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Sustainable Development Goals

13 CLIMATE ACTION

Nature-Based Solutions Handbook

By the Global Council on SDG13 – Climate Action

June 2022

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1. Introduction

Lake Sawa, a Ramsar site once known as the "the pearl" of South Iraq is the most recent victim of a reality faced by the entire Middle East and North Africa (MENA) Region: severe climate change impacts and mismanaged natural resources. The scenic water body with cultural, religious, and economic significance has run dry for the first time in centuries (AP, 2022). Fortunately, while the dry state of the lake is not a permanent one, many such sensitive, interdependent ecosystems in the MENA Region suffered irreversible consequences, feeding into a cycle of environmental degradation that further enhances and catalyses the effects of climate change.

In fact, the MENA Region is considered a high-risk of impact by climate change region compared to other areas of the world due to a multitude of reasons, both environmental and socioeconomic. This is because of the overall water-stress of the region, which is the highest in the world, the increased risk of desertification of various ecosystems and croplands which increases region dependence on food imports and impact from food supply shocks – as demonstrated by the Ukraine-Russia conflict – and the high coastal population and economic activity of the region which would be displaced as a result of rising sea levels (Chibani, 2022). What further debilitates the region is the lack of concern for issues such as climate change or the environment due to the regional population's focus on non-climate stresses such as conflict, corruption, and employment struggles (Arab Barometer, 2022).

This is where the role of nature-based solutions (NbS) is amplified. Recognising the importance of protecting and preserving nature and restoring many elements of it could aid in curbing the gravity of many impacts of climate change. NbS can also reduce the overall carbon footprint of the region and decrease its contributions to greenhouse gas emissions and its propagation of climate change. There are several opportunities to implement projects with these objectives across the whole region, especially when discussing restorative and new ecosystem developments. Several factors, though, hinder and stunt the growth and prevalence of NbS across the MENA region, mainly the lack of legislative and regulatory frameworks pertaining to NbS, the funding gap and diminished desirability of investing in NbS, and most importantly a general lack of awareness amongst key stakeholders that should be addressed if NbS are to become mainstream.

1.1. Goals of This Handbook

Acknowledging the NbS gaps that need to be bridged in the MENA region, this handbook is produced as a guide to understanding the necessary steps to unlocking the full potential of NbS to address a variety of environmental, socioeconomic, political, and cultural issues. While this handbook will briefly reiterate the types, advantages, and challenges of NbS, the purpose of it will focus on:

- Highlighting unique case studies from around the world that demonstrate the impacts of effective implementation of NbS
- Discussing the necessary frameworks that need to be developed to facilitate the implementation of NbS
- Addressing funding and investment gaps and the business case that could be made for NbS to attract investors
- Leveraging the two regional COPs (COP27 in Egypt, and COP28 in the UAE) to promote the need for NbS support
- Providing recommendations from creating awareness, to increasing implementation, to improving monitoring to build NbS presence in the region
- Inspiring NbS experts and enthusiasts to advocate on behalf of NbS across the MENA Region to overcome hurdles of environmental degradation and climate change impacts.

This handbook is mainly targeting experts in the field of NbS, as well as enthusiasts who are seeking tangible steps that they could adopt to support NbS in the MENA Region. With the rise of start-ups and the high rate of small and medium enterprises (SMEs) in the region as well, this handbook could also inspire the role of these SMEs in catalysing NbS.

1.2. What are Nature-based Solutions?

To briefly redefine and reiterate, nature-based solutions encapsulate new approaches to socioecological adaptation and resilience that place equal emphasis on social, environmental, and economic dimensions. NbS are defined as projects inspired by, supported by, or copied from nature that deploy various natural features and processes in a resource efficient and sustainable manner. They are adapted to local systems and promote existing regional natural features, redefine the presence of nature in urban, rural, and natural settings, and combat socioeconomic and environmental challenges.

There are three main categories of nature-based solutions being:

1. Existing ecosystems with minimal human intervention such as conservation sites, protected areas, and wildlife reserves – i.e., the Lewa Wildlife Conservancy, Bialowieza Forest, and the Australian Great Barrier Reef
2. Existing ecosystems with moderate human intervention for sustainability purposes such as restoring degraded ecosystems or sustainably managing existing ecosystems – i.e., the restoration of the Peruvian Amazon, the Belize Barrier Reef System, and the Prime Hook National Wildlife Refuge
3. The development of new ecosystems through human intervention such as intensive urban green space management or constructed wetlands – i.e., New York's Central Park, the Ras Al Khor Wildlife Sanctuary, and the Nimr Water Treatment Project

2. Interdisciplinary Approach to NbS

While the most obvious solutions that NbS can offer are based in environmental protection and preservation, NbS have a multi-functional role that allows them to address social, environmental, and economic aspects of global concerns. Climate change mitigation, water management, land use, and urban growth are just a few of the challenges that NbS have been used to address.

NbS can also be used to address cultural heritage preservation – another pillar of sustainable development. The goals of NbS have often been highlighted as such:

1. Promote and facilitate sustainable urbanization
2. Restore and regenerate degraded ecosystems
3. Enhance adaptation and mitigation to climate change impacts
4. Establish environmental resilience to multiple natural hazards

It is important to note that these goals are not isolated, but rather complete each other. As such, the International Union of Conservation of Nature (IUCN) developed several criteria that an NbS project should possess to label it as one, further reinforcing the need for these projects to be interdisciplinary and to address multiple challenges from various aspects of society. Known now as the Global Standard for NbS, these criteria include:

- NbS design must account for the complexities of natural ecosystems, as well as socioeconomic factors
- NbS need to result in a positive net (evidence-based) response for biodiversity and ecosystem integrity
- NbS need to be economically viable – with a beneficial return on investment and equity in the distribution of costs and benefits
- The governance processes of NbS need to be inclusive, empowering, and transparent, enhancing the NbS's social acceptance and adoption

Moreover, NbS could be used to help achieve the Sustainable Development Goals targets, even those unrelated to biodiversity and ecosystems or the environment in general such as SDG 1 that calls for no poverty through green investments, SDG 2 that calls for no hunger through sustainable farming and urban agriculture projects, SDG 6 that calls for clean water and sanitation through natural water retention projects as well as many other goals.

The production, operation, administration, and usage of NbS are all linked to the surrounding environment. As a result, mapping systems that allocate NbS are critical for:

- Helping urban planners and decision makers identify possible strategic pathways, actions, and NbS interventions

- Finding synergies among diverse actors, and suggesting co-financing derived from different sectors
- Revealing knowledge gaps and research needs that exist in the system around NbS
- Recognising stakeholders and entry points for involving local society

Even still, NbS face several challenges which will be addressed in another chapter in this handbook.

3. Opportunities of NbS

3.1 Assessing NbS and their Impacts at Various Levels

Through their multifunctionality, NbS offer many advantages. It's vital to keep in mind that these advantages aren't mutually exclusive. Instead, each NbS is likely to give many benefits at the same time. Similarly, they use natural resources and, if not carefully planned and installed, may have unintended consequences and degrade ecosystem services. As a result, potential negative consequences are also discussed. These features will be discussed at three different levels which are:

Micro Scale

Smaller, more localized projects, such as yards, gardens, and parks, are considered NbS at the micro scale. Overall, greening at this level may help reduce heat islands and noise and may indirectly reduce energy usage in buildings. Local greening focuses on people's everyday lives, making it easier for everyone to have equitable access to nature, which is fundamental to human equality, well-being, and health. Local residents may enjoy their surroundings more if they have access to nature. Also, a place's unique identity may be shaped in part by its cultural history, which is an important component of long-term growth and development, a characteristic which micro scale NbS could preserve.

Meso Scale

Trees, parks, woods, and other green areas considered NbS at the meso scale impact the surrounding environment by regulating the local climate, improving air quality, preserving biodiversity, reducing flood danger, and saving water. When considering the social impacts, it is critical to have easy access to greenways that connect various points of interest, restorative environments that preserve an area’s

natural features, quiet areas, and visually stimulating diverse landscapes. Traditional human-influenced landscapes, inventive NbS as well as significant natural regions can all be considered a part of a community's cultural heritage.

Macro Scale

As human settlements and infrastructure are constantly changing in size and form, they offer great potential to integrate NbS, where nature can be integrated in various ways. Urban renaturing – spatial transformation from natural expansion - may be a useful approach to radically transform the landscape. Renaturing may be an essential ingredient in all NbS projects and should be conducted on a macro scale to envision nature as an integral part of human-created landscapes. An overall presence of nature (rather than occasional site-limited solutions) means living in an environment with wildlife and such wild or semi-wild biotopes as flood- prone areas, meadows, and woodland. While redefining future perspectives, the overall presence of nature also supports regional scale accessibility to well-connected networks of NbS for restoration and positive health and wellbeing effects.

3.2 Environmental and Socioeconomic Advantages

As previously discussed, NbS have deeply intertwined environmental and socioeconomic advantages. NbS that have been effectively implemented across different regions of the world demonstrate the positive impact and influences they have created not only on the region's environment but on socioeconomic factors such as improved food and water security, greater protection from climate change impacts, cultural identity preservation, and boosted economic activity. This section will hence briefly discuss some advantages from both aspects, but more importantly provide several case studies that showcase how these advantages could be created as well as the lessons learned from implemented NbS.

3.2.1 Environmental Advantages

The main objectives of NbS are mainly attributed to environmental impacts and the improving the overall state of nature in a particular area. This objective is met through several pathways, including:

1. The provisions of goods and services such as:
    a. Enhancing food security
    b. Reducing water scarcity
2. Regulating and maintaining environmental quality such as:
    a. Absorbing carbon dioxide from the atmosphere and improving carbon sequestration
    b. Improving regional biodiversity and protecting pollinators that contribute to food security
    c. Controlling soil erosion
    d. Controlling pluvial and waterbody flooding

3.2.2 Social Advantages

Along with the environmental advantages, there are several social advantages that address the health and well-being of individuals residing close to or in the surrounding areas of an NbS, in addition to culturally or economically significant benefits that contribute to the region's development as well. These include:

1. Social aspects that improve daily lives of individuals such as:
    a. Aesthetic improvement to a region, especially degraded ecosystems that are undergoing restoration
    b. Promoting the development of an active lifestyle by providing easy access to green spaces which is especially beneficial for children and the elderly
    c. Raising awareness and creating knowledge through the existence and presence of NbS, as well as developing long term research and conservation sites
2. Cultural and heritage significance that create a sense of identity and community through:
    a. Planting indigenous trees, preserving natural elements, and maintaining sites with historical or cultural significance to the development of entire conservation and protected areas
    b. Promoting social cohesion and creating a sense of community through NbS
3. Economic significance with the potential to enhance economic growth in the region such as:
    a. Improving the touristic development of an area by creating and preserving natural attractions
    b. Increased value of a particular region due to the presence of NbS

3.2.3. Case Studies

The following case studies will show how NbS creates an overlap between environmental and social advantages:

1. Case study in the Machakos, Makueni, and Kitui counties, Kenya

   Intervention type: Development of sand dams and climate-smart agriculture

   Brief description: As a result of climate change, counties across Kenya were experiencing prolonged drought period, which was impacting the volume of available water as well as crop yields. Communities in these counties then set out to build sand dams that improved water collection and retention during the rainy season and raised the water table. This also led to the increase of soil fertility and coupled with sustainable farming practices such as terracing to prevent run off, use of tree-nurseries, and use of drought resistant crops, communities experienced a multitude of advantages.

   Environmental advantages:

   a) Positive climate change adaptation through increasing water and food security as well as reducing land degradation

   b) Potentially positive climate change mitigation as planted trees would enhance carbon sequestration

   c) 263% (more than 1,500 households) planted native trees, with anecdotal evidence suggesting increased biodiversity through birds and insects

   Socioeconomic advantages:

   a) Over 85% drop in households practicing food saving strategies such as skipping meals or reducing food portions

   b) 74% reduction in families living below the poverty line

   c) Roughly 80% reduction in time spent collecting water, allowing more women to participate in education and income-generating activities

2. Case study in four coastal districts, Bangladesh

   Intervention type: Restoring coastal mangrove ecosystems

   Brief description: The Community Based Adaptation to Climate Change, through Coastal Afforestation program, is an initiative that engaged the communities in coastal Bangladeshi districts to plant various species of mangroves alongside timber and fruit trees as part of the Forest, Fish, Fruit model. The program's aim is to protect inhabitants

of these coastal areas by reducing the impacts of severe weather events, as well as reducing coastal erosion to maintain coastal croplands, saltwater intrusion to preserve freshwater sources, and excess flooding caused by elevated sea levels.

Environmental advantages:

a) Positive climate change adaptation through creating a 'green shield' composed of mangrove forests

b) Positive climate change mitigation with almost 640,000 tons of carbon absorbed annually because of planted mangroves and trees

c) Enhanced coastal ecosystem resilience allowed these coastal habitats to support biodiversity such as fish and birds

Socioeconomic advantages:

a) Long-term benefits for 3,400 households and income opportunities for over 12,000 local people were created as part of the program

b) Food security was addressed through the planting of fruit trees as well as protecting coastal ecosystems that supported fish nurseries

c) Food production reportedly provided households with up $1,000/year per beneficiary as extra income

3. Case study in Wadi El Ku and Kabkabiya in North Darfur State, Sudan

Intervention type: Land management and reducing water stress through community engagement

Brief description: Unpredictability in rainfall in these regions of Sudan has increased pressure and water stress on the scarce resource. This affected both farmers and pastoralists who heavily depended on arable landscapes for their livelihood. Understanding the risk they were facing, and with support from an NGO, the community developed an integrated water resource management plan. This included combining NbS elements and grey infrastructures like dams to improve water retention within the community.

Environmental advantages:

a) Positive climate change adaptation through increasing the availability of groundwater, and the availability of previously dried water points

b) Improved land and resource management helped combat land degradation and desertification

c) Planting of 18,000 seedlings and indigenous grasses could potentially improve ecological activity in the area

Socioeconomic advantages:

a) Anecdotal evidence suggests greater cohesion between farmers and pastoralists to maintain improved resource management practices

b) 50% increases in crop yields were reported in over half of the households within these communities

4. Case study in Odisha, India

Intervention type: Supporting women to participate in conserving biodiversity and adopting sustainable fishing

Brief description: With support from the Samudram Woman's Federation, and the goal of increasing female ownership of key economic activities and improving accessibility to healthcare and education services, a comprehensive system was developed that both protects the environment and promotes sustainable economic growth.

Environmental advantages:

a) Positive climate change mitigation through the cultivation of seaweed, improving carbon sequestration potential of the area

b) A reported 15% increase in the Olive Ridley turtle population, an endangered species, has been observed

c) Artificial reefs that support coastal ecosystems have also discouraged fishers from overfishing as their nets get stuck on the reefs

Socioeconomic advantages:

a) Annual income of Samudram family members doubled over five years, in part due to the sale of agar-agar, a seaweed by-product

b) Boosted incomes have improved standards of living including access to health and education services

These case studies illustrate the both the interconnectedness and diversity of NbS, and the propensity they have in improving the overall well-being of both the environment and communities residing next to and depending on the NbS projects. There have also been many documented cases of NbS that preserve indigenous ecosystems that are historically significant and fundamental to the cultural identity of a community or people. An example includes the creation of the Indigenous Council of the Tacana People who oversees community engagement in preserving forest and savanna ecosystems that the Tacana

People have inhabited since before the Inca Empire. Many of these advantages are deeply woven within each other that is difficult to isolate one benefit without intentionally neglecting another.

3.3. Unwanted Consequence and Obstacles

As a result of implementing and introducing NbS into a region, especially ones that were not based on scientific data and evidence to support the viability of a particular ecosystem and its compatibility in the installed region, some environmental and socioeconomic disadvantages may be expected. This includes:

1. Increased air pollution caused by reduced air flow due to increased mass and volume of vegetation in an area
2. Declining native biodiversity species due to the presence of alien or invasive species
3. Heat is retained due to reduced air flow, with potential higher scale risks leading to increased climate change
4. Perturbed mobility and interactions for local biodiversity at the micro level which may cause an increase of unwanted organisms at the macro level
5. The exclusion of certain groups due to neglecting the needs or demands of certain groups, leading to increased inequalities and segregation
6. The gentrification of certain areas that could lead to driving out at-risk or low-income individuals and households
7. Wasting natural resources and space availability that is disconnected from the NbS ecosystem and its surroundings

4. Challenges

While there is a clear definition of what features an NbS should have, and the multifaceted nature of NbS is an inherent advantage, it is frequently difficult to establish a relationship between science, policy, and practice due to the complexities and long-term goals of NbS. This then brings about several challenges that hinder the popularity of NbS. These challenges could either be socioeconomic, political, embedded in

incompatible existing 'grey' infrastructure that is incapable of supporting NbS, or a lack of investment and funding for NbS projects.

4.1 Socioeconomic Challenges

These challenges are more associated with a general lack of understanding and awareness from key players including the public on the usages and advantages of NbS. As a result of this knowledge gap, stakeholders and eventual potential benefactors are often hesitant or uninterested in involvement with the entire NbS process. This form of apathy could prove to be risky as it could develop a sense of inequity amongst stakeholders without them fully realizing it and could potentially create an unrealistic image or idea of the efficacy and efficiency of NbS as there would be a lack of concern for maintaining them to maturity to where their benefits could be fully reaped.

Recently though, frameworks such as the Sendai Framework for Disaster Risk Reduction 2015-2030 have prompted the inclusion of the public in understanding and addressing risk management and practices for reducing perceived risk, one being the adoption of NbS. In order to adequately instil the significance of NbS to both stakeholders and the public, it is important to fully involve them throughout the entire process of designing, developing, implementing, and upkeeping an NbS. As far as the MENA Region goes, the youth of the region were shown to greatly prioritise action to combat climate change, thus including them in these projects is essential to ensuring their success in the region (Shafi, 2019).

A case study that exemplifies public inclusion is the integrated Green Watershed Management Project of the Yunnan Province located in Northwestern China. As a result of the Lashihai Dam Project in 1998 which caused significant flooding to arable croplands across the region all while displacing indigenous people such as the Naxi community, autonomous organisations were created to address the resource management practices of the region. This led to the creation of the Yunnan Green Watershed Management Research and Promotion Center, consisting of organisations that represent indigenous Naxi and Yi communities. The project has been maintained by the communities because of the benefits they have witnessed including an improvement in their livelihoods.

Studies have also shown that there are multiples opportunities that could arise from further raising awareness and engaging stakeholders in the NbS process (Ferreira, Barreira, Loures, Antunes, & Panagopoulos, 2020) including:

1. Enhancing social co-operation and improving social unity
2. Adding value and natural capital to a region
3. Improve people's connectivity with nature and promote a sense of belonging
4. Establish a platform for long-term collaboration and foster partnerships
5. Reduce potential conflicts over natural resources

4.2 Governance Challenges

Due to the novelty of NbS, the relevant frameworks and legislative bodies that govern their design, implementation, funding, operation, and maintenance are either non-existent or too vague. Additionally, due to NbS being long-term system with changing dynamics as all natural ecosystems tend to be, there is often a lack of political will as governments tend to focus on more immediate problems, making NbS unappealing and diminishing the sense of urgency of the issues that they can address (Hawxwell, Mok, Maciulyte, Sautter, & Dobrokhotova, 2019). There is also a general misconception that green projects, of which NbS is a part of, stunt economic activity and growth, thus diverting focus away from them and shifting focus towards conventional grey infrastructure to support job creation and boost the economic state of a region.

While there is growing interest in NbS, the general lack of awareness and knowledge addressed in 4.1 will prevent governance bodies from catalysing the development of the necessary frameworks pertaining to NbS. Thus, it is essential that a public paradigm shift is created, to encourage and incentivize the public to advocate for the development of legislation and policies that are flexible enough to adapt to the changes and needs of an NbS project.

There have been several cases that demonstrated the success of administrative bodies in enabling NbS implementation and propagation. For instance, increased flood risk of the Isar River in Munich in Germany encouraged authorities to collaborate and resulted in the development of a polycentric governance structure which is compatible with the multifaceted approach to nature-based solutions (Isar-Plan – Water management plan and restoration of the Isar river, Munich (Germany), n.d.), providing multiple

bodies with input to enhance plans beyond grey infrastructure solutions. Other governance models could for instance include developing a financial incentive, such as the case of the Wolong National Nature Reserve risk of flood and landslide, where the government rewarded households that monitored illegal logging.

4.3 Financing Challenges

One of the most difficult challenges to address when discussing NbS is allocating the financing for it. When discussing funding from the public sector, there is a restriction on the available funds that could be dedicated to NbS at the municipal level as these funds are often classified as "full freedom" or autonomous funds which are typically smaller amounts than those to fund obligatory or law-related funds (Droste, Schroter-Schlaack, Hansjurgens, & Zimmermann, 2017). As for the private sector, NbS are either viewed as a public sector responsibility and investment that should be taken care of by governments or municipalities, or viewed as more expensive than grey infrastructure which then discourages investors from wanting to commit to these projects, or are perceived to have very vague or uncertain financial benefits and returns on the investments which then disincentivizes investors from adding NbS to the portfolios (Hakanson, 2021).

A report published by the United Nation Environment Program showed that approximately $130 billion/year were flowing into NbS as of 2020, with over three quarter secured from the public sector. While this figure seems promising, it will have to increase by three and four-folds by 2030 and 2050 respectively if the world's sustainability objectives are to be met. Even still, the report mentions that there is still a lack of clear and transparent data, mainly due to the absence of an agreement on definitions, terms, and criteria to report and verify NbS financing. Moreover, while the public sector is contributing to NbS, policies and revenues will have to be developed and implemented, and the private sector needs to be included to ensure NbS finance goals are met.

There are several case studies that demonstrate the favourability of NbS, particularly when discussing the use of NbS for carbon offsetting or positive impact investing. For instance, the Café Selva Norte project in Peru which seeks to restore degraded ecosystems for sustainable coffee plantations is expected to sequester 1.3 million tons of carbon dioxide emissions per year and provide an income to 2400 producers. Another example is farmers deriving incomes for ecosystem services, such as conserving wildlife to

promote ecotourism across Zimbabwe. There are many such innovative solutions where funds could be allocated to create and drive new business and investment models that are beneficial to the investor and to the environment as well. Additionally, studies have shown that NbS could cost as low as 50% less than grey infrastructure with several co-benefits, and could also be cheaper to maintain while having high climate change resilience (IISD, 2021).

4.4 Integration and Scalability

The practice and upscaling of NbS are hampered by knowledge gaps and technological impediments. In general, the knowledge gaps can be characterized as follows:

- Developing, implementing, and sustaining NbS
- Quantifying (including economic assessment) the advantages and co-benefits of NbS-provided ecosystem services
- Monitoring and evaluating the efficacy of NbS

Both decision-makers and practitioners frequently lack the expertise needed to effectively handle potential trade-offs while maximizing the usage of available technology solutions. Technically viable solutions that are suited for resolving various challenges are scarce and undeveloped. The lack of ready-to-use technology and ready-to-apply scientific conclusions and concepts makes NbS adoption much more difficult in many circumstances. There's also a misconception about the expense of NbS procedures (including upkeep), which is sometimes misinterpreted as being more than grey alternatives.

It's critical to figure out how NbS planning is entrenched in government institutions to promote knowledge co-generation and long-term implementation of NbS at the local level. The development of a technological solution may not always have the required policy support, or a new NbS may require regulatory changes to become legally viable. Even if a solution is technically possible, it will not be fully established until it reaches the consciousness of the end-user. As a result, technical advancement is hampered by a lack of expertise. Thus, the importance of societal relevance assessments of NbS should be underlined by measuring co-benefits and costs using multimeric indicators.

5. The Business of NbS

5.1. Opportunities and Feasibility of NbS

While NbS are frequently more cost-effective than traditional grey infrastructure alternatives, the challenges to implementation are more complicated, and include change management, education, forming partnerships, and getting funding for a new and under-appreciated industry. The success of NbS depends on defining a clear business case and gaining funding, but there are still significant obstacles for those who want to put them in place. Many people struggle to communicate the many financial benefits of NbS, frequently owing to a lack of data, inadequate research into quantitative benefits, and a lack of coordinated knowledge transfer – all of which can stymie the development of a well-defined business case.

Recognising Opportunities

Understanding the need(s) for which a well-designed NbS may give a comprehensive, integrated solution for is the first step in evaluating the business case for NbS. Whereas typical grey infrastructure is built to meet a specific purpose, NbS is built to provide numerous advantages and takes a more holistic perspective of the functioning and interaction of natural systems and processes in order to maximize co-benefits and prevent negative repercussions. As a result, NbS frequently include several stakeholders and need knowledge of a wide variety of topics.

Identifying Drivers

The next stage is to identify the drivers of stakeholders who could invest in (and profit from or be harmed by) an NbS after the need and opportunity have been recognised. The justification for investment is mainly determined by who is pushing for the NbS. NbS might be discovered and recommended locally, by the local government or another social or environmental organisation. Alternatively, a firm may recognise an opportunity for NbS as a way to prevent operational risk, decrease inefficiencies, ensure resource sustainability, or open up new commercial prospects.

Government Driven

NbS are frequently driven by their physical position, which means that local governments are in charge of spatial planning and infrastructure delivery. This is to assist in meeting a region's varied social,

environmental, and economic demands. However, this is portrayed as 'locality driven' rather than 'public,' because other local interest groups, such as local environmental NGOs and partnerships, may submit ideas (which will often include the local authorities).

Privately Driven

Businesses are becoming more aware of how natural capital stocks and movements affect and are affected by their activities. While there is a wide range of firms that have adopted this method, the majority of corporations have yet to do so, but it is a growing trend. Integrating the natural capital strategy has a compelling commercial justification, as demonstrated by global leaders in sustainability. There may be institutional opposition to an NbS project due to fear of change, a lack of knowledge of the NbS method, or a short-term economic emphasis for the company, necessitating the need for NbS to be mainstreamed.

In many circumstances, internal capital finance for an NbS program may be insufficient, and external investment will be required. As a result, it's vital to evaluate prospective external finance sources and what would motivate them to invest. Different sources will want different types of returns, which has significant consequences for natural capital management. Blended finance, which provides a variety of sources of investment for NbS, is a logical solution to this problem. In acknowledgment of the fact that there are currently no or few clear finance sources for NbS, there is rising impetus in the creation of new financial mechanisms for NbS that do not commodify all aspects of natural capital while yet providing the required resources.

Stakeholder Engagement

Early engagement with stakeholders, especially the local community, is crucial to foster a feeling of shared ownership of the NbS, design it to maximize its potential advantages, and better understand concerns which can arise from lack of understanding of the scheme as it diverts from traditional schemes. The community is a vital source of local knowledge and may offer design elements that would not have been explored otherwise. Some stakeholders may also become NbS co-financiers.

NbS are frequently funded by multiple stakeholders, or if funded solely, with the understanding that there will be multiple beneficiaries, with the intent or acceptance that the potential benefit to 'free riders' (in the case of business competitors) is worth a single investment because the NbS is strategic.

Equally important is determining which stakeholders stand to lose social permission to operate in the community where the NbS may be implemented.

Promoting NbS

The next step is to create a compelling case for investment after the need, opportunity, and their drivers have been recognised. This will almost always entail a cost-benefit analysis, as well as effective evidence interpretation. The natural capital concept is a useful foundation in this regard (discussed in the following section). It is critical to examine the following factors when establishing a business case for NbS in order to guarantee that appropriate resources are provided to the deployment and maintenance of the NbS:

Knowledge base: Because NbS provide various advantages, they need multidisciplinary competence. To guarantee that the project is as effective as possible, experts in fields such as ecology, hydrology, and environmental science, as well as social scientists, public health practitioners, engineers, and planners – among others – will need to be involved in its design and delivery. Where the NbS represents a departure from business as usual, the requisite knowledge is likely to be external, and best obtained through collaboration. Natural capital accounting should be prepared with the help of environmental economists and accountants to help with decision-making.

Total costs: Implementation, permitting, operating, and maintenance expenses should all be factored into the total cost of an NbS. The whole lifespan cost of NbS is often lower than the traditional option, however there may be a greater initial investment. Furthermore, there is frequently a delay before the NbS is completely functional (for example, as plants grow and ecosystems evolve), and the functionality will often improve over time (depending on the nature of the NbS) (i.e. as ecosystem function, for example biodiversity, strengthens). Despite the fact that NbS maintenance costs are frequently lower than those of grey infrastructure alternatives, in reality, they are often believed to be even lower, and some NbS schemes and systems fall into disrepair or perform poorly.

Land availability: Depending on the nature of the NbS, it may require significantly more land than the grey infrastructure alternative (for example, the building of a new wetland). If this is the case, possible land purchase, new cooperation agreements, and the function of municipal designations, conservation covenants, and community land trusts all need to be carefully considered.

Recognising multiple benefits of NbS

Identifying characteristics that will optimize co-benefits may also be useful depending on the nature of the NbS. Such efforts could come at a higher cost up front, but they could pay off in the long run (or reduce risk). For example, a public engagement effort to assist enlighten public users of the advantages of an NbS might help prevent inadvertent destruction of an NbS due to a lack of awareness, as well as find other co-benefits.

Notes on public money and public-sector tools

The absence of dedicated financing for NbS is a major obstacle to its mainstreaming. An NbS scheme may provide various donors with several advantages, thus it is critical to first identify viable sources of funding.

Public funds are frequently allocated for social infrastructure, yet they are often insufficient to fulfill all social infrastructure demands, much alone environmental programs. Furthermore, it is crucial to explain the multifaceted benefits of NbS, especially their socio-economic benefits. Public sector (local) policies and taxation procedures play an important role in creating the correct market circumstances to support the formation of NbS programs, beyond the problem of obtaining funds. NbS initiatives will benefit from this, as will the local community, which in turn will lead to greater investment.

Adding weight to the argument

When NbS are developed, implemented, and maintained in collaboration, the advantages are likely to be much greater, costs may be reduced (via economies of scale), and the overall success of an NbS is likely to be increased. Together, a region's NbS programs can be a more efficient use of resources. Multi-investment projects aimed at improving the environment in the same location may be more helpful (and more cost-effective) if they are matched.

5.2 Risks and Economic Challenges

An NbS project's economic risk will vary depending on the solution type, intended resilience result and investment level, scope of activities and the NbS's lifespan. The amount of resilience and, thus, the ability to mitigate future risk, will fluctuate over time as a result of changes in the performance metrics of an

NbS. Over time, this might indicate either an improvement or a decrease in performance. Return on investment (ROI) has a significant impact on the tolerable degree of risk. Significant advantages are frequently not measured, monetized or incorporated in business cases or risk-return performance analyses, making it difficult for NbS to discern between the two.

Food security, water security, catastrophe risk reduction, human health and the potential economic implications of climate change may all benefit from NbS. NbS must be able to withstand and adapt to the economic threats posed by climate change, both known and undiscovered. Climate change's unknowns make NbS's required resilience a changing target since ecosystems and the services they provide might be altered as a result. NbS should, in theory, be able to address a wide variety of possible climatic scenarios. As climate change affects people's health and well-being, there is a wide range of steps that may be taken to minimise the negative consequences of climate change.

- Resilience to moderate to extreme catastrophes may be improved, which minimises the costs to the local community and government.
- In addition to reducing heat island effects, trees may be used to promote physical and mental health by creating communal areas.
- Health and well-being may be improved within communities and businesses relocated or invested in may increase within a region if the air quality and visual landscapes are improved.

When compared to grey infrastructure, NbS techniques have the potential to be cost-effective; they can help solve resource restrictions and boost resilience and adaptability to climate change. Thus, the risks are also experienced mainly by the same groups which include:

1. As a whole, governments at all levels (local, regional, national)
2. Local residents and businesses (homeowners, councils, farmers)
3. Small and medium-sized enterprises (business, insurance companies, councils, investors)
4. The local and regional economy.

The most essential characteristic of NbS is its ability to concurrently generate several services in a single location, as opposed to hard or grey infrastructure. Among the ways in which this is accomplished are:

1. Using natural solutions that can provide numerous advantages at the same time
2. Making it possible to invest on a variety of sizes and timescales, preventing path dependence

3. Engaging people in their communities and bringing forward important reforms and improvements: Citizen science is a strong way to get local residents involved.
4. Enabling collaborations between many stakeholders, such as the government and business (PPP), business-to-business and business-to-consumer (B2B2C), and community-to-local government (C2G)

In order to answer specific concerns about the design and implementation of an NbS project, evaluations are conducted on a regular basis and are objective (i.e., non-biased and recorded). A suitable scale (e.g. geographic and temporal) should be used depending on the context in which it is used. There are three sorts of questions that can be asked in evaluations:

1. Questionnaires that ask about circumstances, procedures, and the perspectives of various stakeholders, or more descriptive questions.
2. Inputs, actions, and outputs can all be assessed using Normative Rating Questions (NRQs), which compare "what is" happening to "what should be."
3. What are the consequences of my actions? investigate the impact of the NbS intervention on outcomes.

Impact Evaluation

A large portion of an impact evaluation is devoted to answering why-and-how-questions. How does an NbS intervention influence a desired outcome? This is the most fundamental assessment question. It can be used in several situations. Several methods may be utilized to establish the causal impact and attribute it to the NbS intervention. If the NbS had not been built, these approaches should estimate what the area and its users (residents, workers, etc.) would have been like. The alternative question is: how effective is a certain NbS intervention in comparison to no NbS intervention at all? NbS intervention produces Y (e.g., modifies microclimate or social cohesiveness) and without NbS, Y would not exist. This is the causality approach.

5.3 Financial Instruments

One of the most important considerations is how natural infrastructure and nature-based solutions are financed. NbS are frequently funded by private firms and charitable groups as well as municipalities,

regional authorities, and national governments (together known as "public stakeholders"). State and regional processes, as well as public and private organisations, have a big impact on how much money an organisation may raise. Depending on the local environment and the willingness of the stakeholder to engage, finance can take a number of forms. There are a variety of funding options including:

Instruments that are employed by the government

The long-term viability and quality of all infrastructure services depend on a steady flow of finance. Tariffs (users' fees for specific services), taxes (government revenues), and transfers are the three most common sources of public funds in most jurisdictions, although they are not the only ones (a city can receive a transfer from a federal government or a development agency to use the money for a specific purpose).

There are a number of instruments employed by public bodies that will be examined in this section:

1. Using public funds, such as combining funds from several government agencies or making use of hitherto untapped sources such as the public health budget.
2. Grants from regional and national governmental agencies, charitable contributions, and crowd funding.
3. Green finance: loans from governmental or private financial institutions and green bonds

Using Taxpayer Funds

NbS projects are generally financed by local governments. National budgets for NbS/Green Infrastructure are not sufficient, even if there are examples of national budgets for NbS/Green Infrastructure. It is possible to find a solution by diverting funds from other local agencies. NbS initiatives with cross-sector advantages might be funded by a combination of funds from several city departments or from other sources. One of the most essential things to do is to coordinate NbS design and planning so that different departments may achieve their primary goals.

Grants and charitable contributions

External grants can be used to support NbS initiatives by public stakeholders. Below is a list of the most readily apparent sources of funding for an NbS project:

1. In developing nations, the Subnational Climate Finance project (SCF) is a new blended finance strategy that intends to invest in, and scale, medium sized climate-resilient, low-carbon infrastructure, and nature-based solutions.
2. Grants for environmental initiatives, including green infrastructure, may be available to local governments from higher levels of government.
3. Philanthropic contributions for green projects have typically come from foundations, individuals, businesses, and other sources.
4. Crowdfunding: the practice of getting a large number of people to contribute modest sums of money to a particular project, generally one of public interest. Especially well-suited to helping smaller initiatives that may not be well-served by other forms of funding.

Instruments used by private organisations

NbS's private financing comes from a wide range of sources, including commercial lending, private corporations, and the insurance industry. Instruments that might entice private sector investors to contribute to NbS finance include the following:

1. User fees, taxes (as an incentive rather than a tool for recovering costs), subsidies, tax rebates, credit-trading systems, offsets for leftover impacts on biodiversity/GI, and payments for ecosystem services are all examples of market-based instruments.
2. Developing Business Improvement Districts"
3. Developing Public-Private Partnerships
4. Standard for developing and enforcing regulations

PES (Payments for Ecosystem Services), is an example of a market-based instrument. A commercial company pays farmers or landowners to do specified measures in order to offer specific ecosystem services, such as clean water, through the use of PES.

Business Improvement Districts (BID): This is a group of local businesses working together to improve the district's appeal to residents and companies alike. However, this is only possible if a large number of enterprises in a given region are ready to share the cost of the same services. Companies and other stakeholders contribute to the BID management body by paying an extra charge. Local initiatives sponsored by this organisation include work on public safety and sanitation as well as the planting and upkeep of vegetation. When it comes to BID, these are the features to be expected:

- A long-term and stable source of income for the local community
- A strong collective voice
- Initiatives that are driven by the community to provide a sense of ownership and control at the local level

Public-Private Partnership (PPP): An ideal public-private partnership project is one that provides a positive return to the private sector, such as cutting operational and maintenance costs or producing revenue. An asset or service provided by a private party is described as a PPP when the private party carries considerable risk and management responsibilities.

Regulation and planning standard: There is no financial instrument that can be used to finance regulations and planning requirements. GI implementation by private players, such as infrastructure developers and homeowners, might be incentivized and triggered by financing NbS.

Other financial options for the future of the NbS

Immutability and transparency are two aspects of **Blockchain** that can help access private financing for Nature-Based Solutions. Especially in emerging markets, where project governance generates major concerns and deters more capital from being invested, this is particularly crucial. A strong layer of confidence may be gained by utilizing Smart Contracts to code the drawing of cash in accordance with pre-defined project milestones.

A project's financial and non-financial advantages are also critical to NbS' success. The difficulty of monetizing nature-based solutions is now preventing a wider adoption of this sort of technology. Coinciding with the concept of crowdsourcing, tokenizing assets on the blockchain can aid in raising more money for the NbS project through direct contact with those investors who stand to gain the most (not only financially).

Creating Impact Bonds

Impact bonds refers to a hybrid financing strategy that once again aims to map out the benefits created by project stakeholders and include them in a financing strategy. If a pre-determined measure indicator achieves or exceeds the specified threshold or impact, money will be made available in accordance with this framework. A third party should independently verify the results of this measurement.

Effect investors will give the initial funding for the NbS project's development, while outcome payers will only distribute the funds and, thus, reimburse investors once the initiative achieves its impact goals. Contractually, this is difficult to express, but it ensures that everyone working on the project is focused on the same goal: completing the project on time and on budget.

6. Developing and Implementing NbS

Projects built in the natural environment always face an element of uncertainty. Nature is not fully predictable, and the result of a project may necessitate the adjustments over the course of time. Because of the multiple complexities of nature-based initiatives, the design and execution processes should be more clearly defined. While there are incentives to prefer NbS over grey projects, they must be proven to be successful.

Nature-based programs are characterized by adaptive management. Adaptive management varies from standard management systems in that it permits management operations to continue even if design goals are uncertain. In reality, it is designed to address this type of ambiguity by requiring ecosystem managers to be transparent and explicit about what is known and unknown about the processes. It provides a science-based learning approach that includes evaluating and adjusting outcomes.

In the case of NbS, the design, development, implementation and regulation of NbS are divided into three stages, as with conventional project development. These stages are further divided into steps that highlight the importance.

6.1 Planning Stage

The main objectives of this stage are to define project goals, specify the strategy and the design approach.

Step 1. Problem definition

The issues and problems in a particular region need to be clearly defined, followed by an assessment of these challenges to understand where an NbS might offer the best solutions to address them. This stage of project development should produce a sketch of the problem and potential solutions (resources, timeline, legislative restrictions, etc.).

Step 2. Stakeholder selection

Key stakeholders, in other words those who play a part in planning, designing, implementing and maintaining NbS, as well as those who will be impacted by its presence need to be selected during the early stages of planning. Ideally stakeholders from different disciplines should be selected to meaningfully contribute to the multifaceted characteristics of an NbS.

Step 3. Scoping analysis

After the problem and the stakeholders are clearly identified, the problem and its context now need to be analysed from the socio-economic, political and legislative, and environmental aspects to determine which of these characteristics could be addressed and resolved by NbS, and how an NbS might be tailored to increase the scope of the issues it can address.

Step 4. Multiple scenarios

Due to the unpredictability of nature and ecosystems, multiple designs of an NbS system would be necessary – whereby future developments that hinder a specific part or element of the project do not hinder the overall completion of the project and could be replaced with appropriate alternatives that fulfil the same or similar objectives.

Step 5. Preliminary assessment

An initial assessment including potential advantages and disadvantages of an NbS needs to be designed for any scenario developed. Thus, preliminary data mut be compiled and analysed to understand the impacts of an NbS in the region – which may be collected through the following methods:

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- Multi-criteria assessment (MCA) - An MCA is a semi-quantitative study in which the results of several measurements are compared to a set of criteria, where experts and stakeholders prioritise certain criteria and proceed based on their priorities.
- Cost Effectiveness Analysis (CEA) - A CEA determines the effect or impact created by an NbS based on the investment made for that NbS. A downside to CEAs is they're specific, and often focus on the return from a single feature of an NbS.
- Life Cycle Costing (LCC) - LCC compares costs over the course of a specified long-term time horizon from investment, through to operation and maintenance, and, if applicable, demolition expenses. The option with the lowest LCC is the most appealing in principle.

6.2 Execution Stage

The main objectives of this stage are to develop detailed design, build/construct and implement.

Step 6. Detailed Design

Once the preferred preliminary design has been selected, the detailed design is developed. The amount of information required in the design is highly dependent on the type of NbS and the corresponding presence of legislation and guidelines pertaining to each type of NbS.

Step 7. Assessment

A more detailed and comprehensive assessment of the environmental and financial aspects of an NbS project needs to be carried out. Two formal analyses may be necessary, depending on the scope of the project:

Environmental Impact Assessment (EIA): The Environmental Impact Assessment (EIA) is a more formal assessment of the environmental benefits and consequences of significant infrastructure projects. Its primary use is for grey infrastructure projects, however big NbS projects may be required to do an EIA.

Cost-benefit analysis (CBA): A formal CBA may be required for NbS initiatives that need third-party funding. In a CBA, the project's expenses are weighed against the project's welfare effects/benefits/negative impact.

Step 8. Financing

A business case for the NbS to accumulate the necessary financing and support from either public or private entities, decided in previous stages must be created while highlighting details about the benefits of the impacts of the NbS.

Natural Capital

Natural resources have long been taken for granted, and the advantages they provide have been underappreciated. The environmental implications of economic activity have primarily been considered as externalities, which has resulted in firms not taking responsibility for these larger costs to society or understanding how their own survival depends on more responsible management of natural resources.

Accordingly, demonstrating the value of NbS investment would likely need the use of natural capital accounting. Natural capital accounting is the process of identifying and quantifying the many advantages we obtain from our planet's natural resources within a specific area. For a company's activities or a product, these accounts can be established on a city or even national size. It's possible to establish a case by highlighting an advantage or reliance that was previously overlooked. A cost-benefit analysis (CBA) is frequently necessary to justify the value of investing in natural capital (via an NbS) over standard grey infrastructure alternatives. There are three main methods for valuing a product or service:

a) Qualitatively:
Stakeholder surveys and expert opinion are two methods of demonstrating value.

b) Quantitatively
Demonstrating a difference or change, in air quality for example, might be used to quantify value.

c) Financial:
Giving monetary value to the existing and future stock and flow of natural capital. For example, production-function identifies the value of natural capital to commercial processes; replacement-cost assigns a value based on the cost of man-made infrastructure to provide an equivalent service; and willingness–to–pay assigns a value based on the extent to which stakeholders may pay for nature's services.

However, there are a few downsides to this method of accounting.

These include:

a) There is widespread worry that nature is becoming defined as a commodity by financial pricing
b) Because natural systems are so complicated and varied, there are many different values that have been put up by researchers in academic literature.
c) Budget holders may not find these values compelling because they aren't actual, chargeable charges.

Step 9: Implementation

This step covers the building/construction/realisation of the detailed design. The details (schedule, project management, resources, etc.) depend very much on the scale, the type of NbS, and the location of the project.

6.3 Delivery Stage

The main objectives of this stage are to operate, maintain, monitor and follow-up.

Step 10: Monitoring

The correct functioning and evolution of the NbS must be monitored once it has been deployed. This requires the selection and development of reliable monitoring approaches capable of evaluating important performance indicators. The proper monitoring approaches for any NbS project are determined by a number of criteria, including performance goals, NbS type, size of implementation, predicted impacts and benefits, and monitoring resources. However, there are a few key technique criteria that apply to the vast majority of NbS instances, namely:

1. Long-term and variable scale monitoring
2. Availability of baseline data
3. Feasibility
4. Comparability
5. Replicability
6. Quality and accuracy
7. Cost effectiveness

Step 11: Evaluation / Adaptation

The monitoring data will be compared to the design objectives and performance standards. The assessment establishes whether or not the NbS performs and operates as it should. Because nature-based initiatives are often based on the functioning of dynamic ecosystems, with all the inherent unpredictability that entails, the design objectives are likely to be partially met. In that situation, the feedback data might be utilized to revisit the scoping study or detailed design in an iterative cycle to see whether any revisions are required or achievable to accomplish the main NbS goals. The goal is to fine-tune the performance and evolution of dynamic ecosystems to satisfy the requirements and goals.

6.4. Practical considerations

The many phases in a nature-based project's design and execution process are more complicated than in standard projects. The complexity and unpredictability connected with the functioning of natural systems has resulted in:

- Natural-systems-based projects (NbS) cope with greater uncertainty than traditional ('grey') projects since ecosystem change is by definition unpredictable
- NbS are formed in reaction to external events that evolve in a similar way under uncertainty.
- NbS operate in a dynamic and extremely complex environment as both the NbS and external threats change.
- NbS often include a wide range of benefits in the form of ecosystem services, some of which are only tangentially connected to the project's aims.
- A wide range of stakeholders should support NbS, and they should be consulted on the project's aims and implementation. This necessitates a clear and open design approach.
- In order to establish a fair business case, life-cycle expenses must be included. This has an impact on the assessment's complexity.

Uncertainty must be managed, and this should be done through adaptive management via several feedback loops: one or more in the definition stage, where the choice between several alternatives must be made in the face of uncertainty; and one or more in the implementation stage. A second feedback loop uses data from monitoring throughout the delivery (operational) stage to fine-tune system performance to meet design objectives (adaptive management). A third feedback loop re-connects the impacts to the initial scenario development: this iteration is required if the NbS project's aims have not been met in any way.

Inadequate, or in most cases non-existent, follow-up monitoring of deployed NbS obstructs the evaluation of their efficacy, depriving decision-makers and practitioners of vital insights into the cost-benefit analysis, performance, and long-term viability of NbS. There are currently no widely approved and tested monitoring approaches that meet the fundamental requirements. Additionally, the lack of replicability and harmonization of monitoring procedures and datasets is frequently cited as a key impediment to NbS case study comparability. In many situations, measures that are difficult, expensive, or require highly specialized equipment and staff are included in research studies on NbS effect assessment.

Such information is typically sparse and difficult to duplicate across case studies. The lack of uniform data needed to track many aspects of NbS effects is a major impediment to the creation of a unified assessment methodology.

7. Monitoring

7.1 Monitoring Technologies

Earth Observation

Earth Observation (EO) has made great and rapid advances in the recent decades, both within the framework of Copernicus and beyond. Satellites collect huge amounts of data on both a geographical and temporal scale, documenting the status of the environment in a specific location in the past (baseline) and providing continuous long-term monitoring. In numerous geographical scales, EO can provide inexpensive, high-quality mapping and monitoring of urban and environmental characteristics. Higher spatial and temporal resolution, as well as greater accuracy, are available thanks to recent technology advancements.

Big Data

New technologies in communication, networks, media, measuring systems, and storage capabilities are all contributing to the fast growth of datasets. This new era of data availability, collecting, and analytics provides huge study and inquiry potential in a variety of scientific domains. Big Data opens us new avenues for big socioeconomic studies of real-world issues. However, Big Data raises significant privacy and confidentiality concerns that must be addressed. Every day, a massive amount of data is created in the Earth sciences, consisting of Earth Observations and data simulations. Citizen's science has a lot of possibilities for data collection as well. For both environmental and socioeconomic impact assessment, NbS monitoring approaches may surely take use of Big Data potential.

Modelling Capabilities

Modelling is an important aspect of the monitoring process. To extract the relevant parameters, integrate diverse input information, modify observation size, generate scenarios, and a variety of additional

purposes, modelling techniques are required in all parts of NbS impact assessment. The ability to be translated, changed, recreated, and compared across case studies and contexts is a unique feature of modelling. New modelling tools may be used to analyse the predicted implications of NbS across various challenge situations and across time, as well as to forecast the state of NbS and their expected impacts in the future.

In-Situ Measurements and Networks

In-situ measurement and network technology has progressed in recent years, modernizing the observational capability of diverse processes. Wireless Sensor Networks has mostly been used to produce smart and low-cost sensor network technologies (WSN). WSNs are now widely used to monitor physical or environmental conditions in urban areas (e.g. air pollution, traffic, meteorology, noise), the natural environment (e.g. water quality, animal tracking), risk management (e.g. landslides, forest fires, flooding, earthquakes), industry (e.g. waste monitoring, machine conditions), and health (e.g. (e.g. physical state tracking, health diagnosis). Dense WSNs have the ability to offer low-cost continuous monitoring of a variety of metrics in metropolitan locations, and they may be used to establish baselines and assess NbS environmental consequences.

7.2 NbS Monitoring and Evaluation Plan Development

From the outset of the NbS design process, rigorous planning is needed to provide a comprehensive monitoring and assessment approach. Adequate resources can be allocated by taking a step-by-step strategy to ensure that the evaluation process is both efficient and effective. Six sequential phases can be followed by teams in charge of creating and executing a nature-based solution. There are feedback loops between some of the processes, which are discussed below, so the process isn't fully linear.

Step 1: The first step is to develop a theory of change. For planners and decision-makers, the theory of change allows them to clearly identify and reflect on the links, or pathways, between the local context's significant issues, strategic objectives, and the activities through which these will be achieved.

Step 2: Outlining the theory of change by creating an outcomes chain. It is important to develop assumptions about how NbS activities will have an expected influence on local difficulties, key local goals,

and how NbS actions will accomplish them. As a result of explicitly mapping the intended causal chain, it is possible to anticipate what may be lacking from the design. It is also possible to identify scenarios when NbS may not achieve the desired objectives, and to begin to investigate why this may be the case, by mapping causal pathways.

Step 3: What are the evaluation questions? - This is the third step. In order to determine the direct impact of NbS interventions on addressing specific difficulties and achieving specific goals, rigorous NbS monitoring and evaluation procedures must be developed. What is the purpose of impact evaluation? How much of a role does this park have in a neighbourhood's efforts to reduce obesity? How much and by what mechanisms does this urban garden contribute to the decrease of depression rates in this neighbourhood? The idea of change may be better understood, and the proper indicators can be selected by answering these questions in detail.

Step 4: The selection of indicators and data collection techniques for performance and process evaluation is the fourth step in the process Indicators should be able to answer the following questions: Is the NbS operating as designed, and are the outputs compatible with the theory of change that was developed? This question can be answered using the following steps:

1. Select appropriate indicators
2. Choose an appropriate impact evaluation method
3. Identify and collect all the necessary data to assess the selected indicators
4. Develop a local monitoring and data collection plan

Step 5: Structuring and implementing an effect monitoring and assessment strategy is the next step in the process. Analysing and interpreting the data obtained is the next phase in the process of assessing the NbS's ability to achieve its stated goals, and assessing both positive and negative consequences, synergy and trade-off possibilities. To take into account the differing viewpoints of many stakeholders, multi-criteria analysis can be employed. Analysis of the collected information should yield findings that can be tied back to the original goals indicated in the theory of change. As a result, local teams will be able to determine whether or not NbS activities had the desired effect. In order to better understand changes, it is strongly advised that assessment be a continuous process with diverse data gathering throughout time.

Step 6: Disseminating findings and making a difference in the public policy arena. This is the final phase of the NbS impact assessment process, which includes the distribution of the findings and the

implementation of the findings into policy. For individuals to learn about their local government's operations and for businesses to learn about business prospects, the more widely it is disseminated, the better. Scientists may continue to provide advice on NbS impact assessment approaches as well as research them. Dissemination of outcomes from the process as well as the final product is critical. The accumulation of information and understanding will help everyone working with NbS if all outcomes are reported. As a way to aid in decision-making, it's important to include spatial or GIS elements in the visual representations of impact data that have been created. For future stakeholder engagement, and evidence-based decisions, these data distribution platforms must be more appealing and user-friendly.

8. Policies for NbS

Nature-based solutions (NbS) can be viewed as a flagship phrase aimed at increasing public policy's consideration of nature. A policy is described as a set of goals and principles that serves as a guide for making decisions in order to attain a certain goal. As well as expressing aims and ideals, a policy may also describe the activities that will be taken to attain those goals. Several policies may and should incorporate NbS (health policy, safety and security policy, development policy, energy efficiency, etc.).

8.1 Policy and legislation drivers

The spread of NbS may be hindered by a number of obstacles. However, a diverse collection of motivators may be devised to help overcome roadblocks and encourage the development and implementation of NbS. However, despite the fact that NbS's obstacles and motivators are context and location-specific, there are still solutions at all levels, from municipal guidelines to national legislation and beyond. Investment, research, monitoring of NbS functionality, and product development all require long-term plans. Coercive regulation and vigorous enforcement are also required to ensure that NbS becomes a regular part of everyday life in the United States. In light of the fact that NbS is still a work in progress, policies and best practices should aim to stimulate growth. Government policies must encourage NbS and explain how such policies affect communities at all levels.

Economic and enforcement measures

Many policy instruments are needed to lead sustainable development via NbS. These include policies like laws and norms; strategies; planning tools; financing programs; incentives; and investment in research. In addition to these policy instruments: land use planning, information steering, fees, payment facilities (e.g. storm water charge exemption), tax deductions, jurisprudence and penalties; agreements; persuasive guidance; and obligations to implement NbS along with new construction projects and investment support are all examples of possible effective and useful policy instruments. Prejudices and a lack of understanding or expertise may seriously impede the widespread application of NbS if no coercive legislation or other significant incentives are in place. Environmental taxes, price-based instruments, carbon-trading systems, offsets for biodiversity, certification, payments for ecosystem services, fiscal advantages, and other types of economic incentives might all be used to encourage the adoption of NbS. If NbS are not implemented appropriately, financial consequences may also be necessary in circumstances where the rules or contracts require specified outcomes.

Measures designed to acquire information about the economic efficiency, environmental benefits, and commercial prospects offered by diverse instances should also be included in policy formulations. NbS capacity building should also be supported by a financial legislative framework that invests in experimental NbS and scientific research. With all of these rules, NbS may become a mainstream answer for future difficulties instead of today's popular solutions.

Strategies for using land

Sustainable land use and planning require new and innovative methodologies. Master plans are used to execute spatial policies such as rules that mandate the use of NbS are deemed essential to the growth of NbS. Existing NbS inventories will indicate land use gaps that may be utilized to set environmental equality objectives and timetables. Existing guidelines will need to be updated and new guidelines will have to be developed. The local planning administrations are the best organisations to accomplish this. In addition, it is necessary to mobilize individuals to work for NbS on privately owned property. Local, regional, and national government officials, the media, and the general public all have a role to play. As part of local and regional planning and development, public authorities are expected to conduct NbS interventions. These interventions will be integrated into various forms of sectoral planning. Multi-criteria analysis and environmental cost-benefit analysis are examples of decision support technologies that may be used to promote NbS over traditional methods.

For multifunctional NbS, the construction of standards and comprehensive policies must be co-created.

Developing quantitative and qualitative NbS standards in partnership with other stakeholders might fall to state or local organisations (e.g. environmental departments). NbS consumers (residents, tourists, landowners, etc.), producers (green constructors, material producers, etc.), and researchers are the key stakeholders. Such procedures might also benefit from the help of competent consultants, non-profit organisations, and pioneers of the NbS.

Since stating in a policy document (e.g. strategy) that a given type of NbS must support biodiversity or be constructed sustainably may not be sufficient, clear requirements and recommendations are required. Concrete guidelines for achieving the intended result should be provided instead (i.e. materials to be used, habitat characteristics, substrate qualities, plant species, etc.). In addition, assessment tools are required to keep tabs on progress toward policy objectives and provide guidance to decision-makers on the best ways to proceed. Both NbS's multifunctionality and budgeting considerations should be stressed.

Local empowerment is supported by policies that encourage collaboration and co-design.

Supporting and requiring effective means of communication, cooperation, and co-design are essential if NbS are to achieve their goals. Empowering the public is one way to attain these objectives. Public participation can be utilized to build additional green space on empty property, to co-manage the management of existing green space with local inhabitants, or to generate new opportunities for community collaboration and interaction. Guidelines from legal and policy frameworks should be provided to authorities, and practitioners and authorities should oversee the whole process.

8.2. Governance perspectives from local to regional level

The concept of NbS is by essence multifaceted and covers a wide range of realities. In addition, it is utilized in a wide range of circumstances and its contexts vary depending on location and period. It's a complicated idea that has to be viewed in its whole if it's to be used to address a wide range of concerns, including resilience, climate change adaptation and mitigation, human health and well-being, and the preservation of ecosystems and biodiversity. Indeed, NbS might be seen as a perfect instrument for facilitating a change

toward more resilient and sustainable landscapes and implies a transformation in the trajectory of societies and human behaviours.

Ecosystems and natural systems are interconnected and constrained by a variety of distinct characteristics. A problem at one level is almost always connected to a problem at another level. NbS implementation and dealing with environmental challenges need to address the question of governance and scalability, which necessitates this discussion. Analysing three different forms of governance while dealing with large-scale concerns is a good idea. Rather than focusing on monocentric governance, which is more representative of the traditional model, they move on to discuss multilevel governance, which is more relevant to the implementation of multifaceted projects such as NbS. Spatial dimensions are related with the phrase "levels" (national, regional, and local). The three pillars of this theory stress the shift of governmental authority and control:

1. International players and organisations
2. Cities and other jurisdictions at a regional level
3. Civil society and other non-state actors at the local level

In this sense, the term "governing" refers to the interactions between all the relevant levels of activity. This method emphasises the interplay between several stakeholders, all of whom are working toward the same objective. However, the transaction costs associated with the coordination of actors at various levels restrict the applicability of such a model. Adding feedback loops to the systems might facilitate the transition toward a more uniform application of NbS (i.e. tools for resilience, human well-being, sustainability, and other NbS objectives). When it comes to NbS, it looks as though various layers are needed to work together in order to achieve resilience through a comprehensive set of interconnected measures. Renaturation policies integrating scales and domains of NbS should be examined and developed in order to propose a plan for implementing NbS at various scales.

8.3. Policy and decision-making mechanisms

The efficacy of NbS planning and execution is critically dependent on the policy framework and decision-making mechanisms in place. Because NbS is still a relatively new idea, concrete recommendations are needed to help it gain traction and expand its application. Increased incorporation of NbS in regulatory

frameworks and administrative structures is needed in order to take use of NbS's numerous advantages. The deployment of NbS must also be linked to other policy areas (e.g. transportation, water, agriculture, energy) and relevant objectives (e.g. human health) that will give NbS initiatives a more multidimensional character. To ensure that NbS practices are implemented more widely, these ties might help enhance diffused knowledge and funds.

When dealing with practical challenges and enhancing implementation of NbS solutions, it's important to have an appropriate operational structure in place. Operational guidelines can be broken down into the following categories: a) distinguishing NbS from similar practices; b) measuring NbS interventions' efficacy; c) proposing ways to strengthen NbS interventions; and, finally, d) considering the ecological and societal context in which NbS will be established in. In terms of the framework's structure, the following parameters might be included:

1. Multidimensional nature of ecological intervention
2. The long-term viability of the incorporated interventions
3. The magnitude of initiatives
4. The direct impact of ecological services on society
5. Governance entity flexibility, allowing for easy adaptation in the face of possible changes

Policy mechanisms include a wide range of tools that may help NbS be put into practice. These are only a few examples, however:

1. Coherent information transfer from government entities to the public as well as between government institutions stressing the advantages and disadvantages of NbS; and
2. A wide range of collaboration between the governmental and private sectors and the general population.

In order to execute new environmental and natural resource policy procedures, new multi-level governance mechanisms must be established. In order to identify the requirements of all parties concerned, it is necessary to set up these kinds of procedures. New decision-making structures may be created as a result of these new types of collaboration.

At each geographical level, there may be a different set of stakeholders that might be involved in the process. It is also possible to identify a variety of other ways to implement NbS in the governance environment, including:

1. Regional and local governments (e.g., municipalities) use top-down decision-making procedures that exclude a large number of other stakeholders.
2. To secure enough finance, the public administration collaborates with private businesses and organisations.
3. Decision-making is a collaborative process in which numerous stakeholders, including the public, specialists and decision-makers are involved.
4. Citizens who have a strong sense of environmental responsibility have taken action in support of projects that promote environmental protection, biodiversity preservation, and climate change mitigation.
5. Companies and other organisations in the private sector develop and adopt NbS practices in order to maximize profits and minimise operational risks.

According to a wide range of studies, cooperative governance models are more effective when applied within an enabling framework of federal rules and are consistent with other governance processes like strategic planning and the use of economic incentives. Having stakeholders involved in the planning process may be quite beneficial for:

1. Adding new information to the planning process
2. Enhancing the final planning concept
3. Implementing common solutions that are at least based on the recommendations of everyone involved

To the extent that any environmental governance instrument is based on market incentives and exchanges, the effectiveness of such instrument depends on the internalization of positive environmental preferences among important stakeholders, including citizens and customers.

Engaging citizens in the decision-making process.

When making decisions, individuals play a significant role and should be educated, empowered and ultimately participate in NbS activities, planning and execution. As it turns out, citizen-driven NbS

programs are a great way to improve social cohesion, reconnect people with nature, raise public knowledge of the many advantages of NbS, and inspire a demand for environmental improvement from the general public. As a result, governments and local and regional authorities are able to gain access to information that they would otherwise be unable to collect by giving individuals a voice. Multiple methods may be used to achieve this level of participation, such as creating a citizen engagement process that incorporates both technical competence and regulatory needs, as well as public ideals.

9. Recommendations for NbS Uptake

1. Improvement and harmonization of NbS knowledge and data for worldwide NbS standards development
Upscaling NbS implementation requires a better knowledge basis, including solid scientific proof of its effectiveness. NbS's viability can be persuaded by well-established facts. Monitoring NbS efficacy necessitates a greater knowledge foundation. For the immediate and long term, it is critical to understand the influence of NbS on the environment, the economy, and society or on vital concerns like climate change.

2. Adaptation of monitoring and evaluation indicators
One of the most pressing issues is to develop a standard framework for NbS monitoring and effect evaluation. It is necessary to create and disseminate indicators that take into account all of the positive and negative effects, synergies, and trade-offs of the NbS, and are developed in a coordinated manner across industries and sizes. NbS's long-term and short-term impacts must also be defined. It is also necessary to evaluate the risks associated with a certain NbS and alternative solutions, taking into account the possible implications over time and place as well as future changes in the surrounding environment. For NbS, the same metrics may be used to evaluate its effectiveness. Additionally, these indicators should be used to examine how citizens are affected by NbS.

3. Interdisciplinarity action and the use of participative methods
NbS emphasises a wide range of perspectives and knowledge systems on human-nature interactions. Our comprehension of NbS will only grow if we take into account these factors while generating and accessing NbS. The success of NbS is dependent on the participation of a wide range of stakeholders. A transdisciplinary approach can assist overcome obstacles and take advantage of possibilities, such as merging local and scientific knowledge to provide more effective solutions. Transdisciplinary techniques

involve collaborating across stakeholder groups. The long-term success of NbS initiatives may be attributed to stakeholder empowerment. When it comes to NbS implementation, it is important to look at the methods in which stakeholders (people, officials, etc.) may be involved, and how they can be communicated about successful and failure examples of NbS.

4. Implementation of previously acquired and newly acquired knowledge

Since NbS projects can be expensive, ready-to-replicate, easy-to-install technological items are needed. Digitization or smart technologies can reduce maintenance expenses, e.g. through automated watering systems. Fostering NbS replicability and industrial scale-up would have tremendous effect. If NbS technical performance and life-cycle costs (installation, operation, and maintenance) are comparable, NbS practices will be encouraged over grey and other traditional alternatives. Cost-effective technology will make the solutions available to developing countries and communities. Lack of operational clarity in execution hampers NbS adoption, as policymakers or managers are typically left to interpret how to implement an idea, which can cause lengthy gaps and a negative effect on NbS.

5. Effective knowledge transmission

Every new concept requires the spread of information. Both public administration units (e.g. municipalities) and people require NbS communication. Improving public understanding about NbS can raise public awareness and change people' attitudes (i.e. priorities and views) regarding these solutions, which can influence local choices on green infrastructure and NbS in particular. Technical information should be translated for the above-mentioned target groups to improve communication. NbS promote biodiversity, improve climate change adaption, facilitate recreational activities, etc., and help handle various global concerns. Networking can help share NbS information and advantages. Participation in NbS-related networks, groups, and consortiums may also help acquire NbS expertise and acceptance.

6. Creation of sources of finance as well as effective business concepts

Business cases are essential for any NbS (particularly those that include the private sector), and their incorporation into the decision-making process is critical in order to get the funds necessary for implementation. Finance for NbS activities can be accessed through decentralized funds and credit schemes, while public-private partnerships can be created at the national and international levels. NbS's larger diffusion requires further exploration of NbS's financing/funding and commercial options. In order to make an economic case for investing in ecosystems and watersheds as natural infrastructure, the costs and benefits of ecosystem services must be assessed.

This kind of appraisal may be quite valuable to public, private, and other organisations in order to describe their contribution (with their own resources). Furthermore, they can join in the financing scheme, which will increase the overall investment in NbS dissemination.

7. Ensure that policies are in harmony and that synergies are created across scales and across different agendas.

With regards to policy, there is a wide disparity between levels and sectors. NbS adoption and sustainable development will be facilitated if international, national, regional, and local laws are harmonized. At the municipal level, new regulations and NbS-oriented policies are needed. In addition, there are divergent regulations at the state and national levels that must be reconciled. Regulations should be organised into a unified legislative framework. Those rules should be enacted at the national, regional, and local levels in order to include and be consistent with the specific demands, expectations, and goals of the various regions of the country. Making policies at all levels synergistically and efficiently, as well as encouraging vertical and horizontal collaboration between different policymakers and sectors, is essential for comprehensive NbS initiatives to be implemented. Transparency is a key factor in establishing trust between the parties concerned and the general public. Furthermore, all choices should be widely communicated, and the decision-making process should be adequately transparent.

8. Innovation and governance in the form of new alliances and systems

NbS are initiatives and solutions with many facets that challenge the current, often monolithic, institutions of governance. As NbS is effective in addressing a wide range of issues, new governance structures must be developed. Policy efficacy and coherence must be assessed, while cross-sector and cross-scale approaches must be fostered. Analysis of policy frameworks, as well as political and social resistance to change at relevant levels, is necessary to better understand the governance systems that support NbS.

This includes addressing the consistency of different policies for integrated spatial planning and efficient NbS deployment as well as overcoming some trade-offs. In order to achieve both biodiversity and social benefits while boosting the overall performance of an NbS, creative cooperation and governance methods must be developed. Such frameworks must also take into account socio-environmental fairness.

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