



BRIEFING NOTE

NATURE-BASED CO-CREATIONS AS ECOLOGICAL ENGINEERING
SOLUTIONS FOR URBAN COASTLINES: TRANSDISCIPLINARY
PARTNERSHIPS THROUGH SCIENCE, ARTS, INDIGENOUS
KNOWLEDGE AND INDUSTRY

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The Indigenous Marine Innovations for sustainable Environments and Economies project

Objective – A briefing note aims to provide a concise outcome based synopsis of recent research or expert opinion that may inform decision making and activities by authorities, NGOs and NPOs. The briefing note series complements the academic peer reviewed literature published by SAIAB.

OBJECTIVE OF BRIEF

The purpose of this briefing note is to provide an in-depth overview on ongoing research pursued by researchers at the South African Institute for Aquatic Biodiversity (NRF-SAIAB) on nature-based co-creations as ecological engineering solutions for urban coastal environments. The overview of this innovative research was recently published in the Cambridge Prisms series: Coastal Futures in 2023: “Eco-creative nature-based solutions to transform urban coastlines, local coastal communities and enhance biodiversity through the lens of scientific and Indigenous knowledge”, which outlined the ongoing Indigenous Marine Innovations for sustainable Environments and Economies (IMIsEE) project. The briefing note further highlights key elements of the IMIsEE project such as its aspiration to sustainable, inclusive and equitable eco-engineering solutions, forged by a deep collaborative partnership between scientists, members of a local rural community and maritime industry, and its potential impact on coastal environments, communities and knowledge systems.


SUMMARY

Research on ecological engineering is on the rise worldwide aiming at the rehabilitation and restoration of impacted environments and the IMIsEE project, an initiative funded by the South African National Research Foundation and hosted by the South African Institute for Aquatic Biodiversity (SAIAB), is fully embedded within this framework to innovatively use Indigenous knowledge and practices to counteract the negative impacts of coastal armoring by improving the biodiversity value of marine urban habitats. Embedded in a rural community setting, and merging innovation and natural materials with the traditional African artisanal practice of weaving, the project is set to revolutionise the coalescence of scientific research and Indigenous knowledge, with the specific focus on enhancing the sustainability of coastal ecosystems in the Eastern Cape Province of South Africa and ultimately increase the biodiversity value of urban coastlines.

BACKGROUND

Ecological engineering in the built coastal environment

Increasing anthropogenic pressure, through urbanisation and coastal development, poses a threat to coastal ecosystems, primarily due to the hardening of shorelines – coastal defences or armoring (e.g., seawalls, breakwaters, revetments, bulkheads, pontoons, jetties and slipways). These coastal defence structures bring irreversible ecological impacts which may have profound implications for the long-term sustainability of marine ecosystems and blue economies. Direct ecological impacts from coastal defence structures include habitat loss, fragmentation and degradation, reduction in microbenthic diversity, changes in physical and chemical properties and processes, and increases in marine pollution associated with sewage and urban runoff. Indirect ecological impacts from coastal defence structures include altering



species composition, abundance and predator-prey interactions, decreasing the reproductive output of species, and altering trophic transfer.

To address the impacts posed by the defence structures on coastal ecosystems, research on ecological engineering is rising as a promising remediating avenue. By focusing on species' adaptability to changing environmental conditions and interactions between stressors, ecological engineering approaches seek to mitigate the anthropogenic degradation of the modified coastlines and rehabilitate or restore natural biodiversity. Innovative approaches like "hard ecological engineering" focus on using replacement habitats made from materials such as concrete and metal (e.g., attaching concrete tiles and flower pots to seawalls) (Figure 1). The greenest and latest innovative approaches include "hybrid ecological engineering", which combines ecologically enhanced hard structures with ecosystem engineers such as seagrass, mussels and oysters to improve water conditions and foster biodiversity (Figure 1). Nature-based solutions, which mimic environmental characteristics and are ecosystem-based, offer a more sustainable way to address the challenges of climate change and coastal urbanisation (Figure 1). Nature-based solutions involve an umbrella of concepts and approaches including sustainability, community involvement, respect for cultural diversity, and embracing diverse knowledge. Nature-based solutions have the overall scope to maintain and restore diverse and resilient ecosystems while providing critical services, biodiversity benefits, prosperity and human well-being.





<p>Hard Eco-engineering</p> <p>Concrete tiles and flower pots attached to seawalls</p>	 <p>https://onlinelibrary.wiley.com/doi/full/10.1002/ece3.3475 Image by: F. Porri, World Harbours Project</p>
<p>Hybrid Eco-engineering</p> <p>Oysters attached to artificial reef made of clay pots</p>	 <p>https://reefinnovations.com/services/eco-system-restoration/oyster-reefs/</p>
<p>Nature-based solutions</p> <p>Seawalls made from coconut fibre as part of a community outreach project</p>	 <p>https://theconversation.com/we-built-environmentally-friendly-sea-walls-from-coconut-husk-heres-what-we-learned-122725</p>

Figure 1. Different forms of ecological engineering approaches which include hard engineering, hybrid engineering and nature-based solutions.

Despite the growing interest in ecological engineering, the transition from research to large-scale implementation remains a challenge. Funding agencies, policy makers and stakeholders need to collaborate to create incentives for testing, scaling up and implementing these nature-based interventions, especially outside Europe, in vulnerable coastal regions such as those in Africa, which are likely to face severe consequences from climate change and urbanisation. It is clear that a comprehensive and holistic approach is essential for coastal development, one that aligns economic development with ecological sustainability and socio-cultural equity and institutional objectives to ensure the long-term health of coastal ecosystems.

Nature-based solutions and communities

The integration of local and Indigenous knowledge and community participation in the management, conservation, and restoration of marine ecosystems is increasingly recognised, although it often remains subsumed within the scientific practice rather than given equal recognition. Community-based management has shown success in various cases, but its effectiveness depends on various factors, including the specific landscape and context. Efforts that genuinely integrate community involvement, Indigenous knowledge, and equitable access



to nature-based solutions for improving the quality and functionality of urban ecosystems are still limited. While community involvement is often centred around nature-based (eco)tourism initiatives, broader involvement in supporting innovations to restore ecosystem functionality is largely lacking. This gap is concerning, particularly in the context of the global traction of nature-based solutions for addressing economic development, climate change mitigation, biodiversity preservation, and coastal systems restoration.

Drawing from centuries of cultural and biological co-evolution, Indigenous groups and local communities possess long-standing wisdom that can play a substantial role in the shaping and executing of nature-inspired innovations, mirroring the structure and function of natural ecosystems. Despite the value of their knowledge, the active involvement of these communities in supporting innovations to restore ecosystem functionality remains limited. The failure to fully include Indigenous and local communities and their knowledge in the co-creation of nature-based solutions is inconsistent with the growing prominence of these approaches in international climate and biodiversity policies and their links to Sustainable Development Goals (SDGs), focused on reducing inequality and poverty. Recognising, maintaining, and protecting the customs, practices, and innovations of Indigenous People and local communities are essential commitments, underlined in international agreements such as the Paris Agreement, the UN Declaration on the Rights of Indigenous People (UNDRIP), the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), and the Kunming-Montreal Global Biodiversity Framework (Targets 5, 9, 21) assessments. Prioritising Indigenous and locally-led knowledge and governance is hence crucial for achieving transformative and tangible environmental benefits through nature-based solution approaches.

This emphasis on the importance of incorporating Indigenous and local community knowledge also aligns with a broader perspective that highlights the essential role of these communities as custodians of the world's biodiversity and natural resources. Indigenous People and local communities manage a significant portion of the planet's lands, including protected areas. Their close relationship with nature and their innovative practices demonstrate the critical link between traditional knowledge and technological and engineering innovations. While a plethora of international agreements and declarations emphasise the rights of Indigenous people and local communities, the exclusion legacy of their knowledge and involvement continues, hindering the potential of nature-based solutions to address pressing environmental and societal challenges effectively.

THE SOUTH AFRICAN CASE STUDY

The Indigenous Marine Innovations for sustainable Environments and Economies (IMIsEE) project

In South Africa, the intensification of human activities and coastal urbanisation has raised concerns about the preservation of marine biodiversity, with obvious links to risks to food security. This is especially significant in the context of Operation Phakisa, a governmental initiative aimed at unlocking the blue economy of the Republic. While Operation Phakisa has achieved modest economic results, its focus on economic growth, mineral and oil exploitation, seismic exploration, harbour development, and aquaculture poses a significant threat to marine biodiversity and undermines the livelihoods of local coastal communities. Despite a national prioritised focus on ecosystem-based resources and identification of service hotspots, most management plans for harbours (large and small) primarily address threats to sediment and water quality rather than the preservation of biodiversity, with concerns emerging regarding the impact of sea mining on marine ecosystems.

The value of Indigenous knowledge associated with biodiversity has gained international recognition through agreements like the UN Convention on Biological Diversity and its Nagoya Protocol. In South Africa, the Indigenous Knowledge Systems Act (6 of 2019) and the establishment of the National Indigenous Knowledge Systems Office (NIKSO) have set the framework for the protection and management of Indigenous knowledge rights. Recognising the role of technological innovations to support economic development, South Africa has also recently re-aligned its emphasis from the Department of Science and Technology to the Department of Science and Innovation. The production of innovative applications, embedded with Indigenous knowledge, is particularly relatable to South Africa, where rural communities rely on traditional expressions and practices. Despite being economically marginalised and often overlooked in national decision-making, plant materials play a crucial role in rural communities, contributing to livelihoods, Indigenous knowledge and heritage.

To address the gaps identified, a nonconforming research project funded by the South African National Research Foundation has been initiated, spanning from 2022 to 2024. The Indigenous Marine Innovations for sustainable Environments and Economies (IMIsEE) project established a collaborative partnership between scientists (NRF-SAIAB, Rhodes University, Nelson Mandela University, University of Cape Town), stakeholders (Keiskamma Trust) from a local rural coastal community in Hamburg, Eastern Cape Province (Figure 2), with participation of the regionally privately -and state-owned maritime enterprises . The project focuses on the co-creation of natural woven biodegradable structures to retrofit the built coastal environment, including small and large harbours, and natural rocky shores. These structures are tested for their short-to mid-term ecological function value for early stages of marine species in urban settings within one of South Africa's economically disadvantaged provinces, the Eastern Cape (Figure 2). By merging scientifically innovative, eco-creative approaches with traditional cultural expressions (TCEs), the project aims to enhance the functioning and diversity of urban coastal habitats. The IMIsEE project takes a holistic approach, the one that combines urban and sustainable development with the needs of traditional rural communities, Indigenous knowledge, job creation, and increased biodiversity and ecological functionality in urban coastal ecosystems,

addressing marginalised rural coastal communities in the context of urban development and blue economy initiatives.

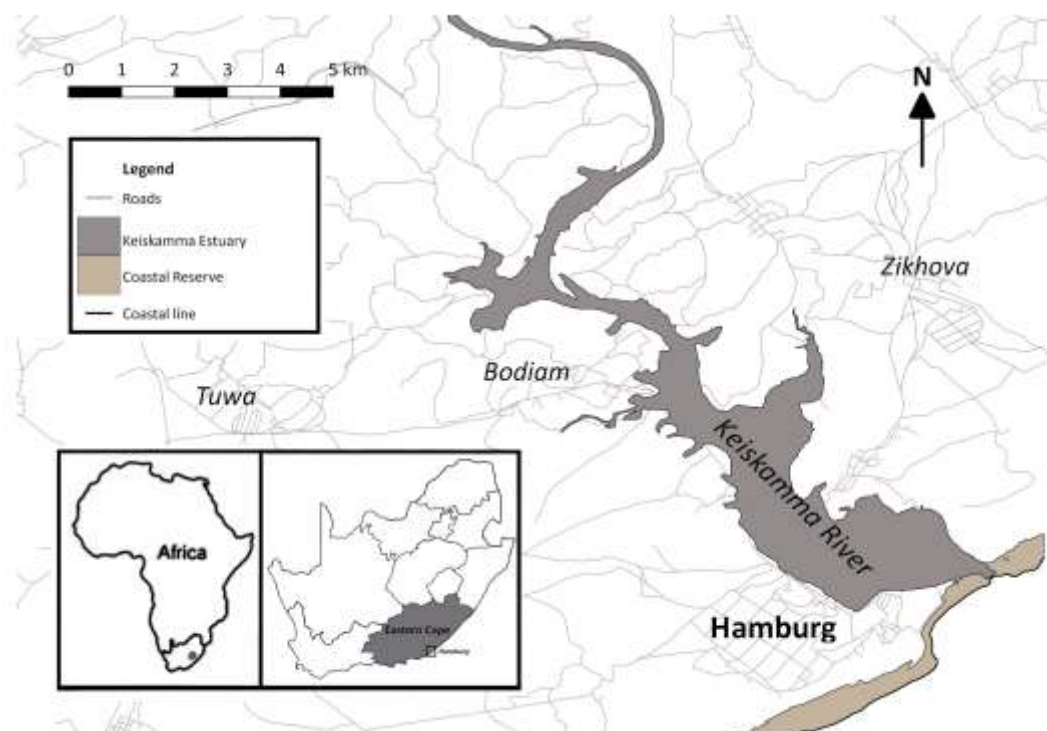



Figure 2. The geographic location of the Eastern Cape Province, South Africa, where the co-creation component of the IMIsEE project is conducted, as well as the village of Hamburg, where the rural community is based through stakeholder partners (Keiskamma Trust).

The IMIsEE project is centred around the co-design and manufacture of nature-based structures using *Cyperus textilis*, a grass-like sedge locally known as *imizi*. This natural fibre is extensively used by artisanal crafters, primarily women, in the rural areas of South Africa's Eastern Cape Province (Figure 2). It is traditionally employed in weaving sleeping and sitting mats, baskets, and serving trays. For the IMIsEE project, Indigenous knowledge and specialised weaving skills are essential to craft the woven structures required for retrofitting the coastal environment. Women from the local community, who are the traditional knowledge-bearers of this weaving practice, play a crucial role in the project, and their involvement empowers them significantly addressing social, especially gender-based, inequalities and poverty. Furthermore, the project aims to boost the heritage value of this local innovation, providing a benchmark for direct economic empowerment of the rural Hamburg community while actively involving local communities as co-creators of innovative science and champions of coastal biodiversity conservation principles.

The partnership with the Keiskamma Trust, Hamburg, Eastern Cape, emphasises a democratic community engagement and has been facilitated through community gatherings, workshops, informed consent and memoranda of understanding. The project's approach involves



translating informed consent, drafting Intellectual Property agreements, a code of conduct for scholar-community research engagement and protecting Indigenous knowledge, with the potential for upscaling and commercialisation.

The IMIsEE project is not only limited to ecological innovations, but extends into enriching Indigenous pedagogies through ecomusicology. Ecomusicology is a pivotal element of the research, as it explores the intersection between culture, nature, music, and the impact on humans. By using a range of creative methods, including songs, stories, handicrafts, and narratives, the project aims to disseminate Indigenous knowledge to the community. These approaches include digital storytelling, podcasts, film documentaries, plays, poems, songs, and digital soundscapes. The goal is to create sustained interest within the community regarding their role in maintaining a sustainable coastline and to emphasise the importance of Indigenous knowledge systems in modern society. This innovative approach recognises the cultural value and significance of Indigenous knowledge and promotes it as a contemporary agent in societal reinvigoration and transgressive teaching, ultimately contributing to the sustainability of local heritage, arts, and ecological knowledge.

In conclusion, the IMIsEE project represents a ground-breaking roadmap that strives to change the narratives of research agendas, while directly and comprehensively addressing coastal sustainability. This research offers an opportunity to shift existing paradigms by integrating the needs of both the environment and people, as opposed to prioritising one over the other (Figure 3). This initiative combines novel designs, evidence-based methodologies, coastal biodiversity enhancement and the assimilation of Indigenous knowledge and practices (Figure 3). Its transparent, inclusive and transdisciplinary framework has the potential to create long-term, empowering resolutions to the challenges presented by nature-human conflicts in coastal ecosystems. By bridging the gap between heritage and innovation, this project sets the stage for meaningful environmental perspectives, strategies, policies and governance, ultimately benefiting the well-being of humanity and the resilience of nature and society.

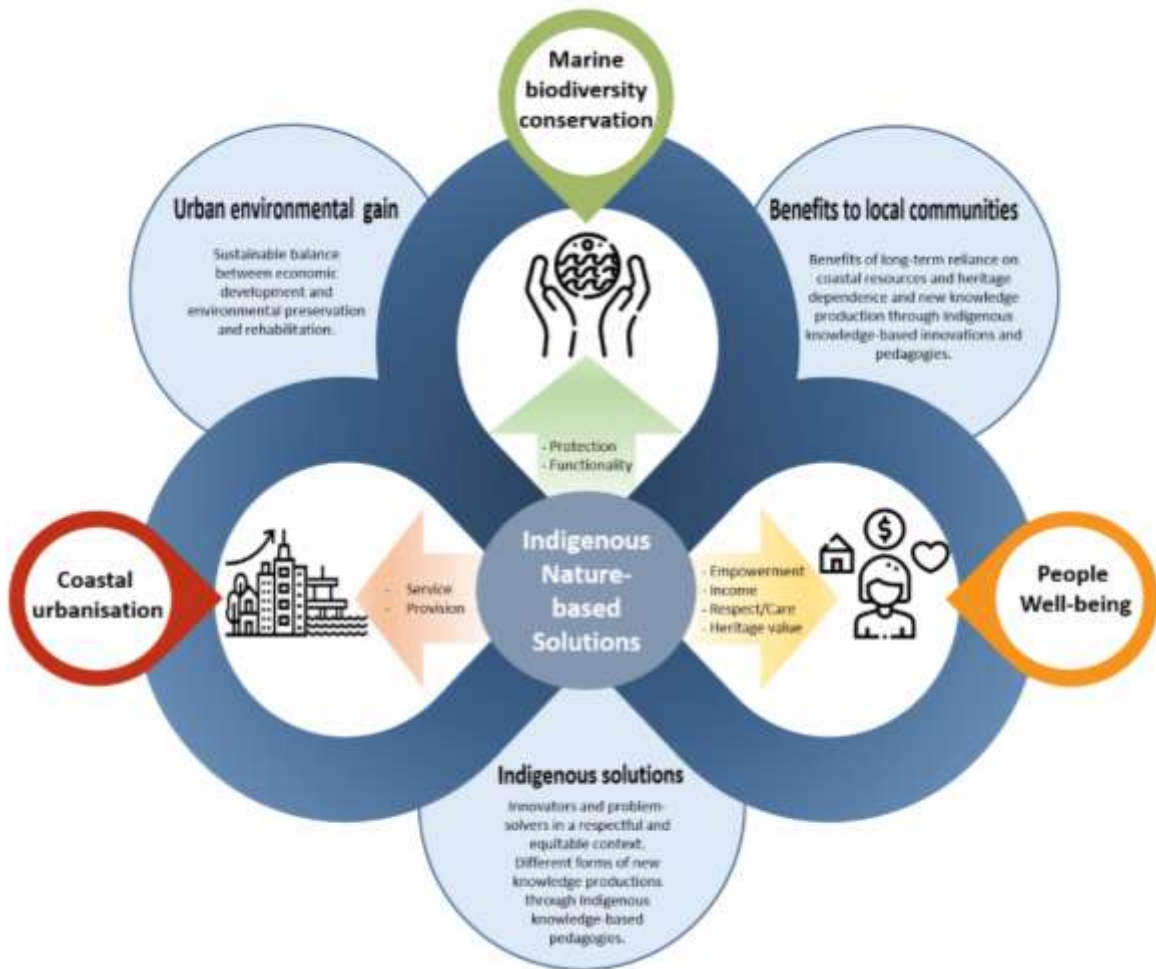


Figure 3. An integrated research framework for research on Indigenous nature-based solutions in coastal systems addressing multiple elements (coastal urbanisation, marine biodiversity, people) and outcomes (innovative designs, environmental improvements, gains to local and Indigenous communities).

KEY PAPER FOR CONSIDERATION

Porri F, McConnachie B, van der Walt K-A, Wynberg R and Patrick P (2023). Eco-creative nature-based solutions to transform urban coastlines, local coastal communities and enhance biodiversity through the lens of scientific and Indigenous knowledge. *Cambridge Prisms: Coastal Futures*, 1, e17, 1–14. <https://doi.org/10.1017/cft.2022.10>

AGENCIES THAT SHOULD BE CONTACTED

Keiskamma Trust
 Royal Port Alfred Marina
 St. Francis Harbour
 Transnet (especially Port Elizabeth and Ngqura)
 Department of Forestry, Fisheries and the Environment
 Department of Environmental Affairs
 NRF (especially RISA, Reviews & Evaluation)