ARPHA Proceedings

Proceedings CAUSummit 2025, 0045-0052
doi: 10.3897/ap.9.e0045

10th Anniversary
World Summit: Civil Engineering-Architecture-Urban Planning Congress

Proposals for Nature-Based Solutions (NBS) for the Sustainable Rehabilitation of the Ponte Gêa Neighborhood in Mozambique

Michael M. Santos[1, a)], Ana Teresa Vaz Ferreira[2], João C. G: Lanzinha[1]

[1] *Centre of Materials and Civil Engineering for Sustainability (C–MADE/UBI), University of Beira Interior, Department of Civil Engineering and Architecture, Covilhã 6201-001, Portugal*
[2] *Polytechnic Institute of Castelo Branco, Civil Engineering Department, Castelo Branco 6000-084, Portugal*

[a)] Corresponding author: michael.santos@ubi.pt

Abstract. The increasing impacts of climate change on urban areas, particularly in vulnerable regions like coastal Mozambique, necessitate innovative approaches to urban planning and management. Nature-Based Solutions (NBS) have gained recognition as effective strategies to address urban challenges, offering sustainable methods for managing water resources, enhancing resilience, and improving living conditions. Despite their proven benefits in various global contexts, there is limited application and research on NBS in African cities, making this study particularly relevant. This research focuses on the sustainable rehabilitation of the Ponte Gêa neighborhood in Beira, Mozambique, utilizing NBS to improve environmental performance, mitigate climate risks, and promote social inclusivity. The methodology involves a comprehensive assessment of the local climatic conditions, urban drainage systems, and socio-economic characteristics of the Ponte Gêa neighborhood. Field surveys and data collection were conducted to identify critical areas for intervention, focusing on flooding risks, urban heat island effects, and the availability of green spaces. Analytical methods include hydrological modeling and spatial analysis to determine optimal locations for NBS implementation, such as rainwater harvesting systems, urban reforestation, and green corridors. The main results demonstrate that the proposed NBS can significantly reduce the risk of urban flooding through enhanced infiltration and rainwater retention. The implementation of green spaces and vegetative barriers is shown to decrease surface temperatures, mitigating the urban heat island effect. Moreover, the integration of NBS has the potential to increase local biodiversity and provide new recreational areas for residents, fostering a stronger sense of community ownership and well-being. A critical discussion highlights the challenges of adapting NBS to the local socio-economic context, including initial investment costs and the need for capacity building within the community. In conclusion, this study provides a model for the sustainable rehabilitation of urban areas in Mozambique through Nature-Based Solutions, emphasizing their role in building climate resilience in coastal regions. The findings suggest that NBS can serve as a viable alternative to traditional engineering approaches, with long-term benefits for environmental management and community development. The proposed interventions in Ponte Gêa could be adapted for similar contexts across Sub-Saharan Africa, contributing to ongoing research and policy dialogue on sustainable urban development in climate-vulnerable regions.

Keywords: Nature-Based Solutions (NBS); Urban Resilience; Climate Change Adaptation; Sustainable Urban Development; Mozambique.

Published by CAUSummit and peer-reviewed under the responsibility of "World Summit: Civil Engineering-Architecture-Urban Planning Congress - CAUSummit-2025".

INTRODUCTION

Beira, located at the confluence of the Púnguè and Búzi rivers, is a low-lying coastal city that faces severe climate change impacts. Mozambique is consistently ranked among the most climate-vulnerable countries, suffering from tropical cyclones, rising sea levels, and recurrent flooding [1]. The devastation caused by Cyclone Idai in 2019, which destroyed 90% of Beira's infrastructure and displaced thousands of residents, exemplifies the severity of climate-related disasters in the region [2]. In the following years, Cyclones Chalane (2020) and Eloíse (2021) further worsened the city's vulnerability, limiting recovery efforts and intensifying socio-economic hardships [3, 4].

Scientific projections indicate that climate risks in Beira will intensify in the coming decades. By 2050, sea levels along the Mozambican coast are expected to rise between 0.16 m and 0.38 m, significantly increasing the frequency of coastal flooding [5]. Moreover, the warming of the Indian Ocean is expanding the trajectory and intensity of tropical cyclones, making extreme weather events like Cyclone Idai more frequent and destructive [4, 6] These challenges are exacerbated by inadequate urban infrastructure, weak flood management systems, and environmental degradation, emphasizing the urgent need for innovative adaptation measures [7].

Nature-Based Solutions (NBS) have emerged as a sustainable and cost-effective strategy for enhancing urban resilience and reducing climate risks [8]. These solutions include mangrove restoration, green infrastructure, and natural drainage systems, which can effectively mitigate flooding, reduce coastal erosion, and improve urban water management [9]. Additionally, implementing urban green spaces and ecological corridors contributes to lowering urban temperatures, improving air quality, and enhancing overall livability [10, 11].

In response to these challenges, Ponte Gêa, a particularly vulnerable neighborhood in Beira, has been selected as a case study for the implementation of NBS. This research aims to assess the potential of NBS in enhancing environmental performance, mitigating climate risks, and fostering social inclusivity within the community. By developing a replicable model, this study contributes to the broader discourse on sustainable urban development in climate-vulnerable African cities [12].

MATERIALS AND METHODS

The implementation of Nature-Based Solutions (NBS) in Beira follows a structured methodology that integrates scientific research, geospatial analysis, community engagement, and pilot testing. Given the city's high vulnerability to coastal erosion, flooding, and cyclones, the methodology was designed to identify critical areas for intervention, evaluate the feasibility of NBS, and propose sustainable urban resilience strategies.

Data Collection and Site Analysis

A comprehensive assessment of Beira's climatic, hydrological, and socio-economic conditions was conducted using remote sensing, field surveys, and historical climate data analysis. Satellite imagery from Sentinel-1 and Sentinel-2 was employed to map flood-prone areas, land use, and vegetation cover [13]. Hydrological models were applied to simulate storm surge scenarios, urban water drainage efficiency, and the impact of sea-level rise [14].

Field surveys were conducted to assess soil conditions, mangrove conditions, dune stability, and urban green spaces. Social data were collected through community consultations and stakeholder interviews to understand local knowledge, land-use conflicts, and social acceptance of NBS projects [15].

Selection and Design of Nature-Based Solutions

Based on the site analysis, four primary NBS interventions were prioritized for Beira:

1. Mangrove Restoration and Expansion – Restoration of degraded mangrove areas along the estuaries and expansion of new mangrove belts to mitigate storm surges and coastal erosion. The selection of mangrove species was guided by salinity tolerance, growth rates, and sediment stabilization properties. Mangrove nurseries were established, and local communities were engaged in seedling collection, propagation, and replanting efforts [16].
2. Coastal Dune Rehabilitation – Artificial dunes were designed using sand nourishment and vegetative stabilization techniques, incorporating native grasses and shrubs to enhance dune resilience against storm

surges. Structural reinforcements such as sand-trapping fences were implemented in erosion-prone areas. The project followed best practices from similar interventions in other coastal regions [14].

3. Urban Green Infrastructure and Reforestation – Reforestation initiatives targeted public spaces, riverbanks, and low-income neighborhoods, improving flood absorption and reducing the urban heat island effect. Tree species were selected based on drought tolerance, cyclone resistance, and ecosystem services. Community-based tree-planting programs were integrated into Beira's urban planning policies [15].
4. Flood-Resilient Drainage Systems – The existing drainage network was retrofitted with green infrastructure components, including permeable pavements, rain gardens, and constructed wetlands. These elements were designed to improve stormwater infiltration, reduce surface runoff, and filter pollutants. The Chiveve River restoration project served as a reference model for hybrid flood mitigation strategies [16].

Pilot Testing and Adaptive Management

To validate the effectiveness of the proposed NBS, pilot projects were implemented in selected high-risk areas. Mangrove restoration and dune stabilization were tested in Ponta Gêa and Praia Nova, while urban reforestation and green drainage systems were introduced in densely populated neighborhoods. Performance indicators, including wave energy reduction, floodwater retention, and vegetation survival rates, were monitored over time.

An adaptive management approach was adopted, allowing modifications in design based on real-time monitoring data. For instance, initial mangrove planting trials identified species with higher survival rates, leading to adjusted planting densities and improved sediment stabilization techniques [13].

Community Engagement and Capacity Building

Public participation was a core component of the methodology, ensuring community ownership and long-term sustainability. Local workshops, educational programs, and employment opportunities were created to train residents in mangrove conservation, urban forestry maintenance, and eco-friendly flood management practices [15].

The involvement of local authorities, non-governmental organizations (NGOs), and international partners facilitated knowledge exchange and policy integration. Financial mechanisms, including public-private partnerships and climate adaptation funds, were explored to ensure sustainable financing for long-term NBS maintenance [16].

The implementation of NBS in Beira followed a scientific, participatory, and adaptive methodology that integrated geospatial analysis, community engagement, ecosystem restoration, and urban green infrastructure. By aligning local knowledge with global best practices, these interventions aimed to reduce disaster risks, enhance urban resilience, and improve ecological health. Through pilot projects and adaptive management, the strategy ensures long-term effectiveness and sustainability, setting a precedent for scalable climate adaptation in other coastal cities.

EVALUATION OF PROPOSED SOLUTIONS

The effectiveness of Nature-Based Solutions (NBS) in Beira is assessed through their environmental impact, disaster risk mitigation, and social benefits. Research has shown that green infrastructure, such as mangroves, urban forests, and flood retention parks, significantly enhances urban resilience [17].

Environmental Impact and Disaster Risk Mitigation

NBS contribute significantly to reducing flood risks, enhancing water retention, and mitigating the effects of storm surges. Mangrove ecosystems act as natural storm barriers, reducing wave height and coastal erosion, while urban reforestation and floodplain restoration help to regulate rainwater infiltration and prevent excessive runoff [5]

- Wave Energy Reduction and Coastal Protection: Mangrove belts in tropical regions have been shown to reduce wave energy by up to 66%, minimizing storm surges before they reach urban areas [17]. In Quelimane, Mozambique, restored mangroves helped prevent severe coastal flooding during Cyclone

Idai. Beira's coastal restoration plan follows a similar model, where mangroves and dune reinforcements aim to protect vulnerable shorelines [15].

- Floodwater Retention and Drainage Efficiency: Urban green infrastructure, such as the Chiveve River restoration project, improves flood resilience by increasing water storage capacity. The integration of constructed wetlands, retention basins, and permeable surfaces in the city reduces flood risks by slowing down runoff and enhancing infiltration [18, 19].
- Long-term Resilience and Adaptability: Unlike concrete flood barriers, which require high maintenance and are prone to failure, NBS evolve and strengthen over time. For example, mangrove forests naturally regenerate and expand, increasing their protective capacity against rising sea levels [5]. Similarly, dune reinforcement with vegetation helps maintain natural sand accumulation, ensuring coastal stability.

Social and Economic Benefits of NBS

Beyond environmental impact, NBS offer significant benefits for local communities, including job creation, public health improvements, and social cohesion.

- Community-Based Conservation and Employment: The restoration of mangroves and urban forests has provided opportunities for local employment, particularly in seed collection, planting, and maintenance [15]. Women-led initiatives in coastal cities have successfully trained community members in mangrove nursery management, improving livelihoods while enhancing climate resilience.
- Health and Well-Being Improvements: Urban green spaces, such as the Chiveve Park, have demonstrated positive effects on mental and physical health, providing recreational areas, shade, and air quality improvements. Research has shown that access to nature reduces stress and promotes community interaction, fostering stronger social networks that are essential for disaster recovery [18, 20].
- Cost-Effectiveness and Long-Term Savings: Compared to traditional flood barriers and drainage systems, NBS offer a more cost-effective solution with lower maintenance requirements. The implementation of urban wetlands and permeable pavements has been shown to reduce the cost of stormwater management by up to 30% while providing additional ecological and recreational benefits [5, 21].

Challenges and Areas for Improvement

Despite their advantages, NBS face several implementation challenges, including land-use conflicts, financial constraints, and governance issues.

- Urban Expansion and Land-Use Conflicts: Rapid urbanization in Beira has led to increased pressure on natural floodplains and coastal ecosystems. Encroachment into mangrove forests and wetlands reduces their effectiveness in flood mitigation, requiring strict zoning policies and conservation incentives [15, 22].
- Initial Investment and Policy Integration: While NBS offer long-term economic benefits, the upfront costs of ecosystem restoration and land acquisition can be barriers to implementation. Stronger policy support, financing mechanisms, and international partnerships are needed to scale up NBS projects in Beira [18, 23].
- Monitoring and Adaptive Management: Continuous monitoring of restored ecosystems is essential to ensure their effectiveness. The development of data-driven decision-making tools, such as GIS mapping and flood risk modelling, can improve the management and scalability of NBS interventions [5, 24].

RECOMMENDATIONS FOR IMPLEMENTATION AND PUBLIC POLICY

The successful implementation of Nature-Based Solutions (NBS) in Beira depends on effective policies, governance structures, financing mechanisms, and community engagement strategies. Research has shown that integrating NBS into urban planning and climate resilience frameworks requires a combination of regulatory incentives, stakeholder participation, and long-term monitoring [15].

The Nature-Based Solutions implemented in Beira demonstrate high potential for enhancing climate resilience, reducing disaster risks, and improving social well-being. Mangrove restoration, dune reinforcement, urban reforestation, and flood-resilient green infrastructure provide cost-effective, long-term benefits that strengthen both ecological and human systems. However, to maximize their impact, continued policy support, financial investments, and adaptive management strategies are required. By integrating NBS into Beira's urban planning and climate adaptation framework, the city can serve as a model for sustainable and resilient coastal development.

Policy and Governance Frameworks for NBS

Effective governance is essential for scaling up NBS in urban environments. Key policy recommendations include:

- Institutionalizing NBS in Urban Planning. Local governments should integrate NBS into municipal land-use plans, zoning regulations, and climate adaptation policies. In Beira, this means designating protected mangrove zones, urban green corridors, and floodplain conservation areas as part of its Master Plan 2035 [15, 25, 26].
- Strengthening Legal Protections for Natural Ecosystems. Beira's mangrove forests and coastal dunes play a critical role in flood mitigation. The government should enact stronger environmental protection laws to prevent deforestation, sand mining, and unregulated coastal development. Similar policies in other coastal cities have proven effective in preserving natural buffers against climate hazards [27].
- Enhancing Multi-Stakeholder Collaboration. Implementing NBS requires coordination among government agencies, NGOs, private sector partners, and local communities. Case studies from European and Asian cities highlight the need for inclusive decision-making processes that incorporate local knowledge into adaptation strategies [28].

Financing Mechanisms for NBS Implementation

One of the biggest challenges in scaling up NBS is securing sustainable funding sources. Strategies for financing include:

- Public-Private Partnerships (PPP), encouraging private sector investment in green infrastructure projects can reduce the financial burden on local governments. In Beira, companies engaged in eco-tourism and real estate development could be incentivized to fund urban greening and coastal restoration projects [29].
- International Climate Adaptation Funds, Beira can leverage global climate resilience funding, such as the Green Climate Fund (GCF) and Global Environment Facility (GEF), to finance large-scale mangrove rehabilitation, dune stabilization, and flood-resilient urban parks [30].
- Ecosystem Service Payments and Carbon Markets, mangrove forests provide carbon sequestration benefits, making them eligible for carbon credit programs. By participating in blue carbon markets, Beira could generate revenue for ongoing conservation and restoration efforts [31]

Community Engagement and Capacity Building

NBS projects succeed when local communities are actively involved. Recommended strategies include:

- Participatory Urban Planning, empowering residents through community workshops and decision-making forums ensures that NBS projects align with local needs. In Beira, past infrastructure projects have faced challenges due to limited public participation, underscoring the need for bottom-up approaches [15].
- Educational Programs and Skill Development, training programs in mangrove restoration, urban forestry, and green infrastructure maintenance can create employment opportunities while enhancing local expertise [19].
- Community-Led Monitoring Initiatives, establishing local environmental monitoring groups can help track the health of mangrove forests, urban green spaces, and water retention areas. Involving citizen scientists and local universities ensures that monitoring efforts are scientifically robust and sustainable [32]).

Long-Term Monitoring and Adaptive Management

Ensuring the sustainability of NBS requires ongoing performance assessments and adaptive management strategies. Key recommendations include:

- Establishing an NBS Performance Monitoring Framework, governments should set clear benchmarks and indicators to measure the effectiveness of NBS interventions in reducing flood risks, enhancing biodiversity, and improving community well-being [32].
- Integrating Digital Technologies for Real-Time Monitoring, advanced tools, such as GIS mapping, remote sensing, and AI-driven climate modeling, can help track changes in ecosystem health and urban resilience over time [33].
- Flexibility and Policy Adjustments, given changing climate conditions, NBS policies must remain adaptable. Governments should regularly update regulations and investment plans based on scientific findings and field observations [32].

To maximize the impact of Nature-Based Solutions in Beira, local and national governments must institutionalize NBS within urban planning frameworks, secure sustainable financing, and foster inclusive governance mechanisms. International case studies show that integrating NBS into climate policies, mobilizing public-private partnerships, and empowering local communities can significantly enhance urban resilience (Van Ham & Klimmek, 2017). By adopting a long-term monitoring approach and leveraging innovative financing mechanisms, Beira can serve as a model for climate adaptation in other vulnerable coastal cities.

CONCLUSION

The increasing threats posed by climate change, extreme weather events, and environmental degradation highlight the need for innovative, sustainable, and adaptive urban planning strategies. In this context, Nature-Based Solutions (NBS) emerge as a critical approach for addressing urban challenges, particularly in climate-vulnerable coastal regions like Beira, Mozambique. This study demonstrates how the sustainable rehabilitation of the Ponte Gêa neighborhood through NBS can mitigate flooding risks, enhance climate resilience, and promote social inclusivity, offering a model for integrated urban adaptation.

By leveraging mangrove restoration, dune reinforcement, urban reforestation, and green drainage infrastructure, NBS provide multifaceted benefits that extend beyond disaster risk reduction. The implementation of green spaces and vegetative barriers has been shown to reduce surface temperatures, mitigate the urban heat island effect, and improve local air quality, contributing to a healthier and more livable urban environment. Additionally, enhancing water infiltration and retention through nature-based drainage solutions plays a crucial role in reducing the frequency and severity of urban flooding, which remains a pressing challenge for Beira’s residents.

Beyond their environmental impact, NBS foster economic and social benefits. Community engagement in tree planting, mangrove conservation, and urban greening initiatives has strengthened local participation and a sense of ownership, ensuring the long-term sustainability of these interventions. Moreover, the integration of public parks, reforested spaces, and ecotourism opportunities within urban areas contributes to economic growth, supporting local businesses, job creation, and improved livelihoods. These factors underline the potential of NBS to serve as a foundation for resilient and inclusive urban development.

Despite these benefits, the successful implementation and scaling of NBS in Beira require strategic planning, institutional support, and sustainable financing mechanisms. The long-term effectiveness of NBS depends on integrating them into urban policies, securing financial investments, and strengthening local governance frameworks to ensure their continuity and adaptation to evolving climate risks. Additionally, knowledge exchange and regional collaboration between Beira and other coastal cities in Sub-Saharan Africa can foster the replication and upscaling of NBS, reinforcing their role in climate adaptation strategies at a broader scale.

In conclusion, this study underscores the importance of Nature-Based Solutions in enhancing the resilience of climate-vulnerable urban areas. The proposed interventions in Ponte Gêa demonstrate that NBS can serve as a viable alternative to traditional engineering approaches, offering long-term benefits for environmental management, disaster risk reduction, and sustainable urban development. As cities worldwide continue to face intensifying climate challenges, Beira's experience with NBS can provide valuable insights and best practices for integrating nature-driven adaptation strategies into urban resilience planning across the region.

ACKNOWLEDGMENTS

This work was supported by Portuguese national funds through FCT—Foundation for Science and Technology, I.P., under project reference UIDB/04082/2020 (DOI: 10.54499/UIDB/04082/2020) (https://sciproj.ptcris.pt/175080UID).

REFERENCES

1. Building Urban Resilience. Building Urban Resilience. (2013). https://doi.org/10.1596/978-0-8213-8865-5.
2. Kavonic, J., Bulkeley, H.: Generating transformative capacity: ICLEI Africa's urban natural assets for Africa programme. Local Environ. 28, 900–917 (2023). https://doi.org/10.1080/13549839.2023.2190349.
3. Climate Change 2021: The Physical Science Basis | Climate Change 2021: The Physical Science Basis, https://www.ipcc.ch/report/ar6/wg1/, last accessed 2025/03/09.
4. Santos, M.M., Ferreira, A., Lanzinha, J.C.G.: Urban Strategies for a Resilient City in Africa - Beira. In: Aspa Gospodini (ed.) Proceedings of the International Conference on Changing Cities V: Spatial, Design, Landscape, Heritage & Socio-Economic dimensions. pp. 1067–1077. University of Thessaly, Department of Planning and Regional Development, Laboratory of Urban Morphology & Design, Volos, Greece (2022).
5. Sofia, C., Ferreira, S., Potočki, K., Kapović-Solomun, M., Kalantari, Z.: Nature-Based Solutions for Flood Mitigation and Resilience in Urban Areas. https://doi.org/10.1007/698_2021_758.
6. Zhang, R., Chen, Y., Lei, J., Zhou, X., Yao, P., Stive, M.J.F.: Experimental investigation of wave attenuation by mangrove forests with submerged canopies. Coastal Engineering. 186, 104403 (2023). https://doi.org/10.1016/J.COASTALENG.2023.104403.
7. Glavan, M., Cvejić, R., Zupanc, V., Knapič, M., Pintar, M.: Agricultural production and flood control dry detention reservoirs: Example from Lower Savinja Valley, Slovenia. Environ Sci Policy. 114, 394–402 (2020). https://doi.org/10.1016/J.ENVSCI.2020.09.012.
8. Nature-based Solutions for climate change mitigation | UNEP - UN Environment Programme, https://www.unep.org/resources/report/nature-based-solutions-climate-change-mitigation, last accessed 2025/03/09.
9. Beceiro, P., Brito, R.S., Galvão, A.: The Contribution of NBS to Urban Resilience in Stormwater Management and Control: A Framework with Stakeholder Validation. Sustainability 2020, Vol. 12, Page 2537. 12, 2537 (2020). https://doi.org/10.3390/SU12062537.
10. Sunkur, R., Kantamaneni, K., Bokhoree, C., Ravan, S.: Mangroves' role in supporting ecosystem-based techniques to reduce disaster risk and adapt to climate change: A review. J Sea Res. 196, 102449 (2023). https://doi.org/10.1016/J.SEARES.2023.102449.
11. Alongi, D.M.: Mangrove forests: Resilience, protection from tsunamis, and responses to global climate change. Estuar Coast Shelf Sci. 76, 1–13 (2008). https://doi.org/10.1016/J.ECSS.2007.08.024.
12. McEvoy, D., Tara, A., Vahanvati, M., Ho, S., Gordon, K., Trundle, A., Rachman, C., Qomariyah, Y.: Localized nature-based solutions for enhanced climate resilience and community wellbeing in urban informal settlements. Clim Dev. 16, 600–612 (2024). https://doi.org/10.1080/17565529.2023.2277248.
13. Nhangumbe, M., Nascetti, A., Georganos, S., Ban, Y.: Supervised and unsupervised machine learning approaches using Sentinel data for flood mapping and damage assessment in Mozambique. Remote Sens Appl. 32, 101015 (2023). https://doi.org/10.1016/J.RSASE.2023.101015.
14. Van Berchum, E.C., Van Ledden, M., Timmermans, J.S., Kwakkel, J.H., Jonkman, S.N.: Rapid flood risk screening model for compound flood events in Beira, Mozambique. Hazards Earth Syst. Sci. 20, 2633–2646 (2020). https://doi.org/10.5194/nhess-20-2633-2020.
15. Shannon, M., Otsuki, K., Zoomers, A., Kaag, M.: Sustainable Urbanization on Occupied Land? The Politics of Infrastructure Development and Resettlement in Beira City, Mozambique. Sustainability 2018, Vol. 10, Page 3123. 10, 3123 (2018). https://doi.org/10.3390/SU10093123.
16. Favero, F., Hinkel, J.: Key Innovations in Financing Nature-Based Solutions for Coastal Adaptation. Climate. 12, 53 (2024). https://doi.org/10.3390/CLI12040053/S1.
17. Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., Haase, D., Knapp, S., Korn, H., Stadler, J., Zaunberger, K., Bonn, A.: Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action.

Ecology and Society, Published online: Jun 01, 2016 | doi:10.5751/ES-08373-210239. 21, (2016). https://doi.org/10.5751/ES-08373-210239.

18. Frantzeskaki, N., Mcphearson, T., Collier, M.J., Kendal, D., Bulkeley, H., Dumitru, A., Walsh, C., Noble, K., Ordóñez, C., Oke, C., Pintér, L.: Nature-Based Solutions for Urban Climate Change Adaptation: Linking Science, Policy, and Practice Communities for Evidence-Based Decision-Making. Bioscience. 69, 455–466 (2019). https://doi.org/10.1093/biosci/biz042.
19. Rosen, M.A., Birkmann, J., Jamshed, A., Castelo, S., Amado, M., Ferreira, F.: Challenges and Opportunities in the Use of Nature-Based Solutions for Urban Adaptation. Sustainability 2023, Vol. 15, Page 7243. 15, 7243 (2023). https://doi.org/10.3390/SU15097243.
20. Adams, C., Frantzeskaki, N., Moglia, M.: Mainstreaming nature-based solutions in cities: A systematic literature review and a proposal for facilitating urban transitions. Land use policy. 130, 106661 (2023). https://doi.org/10.1016/J.LANDUSEPOL.2023.106661.
21. Van Zanten, B.T., Gutierrez Goizueta, G., Brander, L.M., Gonzalez Reguero, B., Griffin, R., Macleod, K.K., Alves Beloqui, A.I., Midgley, A., Herrera Garcia, L.D., Jongman, B.: Assessing the Benefits and Costs of Nature-Based Solutions for Climate Resilience: A Guideline for Project Developers. Assessing the Benefits and Costs of Nature-Based Solutions for Climate Resilience: A Guideline for Project Developers. (2023). https://doi.org/10.1596/39811.
22. Seddon, N., Chausson, A., Berry, P., Girardin, C.A.J., Smith, A., Turner, B.: Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philosophical Transactions of the Royal Society B. 375, (2020). https://doi.org/10.1098/RSTB.2019.0120.
23. McEvoy, D., Tara, A., Vahanvati, M., Ho, S., Gordon, K., Trundle, A., Rachman, C., Qomariyah, Y.: Localized nature-based solutions for enhanced climate resilience and community wellbeing in urban informal settlements. Clim Dev. 16, 600–612 (2024). https://doi.org/10.1080/17565529.2023.2277248.
24. Sarabi, S.E., Han, Q., Romme, A.G.L., de Vries, B., Wendling, L.: Key Enablers of and Barriers to the Uptake and Implementation of Nature-Based Solutions in Urban Settings: A Review. Resources 2019, Vol. 8, Page 121. 8, 121 (2019). https://doi.org/10.3390/RESOURCES8030121.
25. Masterplan Beira (EKN) | Project Database CMS, https://projects.rvo.nl/programmes/nl-kvk-27378529-29715, last accessed 2025/03/09.
26. Santos, M.M., Ferreira, A.V., Lanzinha, J.C.G.: Colonial moorings on spatial planning of Mozambique. Cities. 124, (2022). https://doi.org/10.1016/j.cities.2022.103619.
27. Van Ham, C., Klimmek, H., Van Ham, C., Klimmek, • H: Nature-based Solutions to Climate Change Adaptation in Urban Areas. Theory and Practice of Urban Sustainability Transitions. https://doi.org/10.1007/978-3-319-56091-5_16.
28. Mabon, L., Barkved, L., de Bruin, K., Shih, W.Y.: Whose knowledge counts in nature-based solutions? Understanding epistemic justice for nature-based solutions through a multi-city comparison across Europe and Asia. Environ Sci Policy. 136, 652–664 (2022). https://doi.org/10.1016/J.ENVSCI.2022.07.025.
29. Van Ham, C., Klimmek, H., Van Ham, C., Klimmek, • H: Nature-based Solutions to Climate Change Adaptation in Urban Areas. Theory and Practice of Urban Sustainability Transitions. https://doi.org/10.1007/978-3-319-56091-5_16.
30. Anderson, V., Gough, W.A.: Harnessing the Four Horsemen of Climate Change: A Framework for Deep Resilience, Decarbonization, and Planetary Health in Ontario, Canada. Sustainability 2021, Vol. 13, Page 379. 13, 379 (2021). https://doi.org/10.3390/SU13010379.
31. Liu, H.-Y., Jay, M., Chen, X., Liu, C.:, Jay, H.-Y.;, Chen, M.;, Asumadu-Sarkodie, S.: The Role of Nature-Based Solutions for Improving Environmental Quality, Health and Well-Being. Sustainability 2021, Vol. 13, Page 10950. 13, 10950 (2021). https://doi.org/10.3390/SU131910950.
32. Cohn, J.L., Copp Franz, S., Mandel, R.H., Nack, C.C., Brainard, A.S., Eallonardo, A., Magar, V.: Strategies to work towards long-term sustainability and resiliency of nature-based solutions in coastal environments: A review and case studies. Integr Environ Assess Manag. 18, 123–134 (2022). https://doi.org/10.1002/IEAM.4484.
33. Aziz, F., Wang, X., Mahmood, M.Q., Awais, M., Trenouth, B.: Coastal urban flood risk management: Challenges and opportunities − A systematic review. J Hydrol (Amst). 645, 132271 (2024). https://doi.org/10.1016/J.JHYDROL.2024.132271.