic (non-profit)
Padlet (community tool)	X	X	X	X	X				X		X		X		X	
Analysis and ecological science																
Spreadsheets (Excel, GoogleDocs)	X	X		X	X	X			X	X			X		X	
SPSS statistics.	X			X	X	X			X			X			X	
R coding language.	X			X	X	X			X			X				X
Local ecological knowledge investigations (LEK)	X			X	X	X										
Environmental DNA metabarcoding (eDNA)	X			X		X										
Agouti: A platform for processing & archiving camera trap images	X	X		X		X		X			X		X			X
Quantum Geographic Information System (QGIS)	X			X		X			X			X				X
Google Earth Engine (GEE)	X			X		X			X			X			X	
Anatrack Mapper	X	X		X		X			X	X			X			X
eBird	X	X				X			X		X		X			X
ArcGIS	X					X			X			X			X	
SRNA CS (Application for Monitoring and Exploring Nature)	X					X	X			X			X			X
Fritidsfiskeappen (application for lost fishery gear)	X	X				X		X			X		X	X		
All categories																
Reciprocal Environmental Decision Support (REDS)	X	X	X	X	X	X				X			X			X

