Cost efficient development of nature-based impact assessments

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Introduction

Environmental Assessment (EA), a participatory *ex-ante* assessment framework for policies, plans, programs and projects, was created in the USA by the National Environmental Policy Act (NEPA) in 1969. Subsequently, it spread widely to jurisdictions of other countries, not just as EA (encompassing both, environmental impact assessment (EIA) of projects and strategic environmental assessment (SEA) of policies, plans and programs; but increasingly also as Health Impact Assessment (HIA), Social Impact Assessment (SIA) and numerous other types of impact assessment (IA) (Fischer *et al.,* 2023).

Known for being expensive, complex, long and ineffective to protect the environment for ongoing activities, EA/IAs are being target of simplification efforts. These initiatives frequently appear to relate to changing political agendas and responses to economic downturns (Bond *et al.* 2014). In this context, this paper aims to provide useful information regarding cost efficient methodologies to assess common environmental impacts, in a way typical datasets/surveys can be complemented without much more effort or even replaced.

Cost-Effective Nature-Based Solutions and Social Indicators: Assessing Environmental Impact

Environmental impact assessments traditionally focus on physical, biotic, and social fields. However, the inclusion of social indicators is crucial for a comprehensive understanding of the impact of cost-effective nature-based solutions (NbS) on the environment. This topic explores the integration of social indicators into environmental assessments and highlights the significance of considering socio-economic factors for successful regional development.

Biotic and Physic Matrixes

Biodiversity has evolved from net zero to net positive impact, with evolution from hectare impacted x hectare restored to insert quality into the equation and increasing the 1:1 balance. Latest best practices correspond to net positive impact (NPI) to effectively contribute based on its own impact assessment and it is not reduced to area footprint. It also may include species conservation projects, restoration efforts, germplasm conservation and ecosystem services.

Climate Change also has evolved from neutral or net zero projects to positive impact, with projects and initiatives with carbon sink targets with carbon capture and storage techniques; multiple projects inform that are not only green but with alternative energy generation and best practices approach can really sink carbon and contribute to the global warming joint effort.

Socioeconomic Matrix

The socioeconomic matrix is a complex framework that encompasses social economic information, material and immaterial heritage, and multiple issues as health, education, cultural, traditional knowledge, governance and politics. It significantly influences regional development and the success of NbS projects. Social economics have a much greater complexity and changes overtime.

There is an interconnectedness of social indicators with these factors and emphasizes the need to improve general indicators such as the human development index, commonly used to compare socialeconomic development. Another key indicators as life expectancy, violent deaths, newborn deaths per thousand of births, and hunger and famine percentage rates combined are much more powerful indicators. To achieve a complete

and integrated net positive impact, sustainability and social-environmental programs must effectively contribute to improving these indicators over time.

A project, initiative or policies cannot be considered sustainable if they reach carbon and biodiversity positive impacts, but the region overtime decrease social economic indicators driven by multiple factors are local inflation or violence increase.

Cost-efficient indicator (Vaclav, 2021):

- Childhood mortality, the number of deceased within the first year of life per thousand is a powerful indicator.
- It is impossible to obtain a low index without a multiple critical combination of conditions that define good life quality: good health services and newborn and related healthcare, adequate nutrition, sanitary and hygiene conditions, social care to vulnerable families.
- As primary data, age, weight, height, are simple and can demonstrate the nutrition status of a region.

The infrastructure and public services impacts must not be left as externalities. NbS projects should not neglect these aspects, as they directly impact the success of social-environmental programs. The inclusion of risk reduction, mitigation, and compensation measures is crucial to ensure the overall effectiveness of NbS in addressing environmental impact and promoting sustainable development.

By incorporating social indicators into environmental impact assessments, we can better understand the holistic impact of cost-effective nature-based solutions. This comprehensive evaluation allows for a more nuanced understanding of the effectiveness of NbS in promoting regional development and improving socio-economic conditions. By considering infrastructure, public services, and promote socioeconomic overall development, NbS projects can maximize their positive impact and contribute to a sustainable future. We can call it Net Sustainable Positive Impact, NSPI, an integrated approach of net positive matrixes.

Air pollution Impact Assessment

Air pollution is one of the main issues existing in urban areas, being characterized by the presence of toxic gases and metal pollutants, the latter of which is generally associated with emissions of particulate matter (PM) from industries or automotive vehicles.

Biomonitoring is a method that can be used to assess air pollution levels because it makes it possible to determine what effects these air pollutants cause in living organisms and their responses. The species *Lolium multiflorum*, known as ryegrass, is considered a good bioindicator of metals, since it accumulates these substances during exposure (Illi *et al*., 2016).

In a study in southern Brazil, ryegrass individuals were grown in a controlled environment and then exposed to four locations with different degrees of urbanization, besides a control site (CS): a semi-urban area - 10 km from a highway and urban areas - 5 km, 200 m and 60 m from the highway. PM 2.5–10 and PM2.5 were collected monthly for 24-h periods at the sampling sites and particles were identified by scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS).

At the Control Site (CS), all the metallic elements analyzed showed medians lower than the values identified at the other sampling sites. In general, Al, Fe, Mn, Zn, and Ba showed the highest median values in all the four sampling sites.

Using Principal Component Analysis (PCA), it was possible to identify three principal components, labeled as follows: PC1 - Earth's crust (strong positive loadings for elements Fe and Al and associated with natural sources of emission, such as resuspension of dust from the soil), PC2 - traffic/industry (association with the

elements Cu, Zn, and Ni and related to vehicle and industrial emissions, such as combustion of fuels, abrasion and wear of metallic parts, and industrial processing of metals), and PC3 - traffic (characterized by the presence of Ba and Mn, and to a lesser extent Cr, and related to abrasion and wear of metallic parts) (Illi *et al*., 2016).

The different levels of anthropization, identified at the four sampling sites, demonstrated the degradation of air quality as well as the effectiveness of the use of bioindicators (i.e., *L. multiflorum*). Furthermore, the use of *L. multiflorum* is a low-cost method, easy to apply, and can be used worldwide as an evaluation tool of the effects of air pollutants in urban, semi-urban, and rural areas and can be used complementarily to other standard methods of investigation of air quality (Illi *et al*., 2016).

Traditionally, air quality mapping involves equipment or station allocation to explore data and high costs but usage of biomonitoring to explore locations is an easy and simple solution to identify hotspots to concentrate efforts in areas of need, which can be later monitored by standard methods for confirmation and detailing.

Biological Signature - Fauna and Flora Survey using eDNA

Environmental DNA or eDNA describes the genetic material present in the natural environmental as sediment, water, and air, including whole cells, extracellular DNA and potentially whole organisms (Ruppert *et al.,* 2019).

E-DNA can be captured from environmental samples and preserved, extracted, amplified, sequenced, and categorized based on its sequence. eDNA may come from skin, mucous, saliva, sperm, secretions, eggs, feces, urine, blood, roots, leaves, fruit, pollen, and rotting bodies of larger organisms, while microorganisms may be obtained in their entirety (Ruppert *et al.,* 2019).

Despite being a relatively new method of surveying, eDNA has already proven to have enormous potential in biological monitoring. Conventional methods for surveying richness and abundance are limited by taxonomic identification, may cause disturbance or destruction of habitat, and may rely on methods in which it is difficult to detect small or elusive species, thus making estimates for entire communities impossible (Ruppert *et al.,* 2019). eDNA can complement these methods by targeting different species, sampling greater diversity, and increasing taxonomic resolution (Deiner *et al.,* 2017).

This process involves metabarcoding, which can be precisely defined as the use of general or universal polymerase chain reaction (PCR) primers on mixed DNA samples from any origin followed by high-throughput next-generation sequencing (NGS) to determine the species composition of the sample (Ruppert *et al.,* 2019). This method has been common in microbiology for years, but in recent years it has been used to assess macroorganisms as fauna *specimens*.

Ecosystem wide applications of eDNA metabarcoding have the potential to not only describe communities and biodiversity, but also to detect interactions and functional ecology over large spatial scales. It also presents superior species detectability, requires lower effort, causes no ecosystem disturbance, allows detection without a priori knowledge of species, and can be implemented in areas where traditional surveys are impossible (Ruppert *et al.,* 2019). Limitations, however, may be linked to false readings due to contamination or other errors.

Metabarcoding can be used to reconstruct ancient ecosystems from DNA found throughout the world, to explore the interconnectedness between plants and pollinators, to assess diet without need for feeding observation or stomach flushing, to detect invasive species before they could possibly be detected via traditional means, to determine community responses to pollution, and even to assess air quality and its implications for human health (Ruppert *et al.,* 2019).

In addition to the biological signature, the chemical signature can also be used to identify the contribution of a certain process/activity, whether natural or not, in the environmental matrices. As an example, there is the chemical composition of sediments, which can be used as a simplified tool for managing watersheds.

Statistical methodology to simplify monitoring of mineland rehabilitation status

Impact of mining operations are mitigated by Ecological restoration, in which is developed a partial restitution of biodiversity and ecosystem structures, functions and services of original ecosystems. To monitor status through time many environmental variables are assessed, representing herculean effort of analysis, manpower and resources. In an iron mining in Carajás National Forest, eastern Amazon, Brazil, was developed a study with the objective to select potential indicators of environmental quality of iron mining waste piles undergoing rehabilitation.

Among 27 variables, including vegetation structure, community composition and diversity, and ecological processes, the Shannon index of tree diversity had the highest predictive power for overall rehabilitation status, qualifying this metric as the most effective indicator for the use in future comprehensive monitoring activities in waste piles undergoing rehabilitation in the Carajás National Forest; moreover, it will simplify and reduce the cost of more comprehensive monitoring activities in minelands undergoing rehabilitation in the future (Gastauer *et al.,* 2021).

The positive relationship between tree diversity and mineland rehabilitation status in the examined areas emphasizes the importance of diverse tree communities in increasing rehabilitation success and ecosystem and soil functioning over short time periods, showing it is a good bioindicator, but also highlights statistical methodology applicability in point out the most efficient variable to monitor (Gastauer *et al.,* 2021).

Statistically sound analyses to validate the selection of environmental variables for environmental assessments encourage similar approaches in cases without binding standards regarding which or how many environmental variables are required monitor rehabilitation or restoration activities. The identification of effective indicators to monitor rehabilitation activities may further contribute to more efficient environmental assessments in future monitoring projects (Gastauer *et al*., 2021).

Ecoacoustics

To quantify and monitor animal biodiversity, diversity indices are usually used, calculated from data obtained by conventional means of sampling, such as observation of footprints and traces, as well as capture and tagging, among others. However, these methods demand prolonged sampling time and effort, as well as substantial financial resources.

Ecoacoustics enables the study of biological diversity through the analysis of sounds in an environment, with low cost and easy data processing. Currently, Ecoacoustics is characterized by three basic components: biophony (biological sounds), geophony (ambient sounds) and anthropophony (sounds resulting from human activities), which enables analysis of the reflections of man's interactions with the natural environment.

By recording sounds, it is possible to identify the fauna of a given environment and obtain ecological indices. However, the acoustic indices are not enough to quantify all the animal diversity of a community, as some species are not sonorous or present an occasional and/or little diverse sound repertoire.

In a study by Soares (2023), it was designed a preliminary way to describe the different components of the terrestrial acoustic landscape of the coastal sandsoils vegetation (*restinga*) in the extreme south of Ilha Comprida, in the south of the State of São Paulo. The specific objective is to estimate the biological diversity from the different biophonic components. As a result, the presence of birds, insects, amphibians and mammals such as bats was observed.

Key Messages

- **Cost Effectiveness:** Addressing cost effectiveness is crucial for efficient economic allocation.
- **IA Expertise:** IA expertise is the primary factor influencing the quality of IA, EA, mitigation measures, and their positive impacts.

- **Methodologies:** Exploring and combining alternative methodologies can lead to cost reduction.
- **Consultancy Costs:** Increasing consultancy costs over time can potentially hinder IA effectiveness.
- **Resource Allocation:** Allocating key resources towards impact mitigation and sustainable development is essential.
- **Choosing the Right Tool:** Selecting the appropriate tool is paramount for effective impact assessment.
- **NSPI – Net Sustainability Positive Impact approach:** to integrate multiple socioeconomic KPIs to monitor projects and initiatives within broad and multiple sustainability aspects.

Effective impact assessment requires a focus on cost effectiveness, leveraging IA expertise, considering alternative methodologies, monitoring consultancy costs, prioritizing resource allocations for mitigation, and making informed decisions regarding the choice of assessment tools.

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