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# THE THEMATIC ATLAS OF NATURE'S BENEFITS TO DAR ES SALAAM

## THE LINKS BETWEEN NATURE BASED-SOLUTIONS AND CLIMATE CHANGE

Dar es Salaam, Tanzania's largest and fastest-growing city, is grappling with increasing environmental and infrastructural pressures driven by rapid urbanization and climate change. With the city's natural green spaces in decline due to uncontrolled urban sprawl, risks such as flooding, urban heat islands, and air pollution are exacerbated.

As part of the INTERACT-Bio project, the city collaborated with ICLEI, UFZ, and other stakeholders to develop a Thematic Atlas of Natures Benefits to Dar es Salaam —an innovative, spatially-informed decision-making tool.

The Atlas maps critical ecosystem services alongside urban challenges, enabling municipal planners to prioritize greening efforts where they can deliver the greatest social, environmental, and economic returns. This co-produced tool integrates local knowledge and spatial data to inform strategic investments in nature-based solutions (NbS), supporting climate adaptation and urban resilience.

While implementation and long-term monitoring are ongoing, the case study demonstrates how simple, participatory tools rooted in ecosystem service logic can guide evidence-based, locally appropriate responses to complex urban challenges.

# Dar es Salaam

Dar es Salaam is one of the fastest growing metropoles in the world and the fastest growing city in East Africa. This rapid urban expansion has resulted in the loss of the City's natural green spaces which provide important ecosystem services to the urban community. Increasingly, cities around the world have recognized that healthy and functioning ecosystems within and around urban areas provide benefits to people, as well as solutions to significant challenges associated with climate change and biodiversity loss. Ecosystems can help ameliorate both the drivers and impacts of climate change and biodiversity loss. The innovative Thematic Atlas produced for the City of Dar es Salaam (2019) aims to show how nature's benefits protect cities, sustains them and makes them liveable. The Thematic Atlas supports Dar es Salaam's journey with nature. This case study focuses on aspects of the Thematic Atlas which address the role and importance of nature-based solutions in addressing some of the effects of climate change in an urban environment.

Dar es Salaam is a major Tanzanian city and commercial port on the Indian Ocean coast. The city comprises 1,393 km$^2$ of land mass within a zone of significant marine, coastal and coastal forest biodiversity, with eight offshore islands. It is known as the economic, industrial, commercial, trading, educational, cultural and transportation hub of Tanzania. However, the City has experienced rapid urban growth over the past three decades, which has caused the deterioration of the living environment and inefficient and ineffective service delivery to city dwellers (ICLEI, 2018).


Map of Dar es Salaam

With a growth rate of 6.5%, Dar es Salaam (current population of 4.365 million) is the fastest growing city in East Africa (ICLEI, 2018). The growing population is putting considerable pressure on basic services such as education, health and housing. With limited urban planning and development controls to guide the rapid growth, the city is now characterized by large unplanned informal settlements that occupy 70% to 80% of all residential land area (World Bank, 2016).

Dar es Salaam is also located within the globally important 'East African coastal forest' biodiversity hotspot. Biodiversity hotspots are areas of exceptional concentrations of endemic species (i.e. species found nowhere else in the world) that are simultaneously undergoing a high rate of loss of habitat (Myers et al., 2000). The city boasts beautiful beaches, pockets of mangroves, remnants of coastal and Afromontane forest and various wildlife elements. As a result, the population depends largely on its natural resources, with a significant amount of food production occurring in the city. Coastal forest remnants in particular, comprise an important natural resource in the City. They provide a wide range of ecosystem services including medicinal plants, fuel wood and building materials (timber and building poles). However, human activities like charcoal making, cattle grazing, fire ignition, pole and firewood collection, hunting and poaching, honey harvesting and construction activities have led to degradation of the coastal and inland forest resources (Dar es Salaam Environmental Outlook, 2011). It is projected that Dar es Salaam will experience continued deforestation that reduces the ecosystems capacity to sequester carbon and increase land degradation that would lead to poor land productivity (World Bank, 2016).

# Explaining the Initiative: The Thematic Atlas of Nature's Benefits to Dar es Salaam

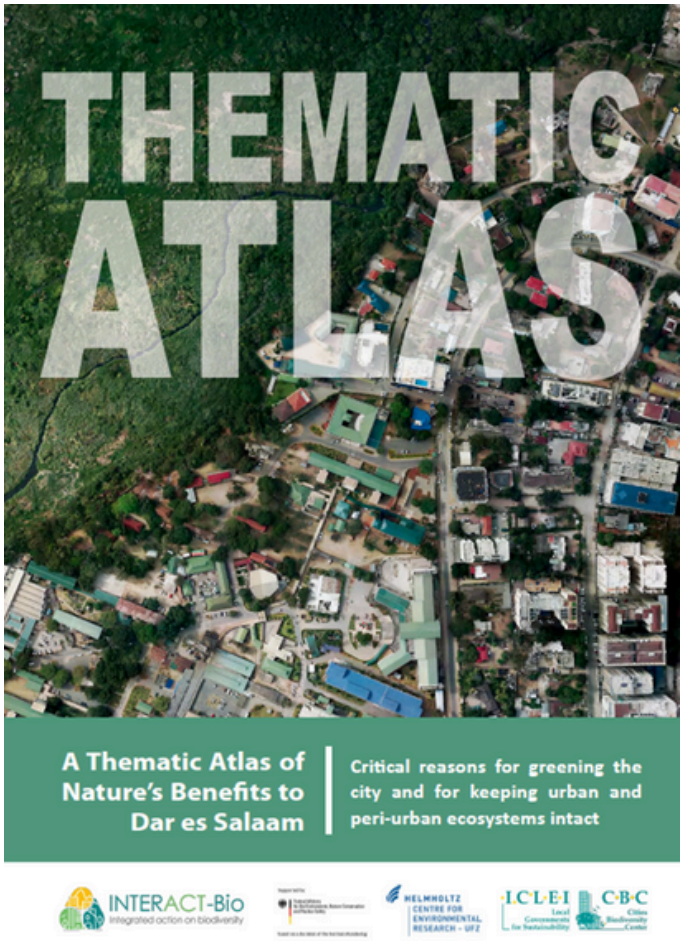
The goal was to co-develop a product to support the City of Dar es Salaam in decision-making, specifically around prioritizing municipal funding allocation to city greening. The City receives funding annually for greening but they had no way of deciding where the investment in urban nature would deliver the greatest benefit. The objective was therefore to use the information and maps in the Atlas, to help facilitate evidence-based decisions on where to invest in greening, to achieve the greatest social, environmental and economic benefits and outcomes.

The thematic maps for the Atlas were co-developed in an iterative way, using data; knowledge and expert judgement. Each 'theme' in the Atlas represents an urban challenge, such as rising urban heat or flooding. Using highly dispersed spatial data, spatial images (i.e. maps) were created to link the location of urban issues with the location of existing green open spaces and the ecosystem services provided by those green open spaces. Together, these aspects provide a logical and spatially explicit basis for prioritising the City's investment in green open space. The technical innovation was in the simple combination of maps of urban issues and urban ecosystem services to build robust arguments/rationale for where urban greening would deliver the greatest benefit. The development, or co-production process, of the Atlas was designed to be collaborative. Many participants gave off their time, data and expertise to create the Atlas and participants were invited to validate, comment and edit at various stages of the process. The approach can be applied in any city and also creates collaborative ownership of the product.

In developing this tool, there was no need for extensive, sophisticated spatial data or information, just a few basic maps and the rationale provided by ecosystem services concepts.

What we did rely on though, was good base land cover spatial data (this was purchased by the project) and workshops to gather expert knowledge where information was scattered and/or not recorded.

Massive informal settlement growth in Dar es Salaam had surpassed the City's ability to plan. This, together with lack of awareness of the value of urban nature, poor development control and an outdated city master plan means that the City relies on small-scale municipal or donor projects to implement change. The INTERACT-Bio project builds on the UN-Habitat-UNEP 'Sustainable Cities' Programme 1992 - 2003.



# Explaining the Initiative: The Thematic Atlas of Nature's Benefits to Dar es Salaam

### Who were the main drivers behind the initiative?

A senior planner in the Dar es Salaam City Council requested the focus of this project during several scoping sessions. Her main need was that decisions around municipal spending on urban greening needed to be guided by rational arguments to optimize the investment.

### What were the particular circumstances and challenges encountered throughout the planning and implementation of this initiative? Were any of these challenges turned into opportunities?

For the biodiversity map, the data and information were not always spatially explicit. A map was then created using the basic spatial information available combined with expert knowledge in a participatory mapping and information sharing exercise. Biodiversity experts help to point out important biodiversity features, functions and areas on the base map. These were digitized to create an updated biodiversity map for Dar es Salaam.

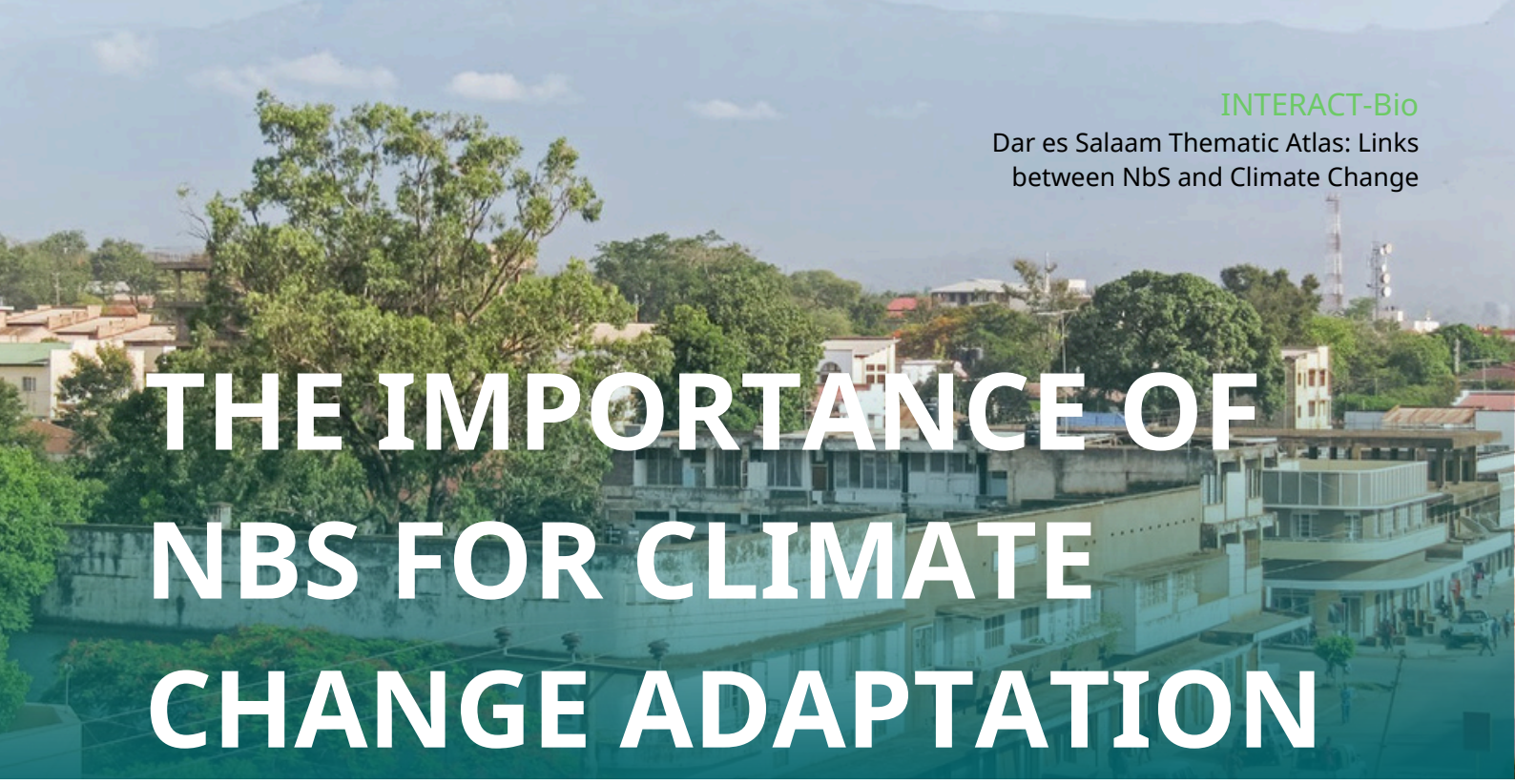
### What role did local and/or supra-local partnerships, networks and collaboration play within the project?

A success factor in this project was a combination of a local champion in the city council, a technical partner with expertise and experience in linking ecosystem services and social needs in urban settings (UFZ) and coordination by ICLEI. These links to key organisations and individuals also enabled engagement with a wide range of stakeholders and experts, who contributed significantly to the data gathering process, which fed into the maps in the Thematic Atlas.

### List of other related actions and initiatives

A number of complementary processes and products emerged from the same project at the same time, which together had the effect of highlighting the importance of the Thematic Atlas:

- The Ilala Municipal Council Local Biodiversity Strategy and Action Plan. This plan (for one of Dar es Salaam's five municipal councils) highlighted the need for specific interventions that align with the larger scale approach used by the Thematic Atlas.
- Planning for a number of demonstration projects in Dar es Salaam during the same time as the Atlas development, allowed for the selection of sites for demonstrations to be guided by the map overlays of the Atlas to indicate where the best social and environmental benefit would be achieved.
- At the same time, the production of an illustrated poster of nature's benefits to Dar es Salaam created awareness of the value of urban nature, which further highlighted the importance of the Thematic Atlas.
- The development of a Biodiversity Catalogue for Dar es Salaam also stemmed from the Thematic Atlas. It was recognized that exotic species were predominantly used for greening in the city and there was a need for a user-friendly list or catalogue of indigenous species, which could provide guidance to the City governments and municipal councils on which species to select to achieve specific environmental and socio-economic outcomes.



# THE IMPORTANCE OF NBS FOR CLIMATE CHANGE ADAPTATION

## The importance of urban green spaces

Over half of the world's population live in urban areas. Due to rapid urbanisation, vegetated surfaces that provide shading, evaporative cooling, rainwater interception, storage, and infiltration functions have been replaced with grey infrastructure (i.e. buildings or engineered structures). The increased loss of natural systems results altered energy exchange and hydrological systems, which then create urban heat islands (UHI) and increase surface runoff, respectively (Gill et al., 2007).
Urban green spaces provide essential ecosystem services which humans depend on, such as clean water, clean air, food, regulation of floods, soil erosion and disease outbreaks, as well as recreational and spiritual benefits. Healthy ecosystems are the foundation for sustainable cities, influencing and affecting human well-being and most economic activities (TEEB, 2011). Apart from mitigating air pollution, noise pollution and UHI effects, there is clear evidence that human minds and bodies benefit from being exposed to nature, even man-made nature (Karutz et al., 2019). However, the ecosystem services provided by urban green space and biodiversity are often overlooked and undervalued (Gill et al., 2007). With less green spaces and biodiversity within cities a large and growing proportion of the world's population will be cut off from daily contact with nature and the options for adaptation disappear (Solecki & Marcotullio, 2013).

## Climate change and its effects on cities

In a changing climate, the functionality provided by urban green space and biodiversity becomes increasingly important. According to the Secretariat of the Convention on Biological Diversity (SCBD 2019), people and nature are facing unprecedented climate change, which are altering the ecosystems that provide life-sustaining services. Climate change will alter processes such as temperature and precipitation regimes, evaporation, humidity, soil moisture levels, vegetation growth rates, water tables, and aquifer levels, and air quality (Solecki & Marcotullio, 2013; ICLEI, 2015; SCBD, 2019), which will in turn, affect human health and wellbeing. Extreme weather and climatic events such as floods, droughts, and heat waves are also changing in frequency, intensity, and timing which in turn is causing human mortality and damage to infrastructure and settlements. Responding to these changes are some of the greatest challenges that nations, especially developing countries, are currently facing (Solecki & Marcotullio, 2013). Therefore, with increasing risk of climate disasters, there is an urgent need to prioritise proactive disaster risk reduction.

Additionally, although climate change is not currently shown to be a primary driver of the current loss of biodiversity and ecosystems, it has a range of impacts to biodiversity and ecosystem functioning.

For example, recent climate change has worsened habitat loss and fragmentation, as well as altered species ranges, community composition, and physiology (Arneth et al., 2020). These changes will not only enhance existing pressures on biodiversity but can also lead to challenges for conservation (Arneth et al., 2020).

Climate change is therefore, projected to be an increasing additional driver for biodiversity loss. Previously, climate change and biodiversity were usually dealt with in isolation. However, we can no longer do this. Addressing climate change and biodiversity issues should be linked since maintaining ecosystem integrity is very important for climate resilience, particularly in cities. Nature and healthy ecosystems, in particular, are increasingly being recognized as important tools to prevent and minimize disaster risk and assist with climate change mitigation and adaptation (Monty et al., 2016). Therefore, preserving, restoring and connecting ecosystems will slow down biodiversity loss and have benefits for climate change. Arneth et al. (2020) state that, to slow down biodiversity loss, the ambition of retaining, restoring, and preserving natural ecosystems will be extremely difficult to achieve, unless climate change is considered explicitly as a main threat to biodiversity and ecosystems. Since both climate change and biodiversity loss have a huge impact on human societies, particularly the poorer populations and city dwellers, bold and effective solutions that integrate environmental and societal objectives are required (Arneth et al., 2020). Promoting discussions between important conventions, such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD), as well as associated science-policy platforms including the IPCC and IPBES could help align policies and create added value to address these challenges. According to Arneth et al. (2020) “a better alignment of conventions and scientific assessments could stimulate the urgent decarbonization of the economy and ensure that climate change is minimized through actions that benefit from rather than compromise biodiversity protection”.


## Adapting to the effects of climate change

Nature-based Solutions (NbS) are defined by IUCN as actions to protect, manage, and restore natural or modified ecosystems to address societal challenges—such as climate change, food and water security, and disaster risk—while enhancing human well-being and biodiversity (Cohen-Shacham et al., 2016; Cohen-Shacham et al., 2019). NbS are cost-effective and provide environmental, social, and economic benefits, supporting resilience (European Commission, 2016). They encompass a range of ecosystem-based approaches, including ecological restoration, forest landscape restoration, green infrastructure, ecosystem-based adaptation (EbA), and disaster risk reduction (Eco-DRR) (Cohen-Shacham et al., 2016; Nesshöver et al., 2017).

NbS can effectively support climate change mitigation and adaptation by leveraging ecosystems as carbon sinks and buffers against extreme weather (IUCN, 2012; Cohen-Shacham et al., 2016; Nesshöver et al., 2017). Forests, wetlands, and oceans help regulate the climate and protect vulnerable communities, especially those reliant on natural resources, from climate-related disasters through EbA and Eco-DRR (Cohen-Shacham et al., 2016).

EbA utilizes biodiversity and ecosystems to help communities adapt to less predictable climate conditions. These approaches strengthen ecosystem resilience, deliver co-benefits for people and biodiversity, and support broader development goals (GIZ, 2019a).

For planners and policymakers, EbA and Eco-DRR offer integrated solutions to climate risks, biodiversity loss, and socio-economic vulnerabilities (GIZ, 2019b). According to Bertram et al. (2019), eco-system-based thinking should be embedded in key sectors like finance, infrastructure, and urban development.

Healthy ecosystems are central to climate strategies. They reduce vulnerabilities, support human adaptation, and recover more effectively from hazards (Cohen-Shacham et al., 2016; Monty et al., 2016). As evidence grows, EbA is gaining policy prominence and can be applied across natural, rural, and urban landscapes (GIZ, 2019b).

## Funding nature-based solutions for adaptation

Investing in NbS for adaptation is and will continue to be fundamentally important in helping many countries address climate change and biodiversity loss. Both donor and country interest in NbS has increased rapidly in recent years. However, according to Swann et al. (2021), the amount of public international funding flowing to NbS for adaptation is still relatively small. In 2018, it accounted for only US$3.8–8.7 billion, or approximately 0.6–1.4% of total climate finance flows and 1.5–3.4% of public climate finance flows (Swann et al, 2021).

Funding for NbS for adaptation in 2018 was driven by a handful of major bilateral donors, including Germany, the United Kingdom, Japan, and Sweden. The largest multilateral donors and channels of funding were from the European Union, Asian Development Bank, the Green Climate Fund, and the International Fund for Agricultural Development. Funding came mainly through grants, which accounted for as much as 85% of funds to developing countries (Swann et al, 2021). However, there is still a long way to go to improve overall flows of investment for NbS and to see these investments realized and implemented in developing countries. Investing in NbS for adaptation at scale will require greater investment from both public and private sources as well as improved coordination among many stakeholders (Swann et al, 2021).

## Case study: NbS opportunities for Dar es Salaam

In the City of Dar es Salaam, the impacts of climate change have exacerbated the rate and extent of environmental degradation and have made Dar es Salaam's efforts toward environmental management more challenging (Karutz et al., 2019). The Thematic Atlas of nature's benefits to Dar es Salaam presents a number of chapters, based on specific themes, that relate to green open space and it's contributions to alleviating the impacts of climate change, for example: flooding, urban heat and air pollution. Urban vegetation cools the city and green areas can reduce flood risks and protect urban infrastructure. A map in the Atlas, which shows a satellite image of Dar es Salaam's daytime surface temperature in June 2017, illustrates a UHI effect. This is a challenge to public health and to secure energy supply in many cities around the world. Urban vegetation can mitigate the UHI effect by cooling the air. In addition, in light of the city's increasing exposure to flood risks, building green areas, implementing a Sustainable Urban Drainage System (SuDS) and enhancing its adaptive capacity will be of major importance for city resilience in the coming decades (Karutz et al., 2019).

Climate change is projected to affect precipitation variability, storm frequency and temperature, resulting in droughts and rivers flooding, sea level rise and storm surges; coastal and beach erosion; submergence of some nearby islands; intrusion of salt water in fresh water bodies (wells and boreholes); and erosion and destruction of lifelines (i.e. roads, bridges and coastline) (Karutz et al., 2019). A higher frequency of heavy rainfall which causes flooding in the city, particularly in low-lying, flood-prone informal settlement areas, means that poorer people are exposed to heightened vulnerability to flooding. In addition to property loss and occasional loss of life; widespread health risks result from overflow of onsite sanitation sewers and drains, contamination of wells and springs, and the spread of diseases such as malaria, lymphatic filariasis, and diarrhoea.

The rise in temperature, coupled with an increase in precipitation, would undoubtedly have wide-ranging impacts. By 2100, the mean annual temperature for Tanzania is expected to increase by 1.7°C, including areas around Dar es Salaam. This rise in temperature could also trigger an increase in the UHI effect, which would result in a gradient of higher temperatures where densities of people and the built environment are greatest. These higher temperatures could impact urban agriculture (evapotranspiration, heat stress), disease incidence (direct effects of extreme heat on humans, as well as on disease vectors, e.g., by increasing humidity), hydropower generation (increased evaporation in reservoirs), and household electricity requirements. Models also anticipate a projected increase in the number of days exceeding 32°C by 2050 (Karutz et al., 2019).

Considering all the climate and environmental risks that Dar es Salaam and many other developing cities face, it is critical that nature positive approaches are adopted to reduce the risk to people, the economy and the environment. Approaches such as the integration of NbS into development and planning, using tools such as the Thematic Atlas, could contribute to development needs, with positive biodiversity contributions. The Thematic Atlas has highlighted some of the potential that the City has to address the risks of climate change and biodiversity loss and has also inspired some other nature positive initiatives.

# POSITIVE SPIN-OFFS OF THE THEMATIC ATLAS

The completion of the Thematic Atlas can be seen as a result. But the use and implementation of this tool has yet to be tested. The development of the Atlas did lead to a number of outcomes and has created opportunities for implementation:

- The development of the Thematic Atlas created much awareness about the value of urban nature and the realization that this awareness can be used in the form of a tool (i.e. the Atlas) to make rational and defensible decisions on investing in urban nature and the kind of social benefits that can result. Monitoring and evaluation of the impact of such decisions is still premature;
- The City Council has asked that the Atlas be launched in a formal ceremony, during which the five municipal councils of Dar es Salaam each make a set of commitments based on the information in the Thematic Atlas. This took place at the end of 2019;
- The World Bank has already used the concepts in the draft Atlas to add urban nature elements to the Msimbazi Valley opportunity plan, an ambitious initiative to restore the Msimbazi catchment flowing through Dar es Salaam and which is the subject of dramatic seasonal flooding;
- The Thematic Atlas and the focus on urban greening gave rise to the idea of a 'biodiversity catalogue' for Dar es Salaam, to raise awareness of Dar's natural heritage (i.e. indigenous fauna and flora) in the City and their use and maintenance in restoration to solve urban issues; For example, exotic tree and shrub species are mostly used in plantings, as these are popularized by politicians, whereas the catalogue would encourage the planting of indigenous plants, in line with urban needs and the species that form elements of the East African Coastal forest hotspot.
- Other cities have started to notice the Thematic Atlas and its value. The City of Johannesburg has requested that ICLEI develop something similar for Johannesburg but with more emphasis on economic valuation of ecosystem services.
- The Thematic Atlas laid the foundation for exploring multi-sectoral partnerships in the city's greening endeavours. For example, through the Atlas process, it became apparent that the roads department also invest in greening and that the City Council could partner with transport to co-invest in tree planting but importantly, to ensure tree survival to maturity.

# LESSONS LEARNED

**Innovation.** The innovation at a technical level was in the simple combination of maps of urban issues and urban ecosystem services to build robust arguments/rationale for where urban greening would deliver the greatest social benefit. The Atlas development, or co-production process, was designed to be collaborative. Many participants gave of their time, data and expertise to create the Atlas and participants were invited to validate, comment and edit at various stages of the process. This approach created a lot of ownership of the product. With minimal data (but great local knowledge) a useful tool was produced.

**Mapping and GIS.**

- Ground-truthing – provides local spatial information about urban natural features and associated challenges. A local person from the municipality accompanied the team to the field also giving the team details about the area.
- To fully cover all the green spaces more time would be needed - It would be ideal to have 2 teams to cover more areas.
- Identify municipal delegate/s (beforehand if possible) to accompany the team for the duration of the site visits.
- Data capturing - The data for each site is collated separately in a live MS Excel spreadsheet to aid further mapping.
- Obtaining permission beforehand – to get access to areas such as forest reserves further data could have been gathered.

**Opportunities for replicating the learnings associated with the initiatives.**

- Integrate ecosystem services with urban issue mapping: Cities hoping to replicate the Thematic Atlas approach should start by identifying their priority urban challenges (e.g., flooding, heat, air pollution), mapping these alongside existing green infrastructure or ecosystem services to reveal where nature-based interventions could offer maximum benefit.
- Adopt a co-production model: Active participation from diverse stakeholders contributes to the overall success and relevance of the output, building credibility and fostering local ownership. Cities should form multi-sectoral working groups including municipal departments, local experts, NGOs, and community members to contribute data, review outputs, and co-develop the final product.
- Leverage local knowledge to supplement limited data: Even with sparse technical data, local knowledge can fill critical gaps. Facilitate workshops and participatory mapping sessions to draw on this knowledge, ensuring the tool reflects on-the-ground realities.
- Create simple, flexible tools: Use straightforward and adaptable mapping methods that can be scaled or modified to suit different urban contexts and available resources.

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## Acknowledgements

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