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Nature based solution to climate change: Ecosystem based adaptation: How effective for climate change strategies?

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Abstract
Climate change is produced by a shift in the planet's energy balance, which determines how much of the energy from the sun that enters the earth (and its atmosphere) is released back into space. The planet gains energy when we lower the quantity of solar radiation reflected into space, just as individuals gain weight when there is an imbalance between calories in and calories out [1]. Climate change is an important thing that we must note, the climate may change but in the change there are things that we must consider, namely about the impact of climate change, this is related to SDG 13 which seeks to combat climate change and overcome its impacts. The SDG 13.1 target specifically aims to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters. Such events represent the cutting edge of climate change. The frequency and intensity increase. There are many ways to mitigate and adapt to climate change some that we can do by apply of Nature Based Solution to Climate change and Ecosystem based adaptation that can be expected to play an effective role in climate change mitigation strategies. In addition, there are several things that must be considered in terms of social, environmental and also economic so that what we apply in handling climate change can be optimal and work well, the object in this discussion is about Nature Based Solution and Ecosystem Based Adaptation how effective it is to overcome climate change problems by using several methods such are measurements, vulnerability, a case, tools, several data and evidence that ultimately in this discussion proved that both are very helpful and effective in adaptation and mitigation to climate change. Nature based solution and ecosystem based adaptation are both things that cannot be separated because both are one part that has the same function in one way of handling climate change.
Keywords: biodiversity; climate change; ecosystem based adaptation; mitigation and adaptation; nature based and impact; nature solution based

1. Introduction

Climate change encompasses the variability of the climate system, affecting the atmosphere, biogeochemical cycles (Carbon cycle, Nitrogen cycle, and Hydrological cycle), land surface, ice, and the biotic and abiotic components of Earth. The notable consequence of climate change is global warming, characterized by a temperature increase. Greenhouse gases (GHGs) like carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) primarily contribute to global warming. This phenomenon is a subject of interest across various disciplines, from social science to applied science. Recent climate extreme events, including heatwaves and altered rainfall patterns, pose threats to global climate cycles and world food production systems. Mitigation and adaptation measures are imperative for risk reduction and minimizing the impacts of climate change, requiring global cooperation and sustainable actions (Ahmed, 2020).

Communities highly dependent on natural ecosystems for livelihoods face tangible impacts from environmental and climatic changes. Integrating climate change adaptation strategies into national development planning is essential. While traditional "hard" engineering solutions like coastal defenses are favored by some governments, they may prove unsustainable in the long term. Natural ecosystems, such as forests and wetlands, play a crucial role in supporting livelihoods by providing essential services like food, water, and building materials. Ecosystem-based Adaptation (EbA) emerges as a promising approach, relying on biodiversity and ecosystem services to enhance community resilience to climate change impacts (Ilieva, 2019). This approach considers equity, gender, and local knowledge as critical elements in effective adaptation efforts.

Ecosystem-based Adaptation (EbA) is gaining attention for its potential to reduce vulnerability to climate change impacts, providing social and economic benefits. Examples of EbA measures include coastal habitat restoration, agroforestry, and sustainable forest management, utilizing nature to decrease vulnerability. These measures aim to secure ecosystem functions and services, promoting resilience in the face of climate change (Ilieva, 2019).

Nature-based solutions (NbS) involve actions that work with and enhance nature to address societal issues, providing benefits to both humans and the environment. NbS encompasses various approaches, including ecosystem-based adaptation, disaster risk reduction, and forest and landscape restoration. The collaborative role of NbS in addressing climate and biodiversity issues is a primary focus. Natural habitats serve as NbS for climate by sequestering carbon or enabling adaptation to climate change consequences. Despite its advantages, NbS should complement, not replace, other climate and conservation initiatives. While NbS can contribute to achieving Net Zero goals and provide economic benefits, they are not a standalone solution, and their broad-scale implementation is crucial for significant climate change mitigation (Stafford et al., 2021). In alignment with the provided description, WWF has identified five key characteristics for effective nature-based climate change solutions.

Figure 1. Five key principles for nature-based solutions for climate change (Wilhelm et al., 2015)

Nature-based solutions (NbS) play a pivotal role in enhancing climate change adaptation and mitigation efforts, ensuring synergy with essential net-zero energy, food, urban, and infrastructural changes. Understanding the impact of climate change on nature is crucial for improving ecosystem functioning and managing associated risks effectively (Wilhelm et al., 2015). NbS, inspired by or imitating nature, address environmental, social, and economic concerns sustainably. These solutions utilize nature's characteristics and complex processes to achieve desired outcomes such as reduced catastrophe risk, improved human well-being, and socially inclusive green growth. The maintenance and enhancement of natural capital are critical foundations for implementing effective NbS, which are energy-efficient, resource-efficient, and adaptable to change, contingent upon local circumstances (Seddon et al., 2021).

The concept of NbS has gained popularity as an integrated approach to address climate change and biodiversity loss while supporting various sustainable development goals (UNEP, 2017). These actions involve protecting, restoring, or managing natural ecosystems, sustainable management of working lands and aquatic systems, and creating novel ecosystems. Well-designed NbS, as supported by a growing evidence base, can deliver multiple benefits, including climate change adaptation, carbon sequestration, biodiversity protection, and enhanced urban resilience (UNEP, 2017).

Climate change adaptation focuses on assisting communities and businesses to thrive amidst a changing climate. Ecosystem-based adaptation (EbA) has emerged as a concept harnessing nature's ability to protect human societies from the negative effects of climate change through sustainable delivery of ecosystem services (Munang et al., 2013). EbA involves focused management, conservation, and restoration actions, aiming to decrease climate change exposures by leveraging specific ecosystem services. For example, mangrove forests and coastal marshes can buffer storm surge energy, offering protection to coastal communities against the increasing frequency of tropical storms due to climate change (Reid et al., 2019).

Ecosystems provide services that can meet adaptation needs across various human development sectors, including disaster risk reduction, food security, sustainable water management, and livelihood diversification. EbA offers multiple co-benefits, such as carbon sequestration, social, economic, and cultural advantages, contributing to long-term economic growth and resilience against climate change (Reid et al., 2019). EbA aligns with policy objectives for society and the environment, offering wins for climate change adaptation and mitigation, environmental and biodiversity conservation, and long-term economic prosperity. Despite mounting evidence, national governments have yet to fully grasp and harness the potential of EbA (Munang et al., 2013).

The CBD defines Ecosystem-based Adaptation (EbA) as the utilization of biodiversity and environmental services within a broader plan to help people adapt to the adverse consequences of climate change. This involves four key components: the use of biodiversity and ecosystem services, assistance to others, preparation for climate change, and integration into a comprehensive adaptation plan. Neglecting nature or people, repackaging old work without addressing climate change, or considering EbA as a stand-alone activity undermines its effectiveness (Wilhelm et al., 2015).

Figure 1

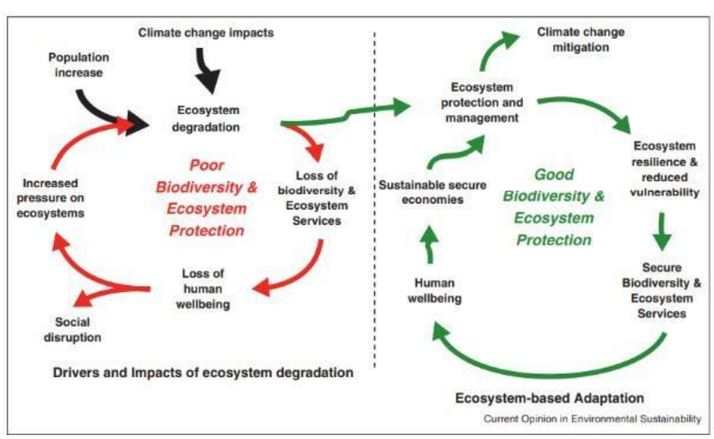

Figure 2. Beating the vicious cycle of poverty, ecosystem degradation and climate change

The global climate is undergoing rapid changes, with climate change mitigation and adaptation ranking among the top five global risks since 2015. Ecosystem-based adaptation (EbA) is recognized as the use of biodiversity and ecosystem services for climate change adaptation within an overall strategy. It falls under the umbrella of nature-based solutions, providing an integrated approach to climate change and poverty challenges in developing countries. EbA has gained endorsement from international bodies, including the IPCC, the Sendai Framework for Disaster Risk Reduction, and the United Nations Environment Assembly (Seddon et al., 2020).

As the data supporting Nature-based Solutions (NbS) effectiveness grows, ecosystems are gaining attention in international climate change policy forums. The Paris Agreement highlights the importance of ecosystems for both mitigation and adaptation. Ecosystems play a crucial role in assisting people in adapting to climate change due to their direct reliance on ecosystem commodities and services. However, maintaining the full range of ecosystem services poses challenges, as trade-offs may occur, impacting crop productivity, fuel wood production, and other services. Effective adaptation interventions require a thorough understanding of dependencies and interlinkages within social-ecological systems, considering both climatic and non-climatic degradation processes (Seddon et al., 2021).

NbS have the potential to protect humans from climate change effects, limit future warming, sustain biodiversity, and safeguard ecosystem services. However, concerns about their dependability, cost-effectiveness, and resistance to climate change need systematic evaluation. Trade-offs and potential maladaptation may arise if policies supporting NbS lack biodiversity value. Addressing the financial and governance hurdles of deploying NbS at scale is essential, along with the need for evidence-based implementation. Collaboration between natural and social scientists and policymakers is crucial to ensure NbS realize their full potential in addressing climate and biodiversity crises while contributing to long-term prosperity (IUCN, 2020).

Climate change is a primary cause of ecosystem deterioration and loss, impairing nature's ability to address civilization's challenges. Integrated nature-based solutions are needed to address both adaptation and mitigation across diverse sectors, goals, and difficulties. Integrating grey with green and blue infrastructure is a strategic opportunity area, enhancing traditional management methods with nature-based solutions. Improved natural resource management through "zero waste" production, viewing waste as a resource, and investing in innovative ways like bio-inspiration and biomimicry are crucial aspects. Investing in low-cost, low-maintenance, and low-carbon-emissions climate change mitigation solutions can increase cost-effectiveness in addressing social, environmental, and economic concerns (Seddon et al., 2021).

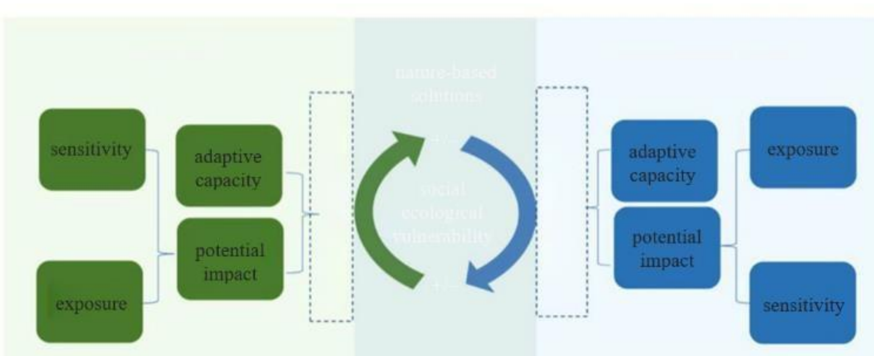

Figure 3. Integrating NbS to climate change impacts into the social–ecological vulnerability framework

Ecosystem exposure refers to the extent of systems being subjected to various pressures such as floods, droughts, landslides, and fires. Determinants of ecosystem exposure include the intensity, duration, and frequency of events, geomorphology, and the extent of natural resource use and management by human societies. Ecosystem sensitivity gauges the degree to which the structure and function of an ecosystem alter due to perturbations. The combination of ecosystem exposure and sensitivity gives rise to potential impact, which is mitigated over time by the adaptive capacity of the ecosystem. Factors influencing sensitivity and adaptive capacity include diversity, heterogeneity, connectedness of the ecosystem, and the characteristics of its component species and habitats. Overall ecosystem vulnerability is shaped by the interplay of potential impact and adaptive capacity, ultimately affecting the delivery of ecosystem goods and services crucial for people and economies. Ecosystem vulnerability, in turn, impacts socioeconomic vulnerability, reflecting the extent to which the social system is adversely affected by change. Socioeconomic sensitivity is further influenced by social, political, and economic factors, such as corruption, low levels of health, education, employment, and a lack of economic diversification. Socioeconomic adaptive capacity, which can moderate potential impacts, involves the ability to innovate, improve health, education, and find alternative sources of income. Nature-based Solutions (NbS) integrate these elements and, if implemented properly and equitably, can reduce social-ecological vulnerability (Wilhelm et al., 2015).

In a case study demonstrating the benefits of biodiversity, the use of NbS for large-scale coastal re-alignment in the United Kingdom is highlighted. The Medmerry project involves controlled realignment of coastal protection infrastructure, combining natural coastal vegetation with the realignment of built infrastructure to retreat and relocate the shoreline inland. This approach allows floods to penetrate deeper inland, reducing the risk of flooding in neighboring communities. The initiative has transformed the ceded property into a biodiversity hotspot for various species. The project employed systematic scientific studies, drawing lessons from engineered infrastructure failures, costs associated with natural disasters, and input from local stakeholders, including 360 residents and property owners. The realignment program, co-managed by the government and local stakeholders, emphasizes utilizing previous trials and experiences to influence continued implementation (Seddon et al., 2019).

Case studies exemplifying best practices for incorporating NbS into Nationally Determined Contributions (NDCs) showcase a variety of techniques, geographic coverage, and lessons for other nations. These examples exhibit strong dedication to NbS by declaring climate impacts on ecosystems, emphasizing the protection of ecosystems and biodiversity, articulating an overarching vision for climate change policy that includes NbS, and outlining NbS actions addressing declared vulnerabilities. They incorporate quantifiable, time-bound NbS initiatives in both mitigation and adaptation components, recognizing synergies between these efforts. Costed plans for NbS are also presented in some instances. Additional examples and details can be found in national factsheets accessible through the Nature-based Policy Platform (Raymond et al., 2017).

2. Methods

This journal employs literature review and descriptive analysis as its methodologies. The literature review involves gathering information on Nature-based Solutions (NbS), implementation, and future challenges. It encompasses references focusing on NbS as mitigation and adaptation measures for climate change. The research utilizes sources such as the internet, academic papers, proceedings, and journal articles from national and international contexts, all centered on the topic. Descriptive analysis is also applied in the research (Wilhelm et al., 2015).

2.1. Single Effect

The assessment of environmental consequences primarily relies on measuring and describing physical factors like temperature, pollutant concentration, or morphological traits. However, these solutions may not always be accessible or can be challenging and costly to implement. Health indicators, for instance, often require specialized equipment to measure cortisol levels. Models, such as the iTree Eco model, can analyze potential consequences based on factors obtained from various settings, offering a database with values on ecosystem services generated by tree species in different climatic zones (Wilhelm et al., 2015).

2.2. Aggregation of Impacts

To support decisions between various Nature-based Solutions (NbS) or alternative investments, the costs and benefits of each option need aggregation. Economic (monetary) assessment methods are commonly used for this aggregation, considering all monetary costs and expected benefits. Cost-Benefit Analysis (CBA) typically considers costs and benefits directly connected to investors, while Social Costs and Benefits Approach (SCBA) includes wider societal costs and benefits. However, challenges arise in assessing non-economic values, such as environmental and social benefits, measured in physical parameters or qualitative judgments, making monetary aggregation difficult. Researchers and practitioners need to recognize the importance of diverse assessment processes, including qualification, quantification, aggregation, and standardization. Multi-criteria analysis methods, allowing assessments based on mixed methods, support consideration of different scales and measures, providing a more comprehensive evaluation (Wilhelm et al., 2015).

2.3. Long-term Measurement and Monitoring

Continuous monitoring of impacts from Nature-based Solutions (NbS) is essential due to the uncertainty associated with NbS behavior in complex urban systems. Monitoring ensures the efficiency of NbS over longer time frames and adapts to changing external conditions, including climatic changes. It also facilitates learning loops to enhance future installations (Wilhelm et al., 2015).

2.4. Thresholds

Various spatial and administrative scales have diverse thresholds for different indicators. Evaluating thresholds for NbS effectiveness should be linked to the local environment, where it is more appropriate to set them, particularly in the absence of legislative norms. Identifying "critical thresholds" in relation to key indicators aids in adaptive strategies, pinpointing instances requiring modifications in NbS design or the introduction of new solutions (Wilhelm et al., 2015).

3. Results and Discussion

3.1. Actions and Impacts

Assess the synergies and trade-offs of Nature-based Solutions (NBS) for specific objectives within and across climate resilience challenges. Note the full range of synergies and trade-offs across socio-economic, socio-cultural, climate, biodiversity, and ecosystem domains, using both ecosystem service assessments and other forms of environmental and social science inquiry. Identify and analyze the co-benefits and costs of NBS within and across climate resilience problems, considering the interdependence of socioeconomic, sociocultural, biodiversity, and ecological factors. This includes components of inter-economic and intercultural relationships between the economy and biocultural variety, intercultural and interspecies cooperation between ecology and social justice and social cohesion, and intergenerational partnership between justice/cohesion and economy. Model and quantify the potential for positive and negative NBS impacts within and between challenge sets, as well as across multiple temporal and geographic scales, including how their efficacy evolves over time.

Focus on NBS coproduction to go beyond a limited knowledge of the ecosystem's instrumental advantages for human well-being to a more comprehensive understanding of the function of NBS in repairing and maintaining parts of socioecological systems. Develop, in tandem with the NBS plan, a flexible management strategy that takes into consideration the changing nature of the implemented NBS, society, and urban ecology over time. Make a socio-spatial evaluation of inhabitants who gain the most and least from NBS initiatives to remedy any unplanned or unexpected disservices, taking into account social exclusion or disparities.

3.2. Indicators

Determine the relevance and sensitivity of indicators across geographic scales to inform NBS upscaling. Create multi-metric indicators capable of assessing the possible effect and co-benefits of NBS on different issues from a quantitative and/or qualitative standpoint, perhaps to be used as proxies for overall change in resilience (environmental, social, and economic). Develop indications of how the living component helps to improve the operation and resilience of constructed systems where NBS blend natural and artificial tools, and vice versa. Conduct longitudinal studies to test the internal and external validity of indicators over time, as well as their dependability in the face of various socioecological forces such as climate change and migration. Wherever feasible, employ standardized indicators per unit of area and/or unit of time that can be easily compared across different projects and case studies, as well as used to scale up. Combine indicator systems to map and analyze co-benefits of NBS initiatives. Consider integrating qualitative and quantitative indicators to evaluate tradeoffs across NBS project difficulties. Consider quantity and quality factors in NBS assessments using both exploratory and explanatory indicators. Consider the external validity of indicators across climate resilience problems and cross-cultural contexts. Determine the relationship between thresholds established by legislation and regulations and the performance of indicators relevant to NBS development programs.

3.3. Methods

Create novel modeling approaches for measuring the predicted consequences of NBS across various challenge scenarios and throughout time. Create models that can anticipate the state of NBS and their predicted implications in the future (long term), while also taking into consideration changes in the surrounding environment. Develop novel approaches for bridging qualitative and quantitative indicators, as well as their appraisal, that may be applied in a variety of urban environments. Develop new connectivity analytic methodologies to better understand how NBS help conserve and improve existing, modified, and new natural spaces. Use multidisciplinary, mixed methods research approaches to investigate and explain the effects of NBS inside and across climate resilience concerns. Utilize the urban-rural gradient as a unique technique to examine NBS implementation across various environmental and sociocultural contexts, as well as their efficacy in improving the original deteriorated status.

3.4. Governance, Communication, and Engagement

Develop new participatory planning and governance processes to engage multiple stakeholders in NBS assessment and to weave multiple types and systems of knowledge into NBS assessments. Develop new participatory planning and governance processes to bring to the surface perceptions, values, and elements of ecological memory that can enable the creation of a sense of place through an NBS project in neighborhoods and city areas. Create multi-stakeholder international networks on NBS planning and implementation with the scope of transferring successful approaches from one country to another or from one case study to a wider community. Develop new education and learning initiatives to promote literacy about

NBS impacts and climate resilience among citizens. Introduce specific thresholds in international or national legislation about the requested investment in NBS for climate resilience in urban areas.

4. Conclusions

This investigation has elucidated specific measures that may be employed to address individual climate resilience challenges, and the utilization of indicators to gauge the effectiveness of such efforts. The potential interactions between Nature-Based Solutions (NBS) activities necessitate inclusion in NBS evaluations. Indicators applicable to diverse NBS impacts can be pertinent to various climate resilience concerns. Thus, an in-depth analysis of the ramifications of NBS on distinct systems, encompassing socioeconomic, sociocultural, and ecological aspects, becomes crucial, considering spatial and temporal scales. The relevance of indicators varies with geographical scales, underscoring the importance of independently addressing regional, metropolitan, urban, street/neighborhood, and building impacts. An evaluation of NBS impacts in the short, medium, and long term is imperative, requiring systems that extend beyond project completion. NBS effects exhibit multidirectional complexity, incorporating synergies and tradeoffs across environmental and sociocultural facets. Comprehensive examination of multiple challenge areas concurrently, with the active involvement of all stakeholders, can optimize the benefits provided by NBS for environmental, sociocultural, and economic services.

Beyond the assessment phase, consideration of each factor is imperative before adopting NBS, aligning with the specific issues of the region under investigation. Crucial subjects for future exploration and application have been identified, with limited attention in the literature given to the regional and temporal aspects of NBS effects. While environmental impacts have received substantial scrutiny, little research has focused on assessing potential co-benefits, synergies, and tradeoffs across sociocultural, socioeconomic systems, ecosystems, biodiversity, and climate elements. Addressing these gaps necessitates interdisciplinary approaches and the development of tools for assessing synergies and tradeoffs outside the realm of ecosystem services. Coproduction processes involving various knowledge types and systems are vital to managing ecological and social complexity.

Despite the primary focus on NBS performance analysis in this research, there is a notable emphasis on integrating NBS into international, national, and regional strategy and planning documents. Implementation of an effective NBS strategy could set diverse objectives, promoting NBS use across Europe and implementing them through existing legal, regulatory, and financial instruments. An essential research gap exists in understanding how to integrate NBS effect evaluation with implementation, requiring coproduction processes to bridge these traditionally independent sectors. This integration entails considering specific resources (natural, constructed, financial), capacities, and agency needed for various NBS forms, along with the environmental, social, and economic co-benefits.

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Author Contribution

Conceptualization, Methodology, Software, Validation, Formal Analysis, Investigations, Resources, Data Curation, Writing – Original Draft Preparation, Writing – Review & Editing, Visualization, A.O., and Y.I.M.

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