

Planting Water

Biomimicry-Based Reforestation for Water Restoration

Report to Rotary IAS Fund

Author: Mila Avellar Montezuma, Delft University of Technology



Rotary



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Introduction

Forests are crucial for maintaining the health of our planet's ecosystems and ensuring a sustainable water supply for both human communities and wildlife. They act as natural filters, absorbing rainfall, replenishing groundwater reserves, and maintaining stable water levels in rivers and streams. Tree roots help bind soil particles, preventing erosion and reducing sediment runoff into water bodies. Additionally, the presence of forests enhances the quality of water by trapping pollutants and regulating water temperature.

Deforestation, driven by factors such as agricultural expansion, mining, and logging, has severe negative impacts on water resources, leading to increased floods, droughts, and a decline in water quality. Reforestation and afforestation is, therefore, a critical strategy for restoring ecological balance and ensuring water security.

1. Rationale:

Sustainable water management relies on reforestation to filter water, reduce erosion, and improve water quality. In this study, we research multiple biomimicry-based strategy for reforestation such as Nucleário, a prototype device. This device is inspired by the Brazilian reforestation project. Our proposed devices are made from waste biodegradable materials that are eggshells and gum Arabic. They will protect tree seedlings and improve their survival rate. Gum Arabic is known to have a complex chemical composition, consisting of a branched molecule with a backbone of (1,3)-linked β -D-galactopyranosyl units, with side chains composed of two to five (1,3)-linked β -D-galactopyranosyl units, joined to the main chain by (1,6)-linkages (Ali et al., 2009). Both the main and the side chains contain other carbohydrates, such as L-arabinose, L-rhamnose, and glucuronic acid (Dos Santos & Grenha, 2015). This combination of sugars results in a MW of about 240–580 kDa. Eggshells, on the other hand, are composed of approximately 95% calcium carbonate (CaCO_3), along with small amounts of protein, phosphorus, magnesium, sodium, potassium, zinc, manganese, iron, and copper (Arunlertaree et al., 2007). Each gram of eggshell provides 381–401 mg of calcium. These chemical elements are important for providing structure, durability, and nutrients to the Nucleário device as it biodegrades over time, nourishing the seedling and surrounding soil. The presence of CaCO_3 in eggshells will also help neutralize acidic soils, improving growing conditions for the young trees. This research aims to restore forests, mitigate climate change, and provide co-benefits. Furthermore, it will improve water supply and quality for communities and agriculture by applying biomimicry approaches and repurposing solid waste. The innovative use of waste gum Arabic and eggshells in the Nucleário device will offer a sustainable and cost-effective solution to promote reforestation and support the long-term health of forests and water.

2. Goal and Objectives

The overarching goal of this project is to restore degraded areas by rewilding, mainly focusing on biomimicry-based reforestation as a strategy to naturally improve water resource management.

The specific objectives are to:

- (1) to conceive and design a biomimicry-based reforestation strategy (such as tree seedling using eggshells and gum Arabic);
- (2) Select pilot areas to increase the forest coverage.
- (3) to provide a community and science education for empowering the local communities.

The Need for Biomimicry-Based Reforestation

Traditional reforestation efforts often face challenges such as low seedling survival rates, high maintenance costs, and the need for ongoing human intervention. Biomimicry-based reforestation offers a promising solution by emulating nature's designs and processes to enhance the effectiveness and sustainability of reforestation initiatives.

The Nucleário project, developed in Brazil, provides an excellent example of biomimicry-based reforestation. This project utilizes biodegradable pods made from waste materials such as eggshells and gum Arabic to protect tree seedlings and provide them with essential nutrients during their early growth stages. The pods are designed to mimic natural structures such as bromeliads and leaf litter, which collect and store water, deter pests, and suppress weed growth.

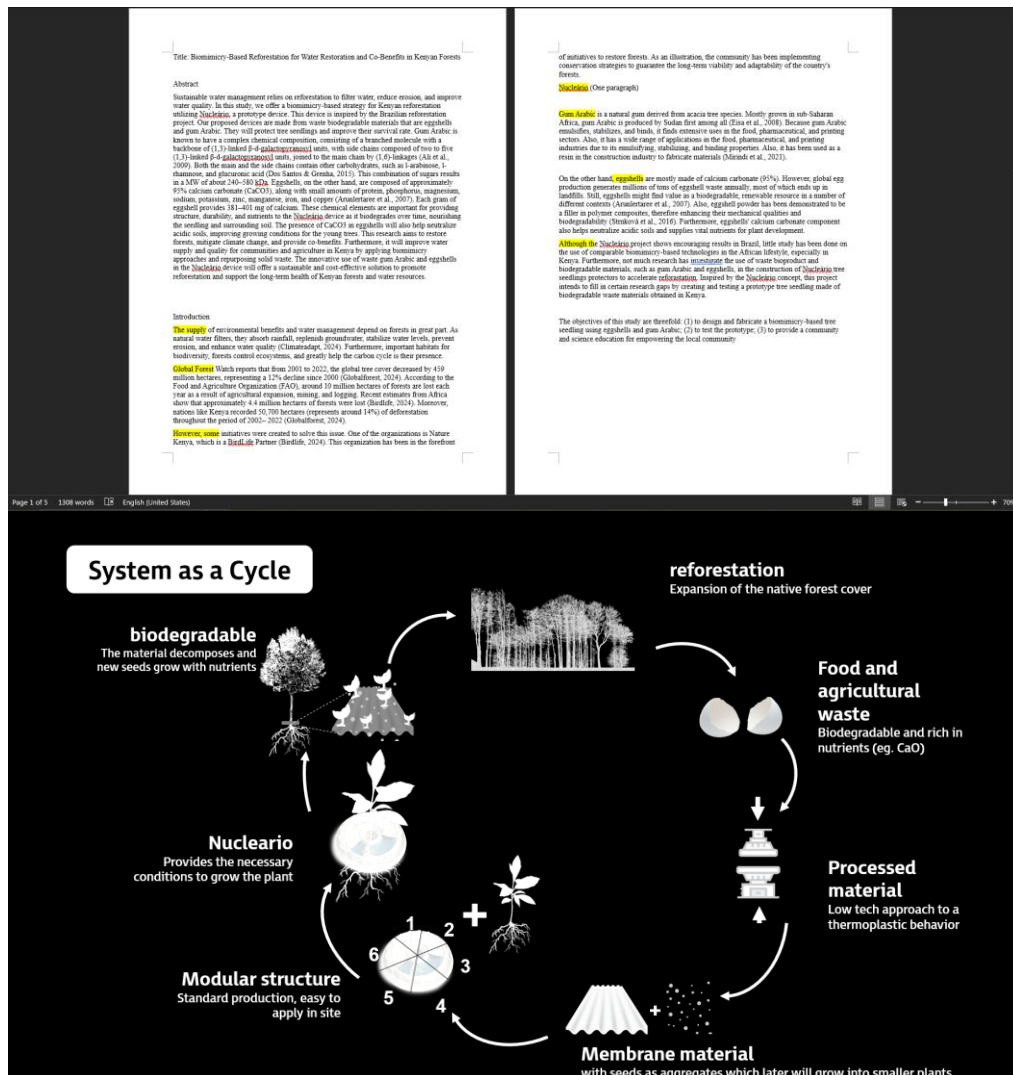
Strategic Approach to Public Policy

To maximize the impact of biomimicry-based reforestation, it is essential to adopt a strategic approach to public policy. This involves engaging with policymakers, researchers, and practitioners to develop and implement policies that support the adoption and scaling up of biomimicry-based reforestation initiatives.

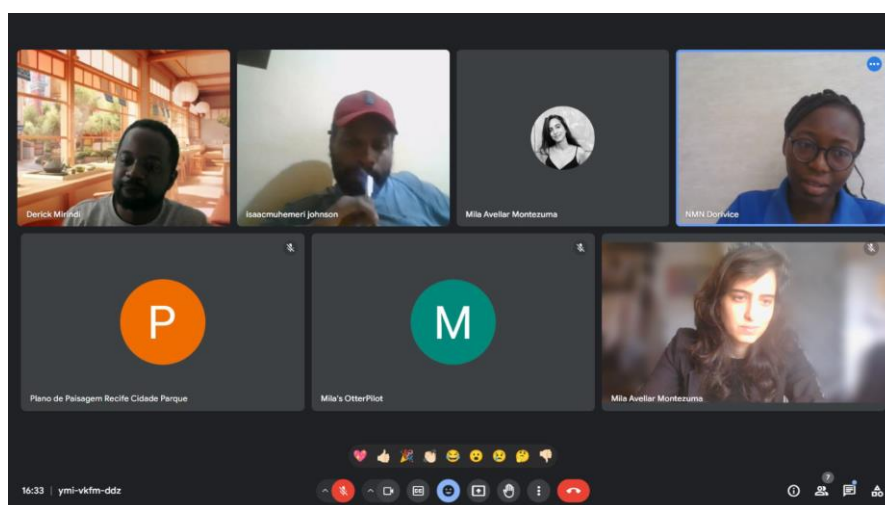
3. Project Activities:

Remote Activities:

- **Hydrological and Biomimetic Literature Synthesis:** Conducted an extensive review of scientific literature, encompassing hydrological processes, biomimicry principles, and their applications in reforestation strategies.



- Collaborative Research and Knowledge Exchange:** Engaged in online discussions and scientific debates with Kenyan MSc students specializing in water resource management, ecology, and material engineering to foster collaborative research and knowledge exchange.

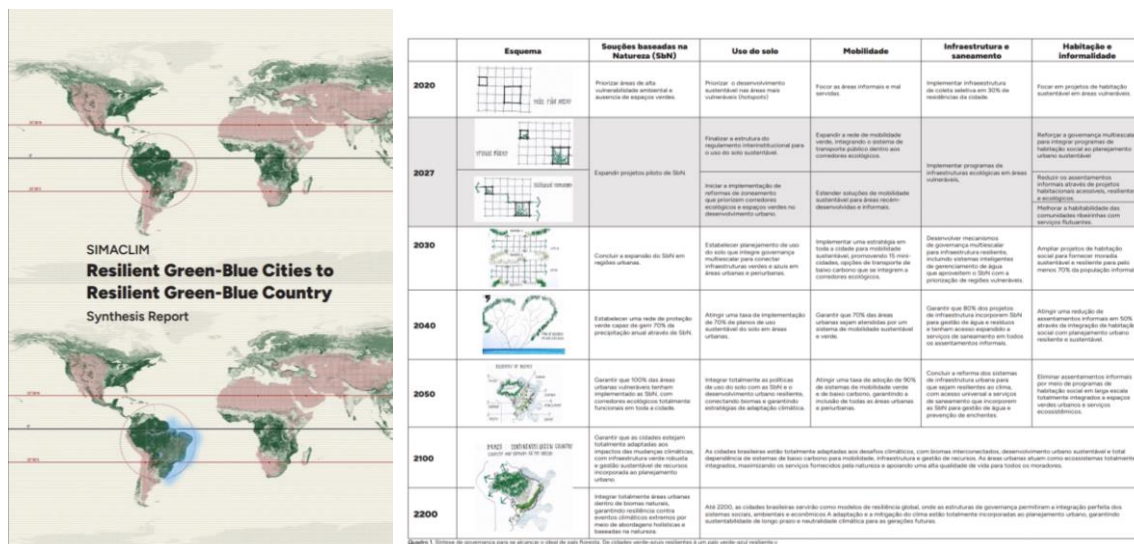


Activities in Brazil:

- National-Level Biome Integration Strategy:** Co-authored to the development of a national report under the Resilient Green-Cities (Cidades-Verdes Resilientes) program, under the umbrella of Ministry of Science, Technology and Innovation, Ministry of Cities and Ministry of Environment and Climate Change of Brazil), outlining strategies for integrating water resource management and biomimicry principles across Brazil's diverse biomes, including the Amazon rainforest and the Atlantic Forest.

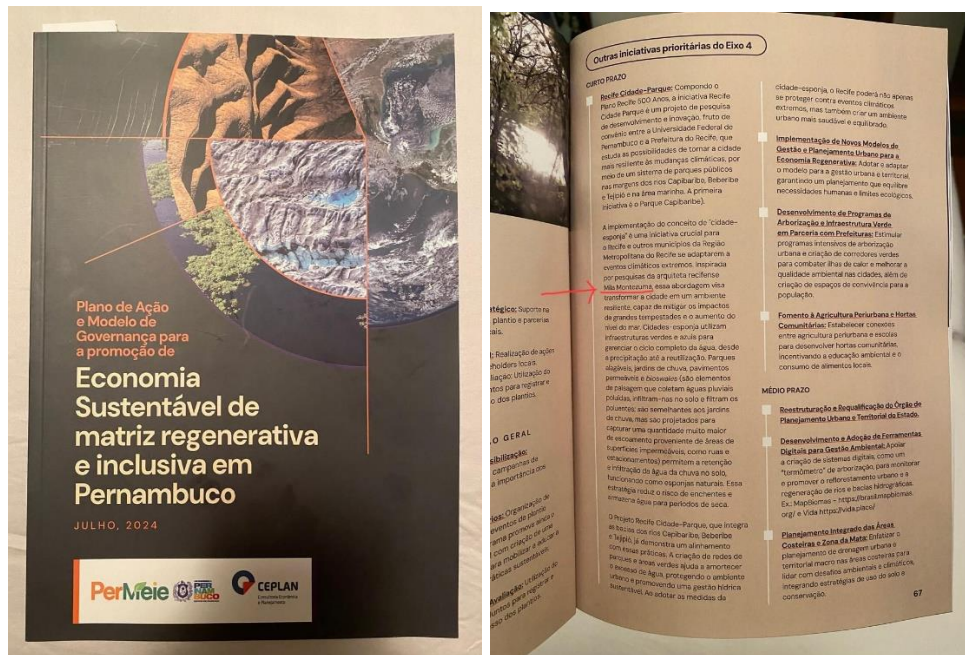


- Science-Policy Interface for COP30:** Co-authored a synthesis report, similar to the IPCC, under the National Program for Resilient Green Cities, integrating scientific knowledge and policy recommendations for water-sensitive urban development to be presented at COP30.



- Dissemination of Policy Recommendations:** Presented a synthesis report to the President of Rede Clima, highlighting key policy recommendations for promoting biomimicry-based reforestation and water restoration.
- Regional Policy Impact:** Contributed to the development of Pernambuco's "Action Plan for a Sustainable, Regenerative, and Inclusive Economy," which

incorporates biomimicry and reforestation as key elements for water resource management and ecological restoration.



- **Policy Engagement for Water-Sensitive Urban Design (06/12/2024):** Presented at the Congress of Brazilian Congress of Architecture and Urban Planning in Brazil (CAU/PE), advocating for the integration of biomimicry and water-sensitive design in urban planning policies.



- **Amazon Rainforest Workshop (09-13/12/2024):** Participated as an expert in a COP-30 preparatory workshop in Belem (capital of Para, in the Amazon rainforest), collaborating with researchers and practitioners from Massachusetts Institute of Technology MIT/Brazil, UFPE, Laboratório da

Cidade, and Museum Emilio Goeldi to develop strategies for integrating biomimicry and water-sensitive design in Amazon rainforest Urban Areas conservation efforts.

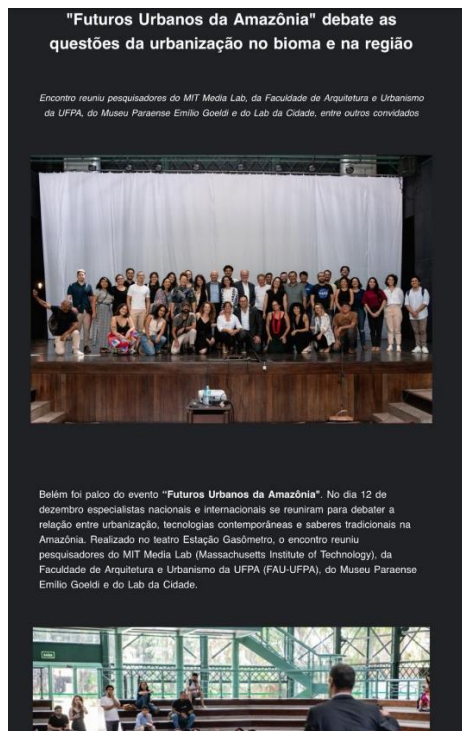


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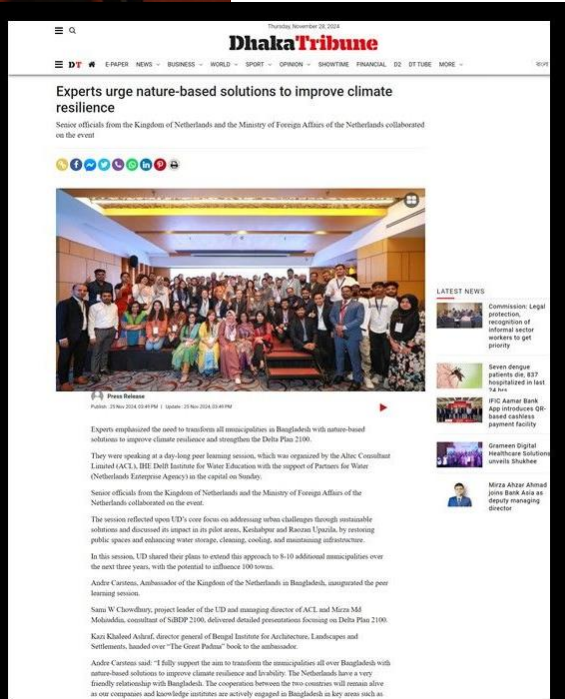
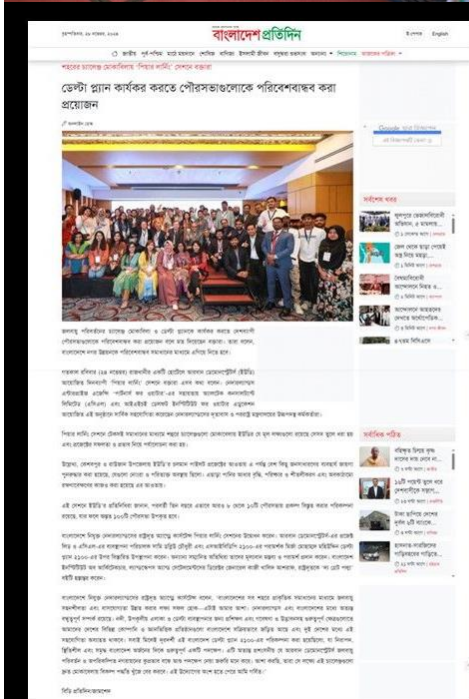


Activities in Bangladesh:

- **Urban Demonstrator Project:** Implemented an urban demonstration project in Keshopbur, planting 100 native trees, including Asian Palm, to showcase the application of Nature-Based Solutions and biomimicry principles in urban reforestation initiatives.







4. Key Policy Recommendations

- **Integrate biomimicry principles into reforestation and urban design policies:** Encourage the adoption of biomimicry principles in reforestation projects and urban design guidelines to enhance water resource management, promote biodiversity conservation, and create resilient ecosystems.
- **Promote Small-Scale Pilots (Demonstrations):** Develop small-scale demonstration projects to showcase the feasibility and benefits of biomimicry-based reforestation and water-sensitive urban design.
- **Promote the use of locally sourced waste materials in reforestation efforts:** Support the development and implementation of innovative techniques that utilize locally sourced waste materials, such as eggshells and gum Arabic in areas with these resources, in reforestation projects to reduce waste and enhance the ecological benefits of reforestation.
- **Invest in research and development of biomimicry-based solutions for water resource management:** Allocate funding for research and development of biomimicry-based solutions to address specific water resource challenges, such as drought, flood control, and water pollution.
- **Adopt a Design-Based Approach with Inclusive Engagement:** Utilize a design-based approach that fosters inclusive participation and provides tailored support for stakeholders with varying levels of influence and resources.
- **Strengthen community engagement in reforestation and water resource management:** Foster community participation in reforestation projects and water resource management initiatives through educational programs, training workshops, and participatory monitoring activities.

___ **Embrace a Learning-by-Doing Approach:** Implement reforestation and urban design projects in small, manageable steps, encouraging active participation, and instilling a sense of ownership among stakeholders.

□ **Incorporate water-sensitive urban design principles into urban planning policies:** Integrate water-sensitive urban design principles into urban planning policies to promote the use of green infrastructure, reduce stormwater runoff, and enhance the resilience of urban areas to water-related challenges.

□ **Support the development of sustainable and regenerative economic models:** Encourage the development and implementation of economic models that promote sustainable practices, such as reforestation, waste reduction, and water conservation, to ensure the long-term health of ecosystems and water resources.

5. Conclusion

Biomimicry-based reforestation, in its multiple strategies, offers a promising pathway for restoring degraded forest ecosystems and ensuring a sustainable water supply for both human

communities and wildlife. By adopting a strategic approach to public policy, we can create an enabling environment for the widespread adoption and scaling up of biomimicry-based reforestation initiatives. This will contribute to achieving our global goals for climate action, biodiversity conservation, and sustainable development.

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Acknowledgements

This project acknowledges the contribution of multiple partners across different stages, listed below:

