



# DAR ES SALAAM AND MOSHI, TANZANIA

## COOLING HOT CITIES: HOW TREES CAN AID IN MITIGATING URBAN HEAT AND INCREASE A CITY'S ADAPTIVE CAPACITY

The benefits of trees and the importance of nurturing trees to maturity and maintaining them in urban environments cannot be underestimated. In 2019, this concept was demonstrated through two INTERACT-Bio outreach initiatives that took place in Dar es Salaam and Moshi, two fast-growing cities in Tanzania.

The goal of both initiatives was to raise awareness on the benefits of nature within urban areas, with a specific focus on trees. Trees have the ability to mitigate urban heat and in turn, increase a city's adaptive capacity to the negative effects of climate change. The initiatives discussed here focused on the point that in order to derive benefits from mature trees, people have to invest in their growth and care.

## Dar es Salaam

*The initiative in Dar es Salaam focused on temperature measurements within the context of the cooling effect of trees in urban areas. The following main activities were conducted:*

- 32 standard five and six pupils (aged 12 to 14) from Msasani 'A' Primary School participated in a two day training on nature's services in the city.
- During the workshop, the students were shown how to construct homemade thermometers to measure temperature variation in areas with and without trees.
- A questionnaire relating to the benefits people derive from urban nature was used to assess students' understanding of the subject. This questionnaire was conducted before and after the training workshop to assess whether the students' level of understanding had improved.
  - \* Before the training, results indicated that students did not have a clear understanding of what nature means and its importance in urban areas.
  - \* After the training, some students showed an improved understanding regarding the value of nature.

The biggest challenge this initiative presented related to embedding understanding and knowledge on the value of nature and trees. To many students, this is a new concept and therefore makes it difficult to grasp within a single training session. Using an innovative and interactive lesson in which students created homemade thermometers to measure temperature variation in areas with and without plants/trees within the school yard, improved understanding of the value of urban trees and the cooling effect they provide. As a result of the training, pupils wanted to create a nature area at their school by planting fruit trees and flowering plants.

*Msasani 'A' Primary School students watching intently as their homemade thermometers get to work. ©Nipe Fagio, 2019*





## Moshi

*The initiative in Moshi was centered around the benefits of nature in the city, specifically raising awareness regarding the ecosystem services provided by trees, as well as how to care for them. The following main activities were conducted:*

- 250 trees were planted at the Kimochi Secondary School.
- 250 people attended the planting event – roughly 150 children and 100 adults.
- Five indigenous tree species were planted – *Ficus sycamore*, *Rauvolfia caffra*, *Syzygium cumini*, *Trichilia dregeana*, and *Khaya anthotheca*. Three of the five are fruit-bearing species.
- An additional training component was conducted in the Kiviwama Arboretum, at which 30 selected students were each given a tree to plant at home.
- The “Tree Tracker” software was used to verify the planting and aid in future monitoring of the 250 trees planted. Anyone can use this software to view how many trees were planted, the exact location and time they were planted, the individual or organization that planted the trees, as well as a geo-tagged image of the sapling.

Although the initiative resulted in a large number of trees being planted, it is difficult to measure to what extent the students internalized the concepts from the training session. The initiative innovatively utilized technology to advance and maintain a high degree of transparency in tree planting and tracking. The tangible result of this initiative is evidenced in the planting of 250 trees, which will be maintained and monitored predominantly by Kimochi Secondary School, with assistance from The Kilimanjaro Project.

*Students from Kimochi Primary and Secondary school gather at the school ground for the tree planting. ©Nipe Fagio, 2019*





*Both Dar es Salaam and Moshi are experiencing rapid urbanization, with both cities' growth projected to continue into the future. As a result, the cities' natural assets and the ecosystem services which they provide are under pressure. The cooling properties of trees, as well as their ability to assimilate air pollutants and store carbon, are vital ecosystem services in urban settings. These services need to be acknowledged and safeguarded.*

## Dar es Salaam

Dar es Salaam is a major city in Tanzania (covering 1,393 km<sup>2</sup> of land mass) and a commercial port on the Indian Ocean coast. The City is the economic, industrial, commercial, trading, educational, cultural and transportation hub of Tanzania. Additionally, Dar es Salaam boasts tremendous marine, coastal and coastal-forest biodiversity. The city is also the leading arrival and departure point for most tourists who visit Tanzania. As a result of these economic activities and migration from rural areas, Dar es Salaam has experienced rapid urban growth at a rate of 6.5 percent, which has not only made it the fastest growing city in East Africa, but has also resulted in the rapid deterioration

## Facts and figures: Dar es Salaam

### Local government name

City of Dar es Salaam, including five municipal councils: Kinondoni, Ubungo, Ilala, Temeke & Kigamboni

### Country and province

Tanzania, Dar es Salaam Region

### Population (2016)

4.4 million; 6.5% annual growth

### Total area

1 590 km<sup>2</sup>

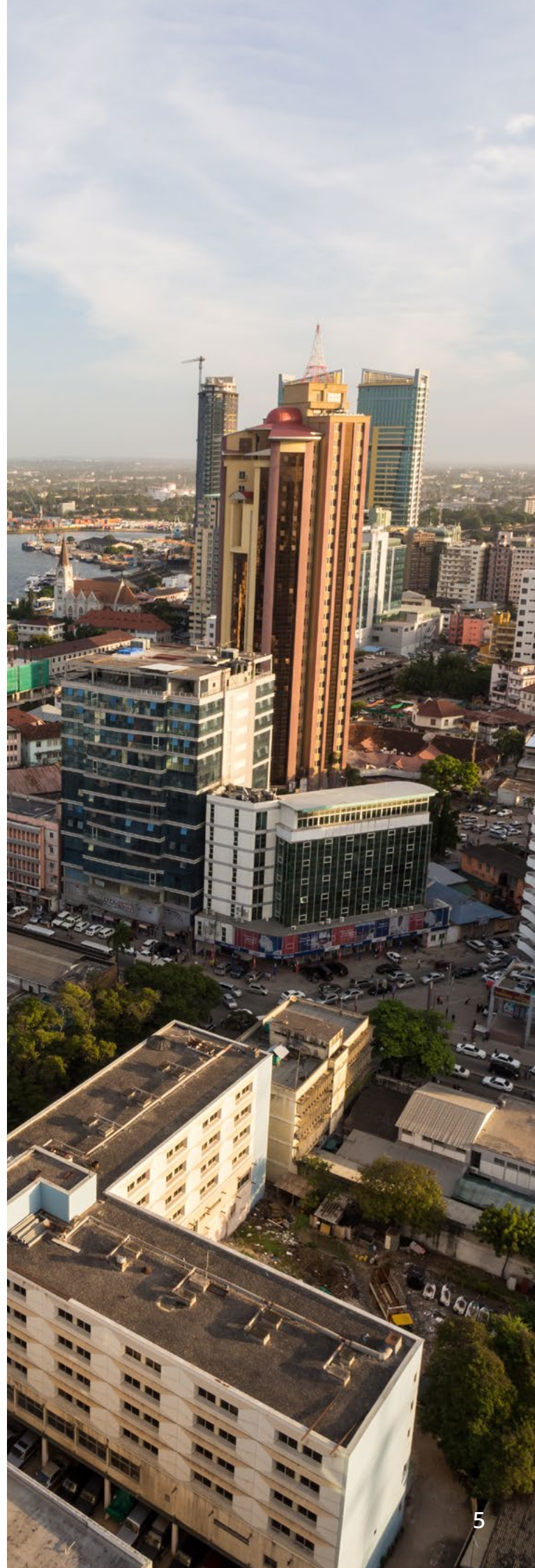


Map of Dar es Salaam



of the natural environment (ICLEI, 2018). Despite rapid urbanization, Dar es Salaam still has a picturesque shoreline, beautiful beaches, pockets of mangroves, remnants of coastal and Afromontane forest and various wildlife elements. These natural assets, and their benefits to people (such as cooling), will disappear unless they are valued and deliberately incorporated into urban planning.

Dar es Salaam is located within the East African coastal forest, a globally important biodiversity hotspot. Biodiversity hotspots are areas with exceptional concentrations of endemic species (i.e. found nowhere else in the world) that are simultaneously undergoing a high rate of habitat loss. Dar es Salaam's population depends heavily on its natural resources, with a significant part of food production occurring in the city. The population needs clean air, food, water, medicines and shelter, and the industrial sector needs raw materials, most of which include environmental services. Waste generated by people and industries will need ecosystems to absorb them. The coastal forest remnants of Dar es Salaam provide a wide range of ecosystem services including medicinal plants, fuel wood and building materials such as 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 have led to degradation of the coastal and inland forest resources (UNEP, 2011). It is projected that Dar es Salaam will experience continued deforestation that reduces ecosystems' capacity to sequester carbon as well as land degradation, which would lead to poor land productivity (World Bank, 2016). Despite the remarkable natural heritage in Dar es Salaam, there is little awareness of the multiple benefits of nature in the context of urban life. Urban heat, for example, is particularly severe in Dar es Salaam (Karutz et al., 2019).



## Moshi

Moshi is situated in the mountain-plains system of northern Tanzania on the lower slopes of Mount Kilimanjaro, close to the border with Kenya. The municipal area covers 59km<sup>2</sup> and the population is around 200,000 with an annual growth rate of 2.9%. The population growth in Moshi Municipality can be attributed mainly to the high rate of rural-urban migration. Moshi is also one of Tanzania's major coffee-producing hubs. Agriculture is practiced within the municipal bounds mostly by residents in sparsely populated areas as an alternative source of income. The residents of Moshi are engaged in horticulture and grazing of cattle, goats, pigs and poultry. The area of land used for urban agriculture is 120 hectares and crops are prone to floods during periods of heavy rainfall and intermittent drought.

Moshi falls within the Eastern Arc Mountain chain in the north east of Tanzania. Like the coastal forests of Dar es Salaam, the Eastern Arc Mountains constitute a globally important biodiversity hotspot, with high levels of species endemism. Moshi boasts a culture of caring for the environment and revering of mountains, rivers and forests. For example, in Moshi, tree cutting and pruning is strictly regulated and over 30 Non-Governmental Organizations (NGOs) in the area assist with tree planting. Water supply is relatively secure as the Karanga and Rau Rivers, which flow through the center of the municipality, are perennial. Moshi has good municipal environmental rules and bylaws that are enforced and enjoy a large degree of compliance. As a result, Moshi routinely wins national environmental awards for cleanliness and environmental care and innovation (INTERACT-Bio, 2018). With that being said, the pressures from increased urbanization are putting Moshi's natural resources under pressure, and it is necessary that Moshi protects the benefits it derives from urban nature.

## Facts and figures: Moshi

### Local government name

Moshi Municipality

### Country and province

Tanzania, Kilimanjaro Region

### Population (2016)

200 000; 2.9% annual growth rate

### Total area

59 km<sup>2</sup>



*Map of Moshi Municipality*



*Farms in Moshi, Tanzania. ©Shutterstock*





# THE IMPORTANCE OF TREES WITHIN URBAN AREAS

Globally, climate change is widely regarded as one of the greatest challenges to today's society (Kabisch et al., 2017). This global challenge has severe local implications as cities are the first to experience impacts from climate change (Kabisch et al., 2017). The effects of climate change include, amongst others; rising temperatures, heat waves, the urban heat island effect, extreme precipitation events, flooding and droughts. These impacts in turn cause economic losses, social insecurity and negative effects on human health and well-being. This compromises cities' resilience and heightens their vulnerability. Thus, impacts of climate change bear implications locally for fast-growing cities such as Dar es Salaam and Moshi, where urban natural assets that can mitigate some of the effects of climate change are under pressure from urbanization.

An additional global challenge is the steady increase in urbanization, which is highly prevalent in both Dar es Salaam and Moshi. Urbanization has adverse environmental impacts such as elevated temperatures, increases in air pollution and storm water flows, and decreases in storm water quality, which pose major environmental and public health problems in cities (Nyelele et al., 2019). Furthermore, urban expansion will

## **Legal protection of trees in Moshi**

The Moshi Municipal Council promulgated Environmental Protection Regulations pertaining to the Planting and Maintenance of Trees and Protection of Vegetation in 1999 (GN 115 of 1999). The Regulations and the associated By-law are indicative of the greening culture in Moshi. Within these Regulations, Section 9(1) stipulates that any planted or growing tree within the Council area may not be cut, uprooted, or tampered with in any manner without written permission of the Council. Furthermore, Section 10 of the Regulations assigns maintenance obligations to any person who occupies land on which trees are planted or growing.





## Urban Heat Island (UHI) effect

In cities around the world the Urban Heat Island (UHI) effect amplifies the heat effect from climate change. Due to their sealed surfaces, an increase in heat storage in building materials and anthropogenic heat release factors (industry, cars, air conditioning etc.), cities and certain areas within cities often have temperatures that are considerably higher than their surroundings. The UHI intensity is defined as the difference between the highest urban and comparable rural temperature (Roth et al., 1989). This difference can be as high as 12°C, for example in Tokyo. High urban temperatures are a major concern for public health, especially during heat waves, as they can lead to severe health problems including an increased number of heat-related deaths. Urban vegetation can mitigate the UHI effect by cooling the air. A single tree can have a cooling performance of up to ten standard air conditioners through transpiration alone. The effect can be explained by evapotranspiration, shading, a low thermal storage capacity and less re-radiation of heat than built-up structures (Cavan et al., 2014).

heavily draw on natural resources, including open space, and will have severe effects on ecosystems and the services they provide (Kabisch et al., 2017). Recent research points to mounting evidence that urbanization also affects cycling of water, carbon, aerosols, and nitrogen in the climate system (Seto & Sheperd, 2009).

Urbanization and climate change are two defining phenomena of the 21st century, and these two processes are increasingly interconnected (Seto & Sheperd, 2009). Therefore, it is imperative that modern-day interventions take into account this nexus and create initiatives that aim to address both challenges. As a result, the outreach initiatives in Dar es Salaam and Moshi were designed to create awareness about these challenges and highlight how urban nature can help address both issues, by connecting with the general public and specifically the youth sector.

The intervention to address the negative effects of the UHI and climate change is cultivating an awareness and appreciation for the benefits associated with trees within urban areas, and as a practical and action-oriented exercise, to plant trees. The potential of this nature-based solution is far-reaching, because experiential learning has the ability to cultivate understanding about the co-benefits of trees: i.e. alleviating climate change impacts and an appreciation for nature-based solutions in urban settings. For example, over and above the cooling performance of trees through transpiration, when other effects such as shading are included, the effect is even larger thermal storage capacity and less re-radiation of heat than built-up structures (Cavan et al., 2014). Furthermore, this intervention has the potential to enhance equity within urban areas, as residents of lower socio-economic profiles are more vulnerable to the effects of heat and should therefore be cooled by additional vegetation (Karutz et al., 2019).



These initiatives present an alternative solution to land and resource management in response to current urban challenges. This nature-based solution addresses the effects of UHI and the effects of rapid urbanization and utilizes nature as the key driver of change. Nature provides humans with a

host of free and readily-available ecosystem services, which, if recognized, utilized and maintained and protected correctly, have the ability to ameliorate the negative effects brought on by urbanization and enhance climate adaptation in urban environments.



*Kimochi Secondary School students (Moshi) gather after their training session in the arboretum, which explained tree species, tree maintenance, and benefits of trees. ©Nipe Fagio, 2019*



*Msasani 'A' Primary School students (Dar es Salaam) learning about the concepts demonstrated by the training facilitators. ©Nipe Fagio, 2019*





# LESSONS LEARNED: DAR ES SALAAM

## 🟡 **Practical exercises strengthen conceptual understanding.**

The students made their own thermometers, conducted their own experiment outside, and used their results to come to a conclusion about the cooling effects of trees. This is an example of how complex concepts such as climate change, UHIs, ecosystem services and nature-based solutions can be simplified and their underlying meaning conveyed in a very practical manner. To build on their learnings, students could use the foundational lesson from the session and continue their experiments. For example, different classes could measure, record and compare results over time, or one class could measure temperatures in a different area to another.

## 🟡 **Diverse teaching methods can help truly reach students.**

When it comes to concepts such as the benefits people derive from nature, a five-question test may not be the most effective method to assess whether the concept has actually been understood. Therefore, it may be useful to compliment the test with additional practical exercises, for example, using art or creative writing or plays, to illustrate and reinforce the concepts in different ways.

## 🟡 **Passionate training staff are key to success.**

Thanks to the passionate training staff, who instilled an appreciation for nature within the students, many students wanted to create their own nature area within the school grounds after the training had ended. This shows how a small number of passionate people can make a huge impact by sharing their knowledge on a specific topic such as the cooling effect of trees in cities.

*Photo above: Msasani 'A' Primary School students celebrating the successful completion of their training initiative. ©Nipe Fagio, 2019*





# LESSONS LEARNED: MOSHI

- **Technological innovation improves transparency.** The Tree Tracker application (developed by Greenstand) is a scalable, open-source tree-tracking software which uses mobile technology to accurately verify tree planting and to track tree survival rates over time. This lays the framework for the long-term evaluation of each individual tree as an environmental asset, which encapsulates the ethos of the tree planting initiative. This is a good example of how technology can be used to advertise, verify and promote the uptake of tree planting initiatives as well as monitoring tree growth.
- **Measuring understanding can be challenging.** There was no mechanism that was built into the project which tested whether or not the aim of the initiative had been met. It must be noted that an appreciation and awareness of the benefits that trees provide may be something that grows over time within an individual and therefore makes it harder to test during or just after an outreach event. It is possible however, to improve on the exercises done during the event to ensure that the concepts were well-understood. Robust and engaging trainings are more likely to improve the durability of urban nature messages within the minds of young people.
- **Well-designed engagement can spark post-project commitments.** Thirty (30) of the 150 students received their own take-home plant and committed to ensure that the tree would be planted and monitored during its growth. The Kilimanjaro Project and the supervising teacher committed to conduct a follow-up twice a month to supervise whether the trees planted at home were in good condition. Additionally, the 30 students and the supervising teacher were given the responsibility of ensuring that the knowledge gained in the training would be transferred to fellow students and neighboring schools. While these follow-up activities are promising, they could be strengthened by a structured feedback channel to convey whether these commitments were met and to learn more about their challenges of growing young trees successfully.
- **Media can be a powerful tool for awareness raising.** The vast array and sheer number of media channels that arrived on the day of the planting at the school helped create wider awareness of the tree planting as well as the INTERACT-Bio project. This coverage helped initiate a broader conversation surrounding trees and their benefits within Moshi Municipality.

*Photo above: A Kimochi School students listen to the planting demonstration while lining up to plant their saplings. ©Nipe Fagio, 2019*



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*In the Dar es Salaam initiative, training was provided by the NGO: Nipe Fagio and delivered by experts Wilyhard Shishikaye, Max George and Olary Tomito. Although the initiative only required a small number of staff, it was imperative that the staff members were well versed within the field of environmental education. The project could not have been conducted without the willingness of Msasani 'A' Primary School administration.*

*In Moshi, the initiative was driven by NGOs Nipe Fagio and BORDA Tanzania. The tree-planting was facilitated by The Kilimanjaro Project. On the day, participants from the Sango village community arrived, including community leaders. The collaboration with Kimochi Primary and Secondary school to own the initiative was an integral component to the success of the exercise.*

*The awareness component was conducted by The Kilimanjaro Project's tree expert Samwel Andrew. It was imperative to have someone so knowledgeable about trees in order to effectively educate an audience of 250 people. Furthermore, Nipe Fagio's community mobilization officer Wilyhard Shishikaye facilitated the training within the Arboretum, and his tree knowledge was a necessity to the success of the training.*

*Both initiatives were part of the Outreach Programme, as part of ICLEI's INTERACT-Bio Project. The City Council in each case provided permissions to conduct the outreach and guided the choice of schools to work with. ICLEI played a vital coordinating role. Furthermore, the initiatives would not have been possible without the involvement from NGOs and in particular, in providing training staff and where necessary, to partner further with city-based NGO's like The Kilimanjaro Project.*

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