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The Source Waters of Tanga



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Synonyms

Spices refers to cloves, candamon, cinnamon and black pepper; **Gemstones** refers to alluvial gold found in the streams; **Wetlands** refers to bogs and other riparian vegetation; **Forest** refers to standing tree area used for no other purpose

Abbreviations

CSR	Cooperate Social Responsibility
EAMCEF	Eastern Arc Mountains Conservation Endowment Fund
EWURA	Energy and Water Utilities Regulatory Authority
GHG	Greenhouse gas
IUCN	International Union for Conservation of Nature and Natural Resources
MoW	Ministry of Water
Norad	Norwegian Agency for Development Corporation
RFL	Rural Focus Limited
TNC	The Nature Conservancy
TWF	Tanga Water Fund
UWAMAKIZI	Umoja wa wakulima wa hifadhi mazingira Kihuhwi Zigi
UWASA	Urban Water Supply and Sanitation Authority

Definition

Biodiversity is the variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems' above ground as well as below ground carbon stock

Eastern Arc Mountains is a chain of mountains found in Kenya and Tanzania. The chain runs from northeast to southwest, with the Taita Hills being in Kenya and the other ranges being in Tanzania. They are delimited on the southwest by the fault complex represented by the Makambako Gap that separates them from the Kipengere Range.

Endemism is the ecological state of a species being native to a single defined geographic location, such as an island, nation, country or other defined zone, or habitat type; organisms that are

indigenous to a place are not endemic to it if they are also found elsewhere.

Public-private partnership is a cooperative arrangement between two or more public and private sectors, typically of a long-term nature source waters.

Source waters refers to water sources (such as rivers, streams, lakes, reservoirs, springs, and groundwater) that provide water to public drinking water supplies and private wells as well as their replenishment sources.

Water funds refers to public-private partnerships that bring stakeholders from both sectors to pool financial resources to support conservation of their source waters. They are founded on the principle that it's cheaper to invest and keep surface water clean while still in the watershed than further downstream like in city water treatment plants.

Water security is the reliable availability of an acceptable quantity and quality of water for health, livelihoods, and production, coupled with an acceptable level of water-related risks

Part 1. Applying a Water Fund Approach to Conserve Tanga City's Source Waters

Introduction

Tanga is a port city located in the northeast region of Tanzania on the shores of the Indian Ocean. The city is the administrative headquarters of the Tanga Region and has an estimated 2019 population of 306,500, which is expected to rise to 406,135 by 2030. The main economic activities in the Tanga Region are agriculture, fishing, tourism, mining (cement, limestone), commercial sisal growing and processing, small-scale business, and commercial port activities.

The Tanga Region is characterized by a bimodal rainfall distribution peaking between March and May and between September and December. Annual rainfall in the region varies with altitude, ranging between 1,100 mm and 1,400 mm on the coast to above 2,000 mm in the Usambara Mountains. Much of the region experiences a warm and wet climate, while some parts of the lowlands are semiarid.

As with other African cities, the call to develop a water fund for Tanga arose from the realization that there was a need to respond to water security concerns – particularly rising demand that outstrips supply combined with declining water quality. The water fund model provides a solution to these challenges by offering a mechanism for stakeholders to work together to promote equitable access to water resources from the source to the points of consumption. At the same time, water funds promote sustainable water use and catchment conservation among stakeholders. It is a science-based approach that launched in Nairobi in 2012 and led to the establishment of the Upper Tana-Nairobi Water Fund. The Nature Conservancy (TNC) has replicated the water fund model in other African cities, including Cape Town, and has responded to the Tanzania Ministry of Water's (MoW) request during the 2016 Africa Water Week to implement the model. Since then, TNC has researched cities in which to establish water funds, resulting in the completion of a water fund in Tanzania (2018) and a feasibility study for Tanga (2019–2020).

This report summarizes the findings from the studies conducted on the Tanga Water Fund (TWF) and builds the case for its establishment by highlighting the benefits for Tanga City, the environment, beneficiary communities, and other stakeholders.

Tanga City relies on the Zigi River in Fig. 1, which feeds the Mabayani Dam for its domestic, commercial, and industrial water needs. Groundwater supplements about 1% of the supply to the city. The region's main economic activities all depend on water. As such, it is in the best interest of water users, catchment dwellers, and all stakeholders to ensure a sustainable and reliable water supply. Tanga Water Supply and Sanitation Authority (Tanga UWASA) handles the water distribution from the Mabayani Dam (28,000m³/d) and the Mwakileo Borehole (3,800 m³/d) to about 98% of the urban population. Tanga UWASA also covers the Pangani township and Muheza District following the MoW directive to cluster the three water supply utilities and expand Tanga UWASA's jurisdiction. This makes all of the region's water



The Source Waters of Tanga, Fig. 1 Zigi river flows out of the Amani Natural Reserve ahead of Mabayani dam. Photo by John Esther

sources, including Muheza's intakes on the Mkulumuzi River, vital to the utility.

Tanga's landscape in Fig. 2, is characterized by diverse land cover and slopes. The Zigi catchment is dominated by forests (61.77%), with 50% of the land on a slope greater than 15%. The upper reaches of the Zigi River forested catchment are steep and mountainous and adjoin tea plantations. The lower reaches are hilly and gently sloping, with more open woodland, bushland, and farms. The Amani Nature Reserve (ANR), one of the most important protected forests in Tanzania due to its rich biodiversity and species endemism, covers over 7,000 ha of the upper Zigi catchment and is the source of the Kihuhwi tributary of the Zigi River. There are 15 forest reserves within the catchment, including the Kilanga (Nilo) Forest Reserve on the northeast end of the catchment area. Nilo occupies 1,415 ha and is the source of the Muzi tributary.

The Mkulumuzi River catchment is characterized by gentler slopes and vegetation, with 80.7% of the landscape consisting of low to moderate slopes (<5 to 15%). Grassland and bushland

cover 50% of the catchment, while forests cover 24.6%. The Mkulumuzi catchment also hosts the Bassi, Magoroto, and mangrove forest reserves, with a total area of 1,160 ha.

The catchments spread across the districts of Korogwe, Muheza, Tanga, and Mkinga. These districts are predominantly rural and peri-urban, with agriculture being the main livelihood activity.

Other than its importance as a source of water to Tanga City, the Zigi watershed plays a critical role in providing ecosystem services and preserving biodiversity. The headwaters of the Zigi River emanate from the East Usambara Mountains, which are globally recognized for their exceptional biodiversity and species endemism. The richness in flora and fauna in this region has been compared to that of the Galápagos Islands.

The East Usambara bloc boasts a variety of endemic and a near-endemic plant, vertebrate, and invertebrate species such as the African violet (*Saintpaulia*), the Sanje



The Source Waters of Tanga, Fig. 2 Water comes from Nature. Eastern Usambara mountain forest quenches Tanga. Photo by Roshni Lodhia

Mangabey (*Cercocebus sanjei*), Iringa red colobus (*Procolobus gordonorum*), the mountain dwarf galago (*Galagoides orinus*), and the Kipunji monkey (*Rungwecebus kipunji*). The Amani Nature Reserve alone has extensive floristic diversity (3,450 vascular plant taxa), 74 genera of animals, and more than 340 bird species (Fig. 3).

The health of the watershed contributes to the quality of water flowing through the Zigi River, with the watershed providing such critical ecosystem functions as flow regulation and sediment retention. Land-use change and the loss of forest cover in both the Zigi and Mkulumuzi catchments, as well as across the East Usambara Mountains as a whole, have led to the deterioration of water quality and reliability to the detriment of water users in Tanga City and within the catchments. The Mkulumuzi River, a perennial coastal river, has recently experienced low to zero flows. The Zigi River suffers largely from soil erosion and sedimentation, with the region most prone to erosion being Boshwa Ward in Mkinga District, where poor farming practices and alluvial gold

mining are common. Gold mining in the Tanga watershed has increased the degradation of wetland ecosystems and natural habitats. The main threats to water resource sustainability are mostly due to changes in land use:

- Further degradation of the habitat, leading to loss of biodiversity
- Soil erosion and sediment yield, leading to loss of capacity at the Mabayani Dam
- Water quality deterioration on Zigi River, leading to high water treatment costs
- Climate change, which may result in increased intensity and frequency of storms, floods, and droughts

Concerns regarding the land-use practices within the East Usambara Mountains have been widely recognized and documented, and various projects focusing on forest conservation to protect biodiversity have been implemented. Examples include the Integrated Usambara Rain Forest project (1983), the Amani Forest Inventory and Management Plan project (1986–1987), and the IUCN/Forest Division/Norad Project in the East Usambara Mountains (1986–1987). More recent



The Source Waters of Tanga, Fig. 3 Silvery cheeked hornbill bird in the Amani nature reserve. Photo by Roshni Lodhia

projects include the Equitable Payment for Watershed Services project (2009–2015); the Securing Watershed Services Through Sustainable Land Management in the Ruvu and Zigi catchments, Eastern Arc Region, Tanzania project (2016–2020); and the TWF feasibility study (2020). Continued efforts from interested parties in the conservation of the East Usambaras shows not only the importance of the mountains as a natural resource but also the potential for more significant impact from conservation activities through enhanced synergy among stakeholders, an opportunity that the water fund model offers.

Various policy and legislative directives across different sectors have also been put in place to support and prioritize catchment conservation, including protections for forest and wildlife reserves and the establishment of riparian areas. The MoW is responsible for the sustainable development and management of water resources, including overseeing urban and rural water and providing sanitation services. The Ministry of Natural Resources and Tourism; the Division of Environment in the vice president's office; the Ministry of Agriculture, Livestock, and Fisheries; the Tanzania Forestry Service; the office of the Regional Administrative Secretary; and the district councils all serve important roles related to the conservation and development of the people and environment within the two catchments. A key feature of Tanzania's policy and legislative

framework is that it provides an enabling environment for multi-stakeholder engagement in catchment conservation and further encourages public-private partnership for enhanced resource mobilization, engagement, and implementation of activities.

The feasibility study (Rural Focus Ltd. 2020) identifies the following interventions as suitable for the landscape. These interventions could improve rural livelihoods through a systematic and targeted effort in which sustainable land management practices are adopted to improve water and food security while also enhancing catchment and forest conservation to protect biodiversity:

- Agroforestry and woodlots
- River riparian conservation
- Integrated watershed management
- Livelihood support
- Marketing and value chain support
- Improved rural roads, tracks, and pathways

The abovementioned interventions offer a variety of benefits to both the catchment and water users, including improved water quality and reliability; improved crop production, leading to better livelihoods (Fig. 4); improved access to markets for produce; and forgone costs of dam desilting and reduced water treatment costs.



The Source Waters of Tanga, Fig. 4 Clean water in Tanga grows healthier families. Photo by Roshni Lodhia

This report analyses the benefits that could be accrued from the proposed sustainable land management interventions specifically for the **preservation of biodiversity, climate change mitigation impacts, clean water provision, and community well-being and livelihood benefits.**

Part 2. High Endemism and Biodiversity Significance of the Tanga Watershed and East Usambara Mountains, Tanzania

Introduction

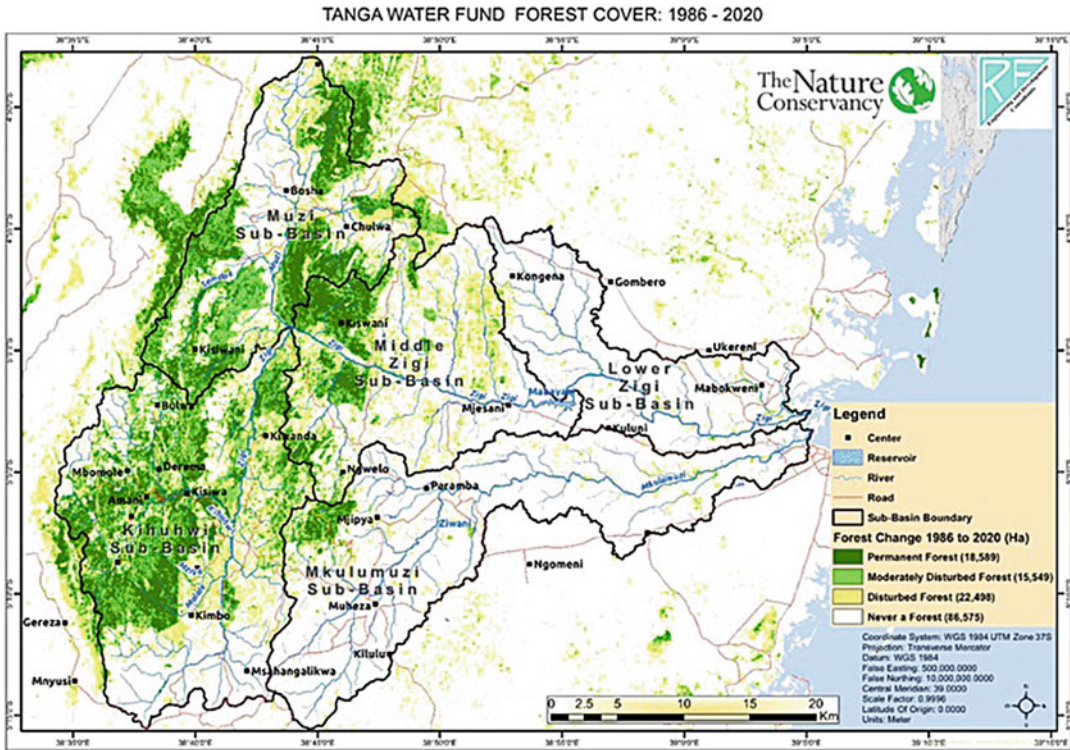
Biodiversity is broadly understood to describe the variety of life-forms in a given community or habitat, but there are several aspects to this generic term. The first is the distinction between diversity and richness, both of which are amalgamated under the term “biodiversity.” Richness refers to the total number of forms (e.g., species), while diversity incorporates the relative abundance of these different forms. The difference between these measures is significant for those threatened and endemic species that may have smaller populations but are of great conservation importance.

Biodiversity may be further separated to include ecological diversity, species diversity, and genetic diversity. Another element of biodiversity worth noting is endemism. This describes a species that is unique to a defined geographic

region. This is important to areas such as the East Usambara Mountains of Tanzania, which possess an unusually high level of endemism, as well as various rare habitats and threatened species.

The East Usambara Mountains are one of 13 mountain blocks comprising the Eastern Arc Mountains, which stretch from southern Kenya through eastern Tanzania. This mountain range is renowned for its biodiversity and high endemism rates, with the East Usambaras having some of the highest (Burgess et al. 2007).

The natural primary forest of the East Usambara Mountains covers approximately 56,636 ha, 38,047 ha of which have experienced some disturbance since 1986 (Fig. 1). Just over 30% (30.6%) of this is classified as submontane rainforest; 63% is classified as lowland forest, predominantly defined by altitude with submontane forest generally occurring above 850 m. Low-altitude forest extending to the coastal plains bear compositional similarity to other coastal forests of East Africa (Hamilton and Bensted-Smith 1989) (Fig. 5). The high-altitude closed-canopy submontane forests carry the greatest biodiversity and are interspersed in the valleys and gentler slopes with swampy “wetland forest,” itself a very important habitat for many species (Senzota and Mbago 2009).



The Source Waters of Tanga, Fig. 5 Map of disturbed and undisturbed forests in the East Usambara mountains

Importance of Biodiversity

The most tangible benefits of biodiversity come in the form of ecosystem services and natural capital, for example, pollination. In a modified mosaic ecosystem where agroforestry is so prevalent, the biodiversity of pollinators (insects and birds) translates directly to higher yields and improved revenue, giving biodiversity monetary value too.

Healthy ecosystems also protect soils from eroding and leaching, resulting in improved water quality in the rivers that drain near them (Van Biervliet et al. 2009). This is important in the Zigi catchment, as 96% of the water for Tanga is drawn from the Mabayani Dam on the Zigi River. The river is experiencing a sedimentation rate of 168,000 m³ per annum due to runoff from the upper catchment, reducing reservoir capacity (Rural Focus Ltd. 2020).

High biodiversity in the Zigi watershed, especially within the protected areas, also directly benefits neighboring communities and Tanzania’s economy through non-timber forest products (NTFPs) such as plants and food sources, for

example, fruit and seeds (Kessy 1998). These benefits are exploited commercially in agroforestry enterprises like tree spice crops, mainly cardamom, cloves, and cinnamon, as well as black pepper in the understory (Bullock et al. 2013; Reyes 2008; Reyes et al. 2009). These production systems also heavily depend on the biodiversity of pollinators to maintain yields.

Fig. 6, shows another biodiversity linked enterprise is the legal trade in rare species, such as butterflies. The Amani Butterfly Project, for example, rears and sells over USD 60,000 worth of butterfly pupas annually, with 65% of profits going directly to local farmers in the East Usambara Mountains and another 7% going into financing development projects for villages involved in butterfly farming. This equates to an average 20% increase in household revenue for participating households (Morgan-Brown 2003, 2007).

Finally, biodiversity generates revenue through tourism. This is done in gazetted and demarcated

protected areas such as the ANR, where roughly USD 10,000 is generated annually through ecotourism. About 20% is shared equally among the 18 villages that surround the reserve, contributing an average of 9.6% of total annual household income (Shoo and Songorwa 2013). However, there are challenges with ensuring equitable distribution of revenue within the community. Tourism is also highly dependent on global and

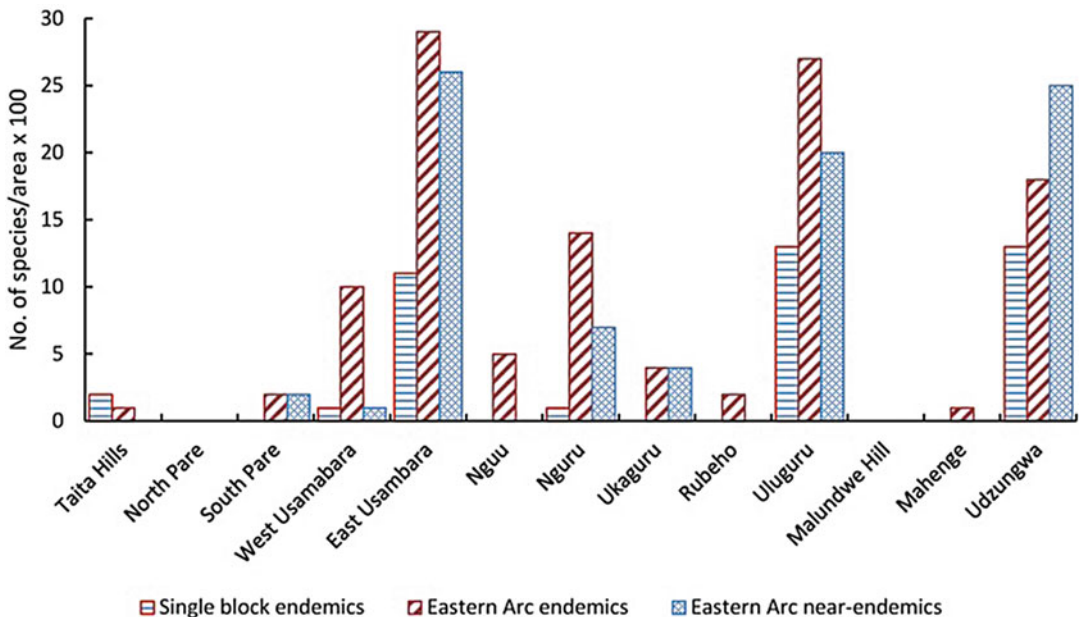
national political and economic events and other market volatilities (Fig. 7).

Endemism and Biodiversity in the East Usambara Mountains

The Eastern Arc Mountains are known for their high biodiversity and endemism rates. This is thought to be due to their age, relative climatic stability, geographic character as isolated forest “islands,” and their role in condensing moisture from the Indian Ocean (Hamilton and Bensted-Smith 1989). Many species have been separated from their closest relatives for long periods, leading to diversification and speciation. Additionally, the mountains provide refuge for species that were previously widespread but are now limited to these isolated patches of forest habitat. Together, these two factors contribute to the exceptional biodiversity and levels of endemism that characterize the Eastern Arc Mountains and have led to their comparison to the Galapagos Islands. This makes these mountain forests some of the most important for biodiversity conservation in Africa



The Source Waters of Tanga, Fig. 6 Unique butterflies of the Tanga watershed



The Source Waters of Tanga, Fig. 7 Endemic vertebrate species relative to the remaining forest area of the Eastern Arc Mountain blocs. (Adopted from A globally important ecoregion Burgess et al. 2007)

The Source Waters of Tanga, Table 1 Summary of biodiversity in the Amani Nature Reserve. This is not exhaustive but is indicative of the species present. (Source: Tropical Biology Association 2017)

Taxon	Total no. of species	% forest-dependent	Non-forest species	Endemic species	Near-endemic species	Forest-dependent endemics and near-endemics
Mammals	59	15.3	6	0	3	2
Birds	65	33.8	15	2	3	3
Reptiles	49	46.7	6	3	15	17
Amphibians	27	66.6	0	2	14	16
Butterflies	112	20.5	4	1	10	9
Trees and shrubs	639	43	22	19	49	53
Total	951	–	53	27	94	100

and the world (Burgess et al. 2007; Hamilton and Bensted-Smith 1989; Tropical Biology Association 2007) (Table 1).

The East Usambaras not only are exceptional in terms of biodiversity, endemism, and threatened species as part of the Eastern Arc Mountains but also stand out from the other Eastern Arc blocs on these measures (Figs. 7 and 8). This highlights the importance of the East Usambaras as a key target of biodiversity conservation at the local, national, and international levels. This importance has been recognized, leading to the designation of the forests of the East Usambara Mountains, among others:

- A global biodiversity hotspot
- An endemic bird area (ICBP 1992) and important bird area (BirdLife International, year 2001)
- A center of high plant diversity (WWF & IUCN, (1994))
- A globally important ecoregion (Worldwide Fund for Nature, 2019)
- Part of the UNESCO Man and the Biosphere Reserve network, 2000

Flora

Of global significance, the Eastern Arc Mountains have a 31% plant endemism rate (Senzota and Mbago 2009). This includes at least 800 vascular plant species, of which about 10% are trees, as well as 15 wild relatives of coffee and most species of African violet (*Saintpaulia*). An additional

32 species of bryophytes are also endemic (Burgess et al. 2007; Tropical Biology Association 2007).

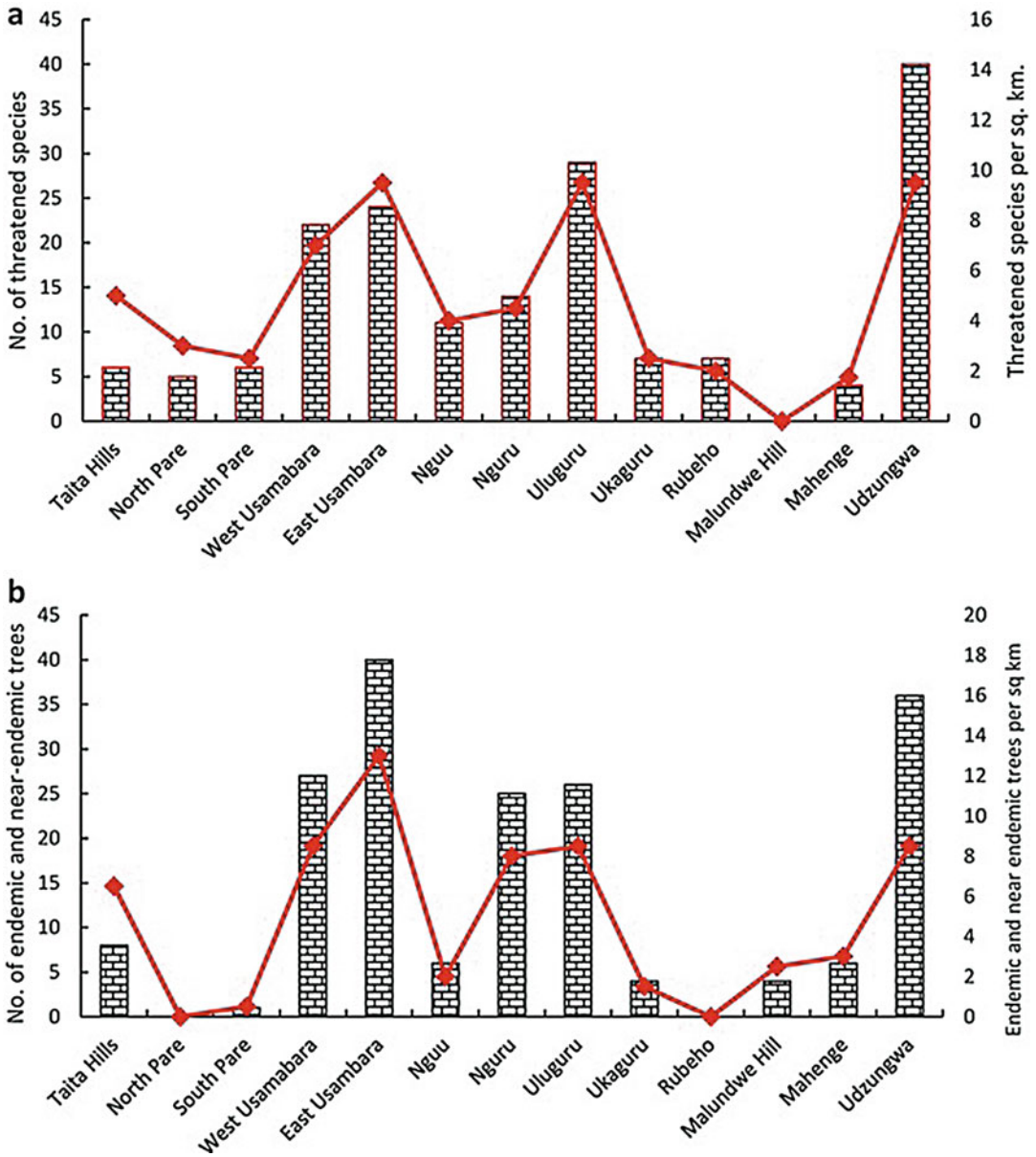
The East Usambaras alone boast 3,450 species of vascular plants (Tropical Biology Association 2007). Of these vascular plant species, approximately 27% depend on primary forest habitats, and of the primary-forest-dependent species, 36–50% are endemic or near-endemic, depending on the forest area examined (Johansson et al. 1998). The East Usambaras also hold the highest number of endemic and near-endemic tree species of all the Eastern Arc Mountain blocs (Burgess et al. 2007).

Vertebrate Fauna

Across the Eastern Arc Mountains, there are at least 96 endemic vertebrate species, including 10 mammal, 19 bird, 29 reptile, and 38 amphibian species. A further 71 vertebrate species are near-endemic (Burgess et al. 2007).

The Eastern Arc is also home to four endemic or near-endemic species of primates – the Sanje Mangabey (*Cercocebus sanjei*), Iringa red colobus (*Procolobus gordonorum*), the Mountain Galago (*Galagoides orinus*), and the Kipunji monkey (*Rungwecebus kipunji*), which is the only species of that genus (Burgess et al. 2007).

Conservation priority assessments have ranked the Eastern Arc Mountains as the second or third most important area in Africa for the conservation of restricted-range bird species. All 19 endemic bird species depend on forest

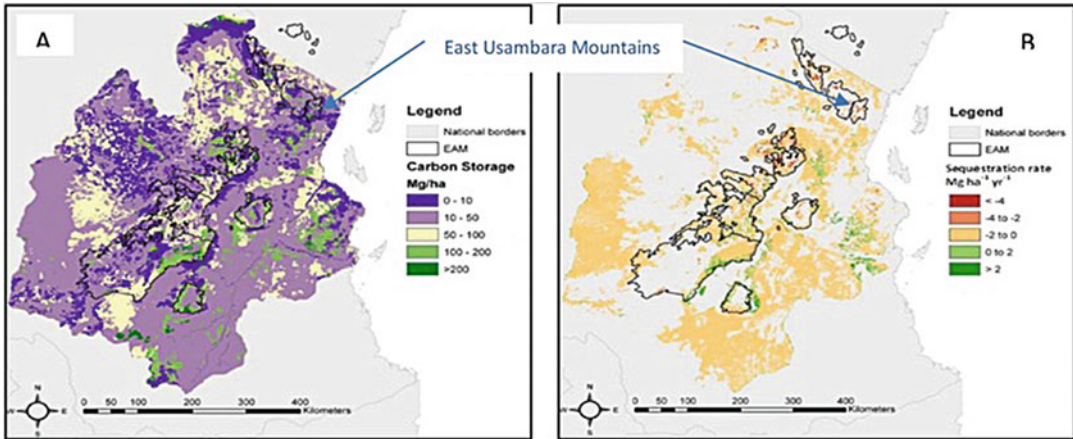


The Source Waters of Tanga, Fig. 8 (a) Threatened species trends across the Eastern Arc Mountains; (b) Endemic and near-endemic tree species trends across the Eastern Arc Mountains. (Adopted from Burgess et al. 2007)

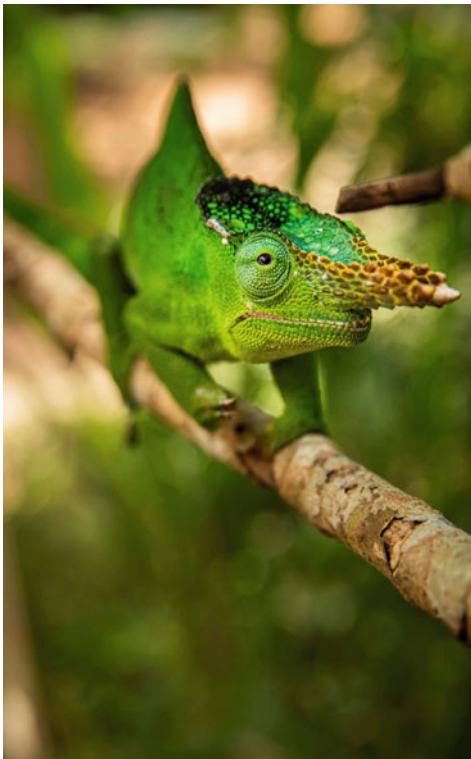
habitats, and at least seven of those species are limited to dense primary forest (Burgess et al. 1998, 2007). The East Usambara Mountains alone host 110 forest bird species (Tropical Biology Association 2007).

In the East Usambaras, there are 30 species of amphibians and reptiles that can be regarded as

dependent on the natural forests of the Usambaras. Of these, 15 are endemic. In the East Usambaras alone, there are seven endemic taxa: two microhylid frogs, one of which is placed in an endemic genus; a rare chameleon (*Chamaeleo spinosus*) such the one in Fig. 10; a very rare lizard (*Bedriagaia*



The Source Waters of Tanga, Fig. 9 Aboveground live carbon storage (a) and sequestration (b) for the Eastern Arc Mountains (Willcock et al. 2014)



The Source Waters of Tanga, Fig. 10 Rare chameleon species of Tanga watersheds. Photo by Roshni Lodhia

moreaui); and a colubrid snake (*Dipsadoboa wernerii*) (Hamilton and Bensted-Smith 1989).

Invertebrate Fauna

The few invertebrate groups that have been studied in the East Usambara Mountains show high rates of endemism, especially taxa with limited dispersal ability, such as millipedes (*Diplopoda*), of which 30 out of the 41 species around the ANR are believed to be endemic to the East Usambara Mountains. Of the terrestrial mollusks (*Gastropoda*), the East Usambaras have 55 endemic species (Tropical Biology Association 2007).

Even in groups that can disperse, the proportion of endemic species remains high. For example, 21% of the Sphecidae family of predatory wasps in the ANR is endemic. Likewise, of the 112 species of butterflies recorded in Amani, 2 species are probably endemic, and a further 9 are near-endemic. While 20% of all butterfly species recorded are forest-dependent, over 80% of endemic and near-endemic species are forest-dependent, further highlighting the importance of conservation of the forests of the Usambaras (Morgan-Brown 2007; Tropical Biology Association 2007).

The endemism of the Usambaras is not restricted to species; it also extends to functional traits and life histories. For example, the East Usambara tree-hole crab has adapted to living in the water-filled boles (tree holes) of various tree species at altitudes between 150 and 900 m above sea level (m.a.s.l.), with the *Myrianthus holstii* tree being the most common host (Bayliss 2002).

This uniqueness of traits is likely due to the isolated island-like biogeography, which provides opportunities for species to adapt to niches that would commonly be occupied by species from other taxa.

Aquatic Biodiversity: Fish and Macroinvertebrates

Four types of fish are common in the waters of the Zigi River. These are tilapia, sardines, carps, and catfish. 68 taxa of macroinvertebrates found in the river include worms, crabs, water mites, mayflies, dragon- and damselflies, bugs, caddis flies, beetles, snails, shrimps, and flies (MOWI 2016).

Threats to Biodiversity

The forests of the East Usambaras and upper Zigi catchment have experienced exploitative human use for at least 2,000 years, but until the last century, this pressure was sustainable. However,

human population expansion (influenced by economic opportunities such as employment in tea plantations, which require up to 4,000 people) is increasing the pressure on the remaining natural forest in the area (own observations, 2019; Tropical Biology Association 2007). Fig. 11 depicts land conversion due to demand for resources and food leads to significant clearance of forest areas for crops and housing, which has resulted in less than 30% of the original primary forest area remaining across the Eastern Arc Mountains (Burgess et al. 2007).

This habitat loss has affected the biodiversity of the region in myriad ways. The overall reduction of area of suitable habitat leads to smaller populations of any given species reliant on that habitat. Not only does this lead to a higher likelihood of extinction of that population (which, given the endemism rates of the area, may be the only population of a given species), but it reduces the genetic diversity, which limits a species' ability to adapt to shocks, including habitat loss, which may result in species extinction.



The Source Waters of Tanga, Fig. 11 Peasant farming in the Tanga watershed. Photo by John Esther

The second aspect of deforestation that negatively affects the biodiversity of the East Usambaras, with some estimates placing this as “the major threat to biological diversity,” is habitat fragmentation (Johansson et al. 1998). This is crucial in the East Usambaras, where the forest has been reduced to fragmented protected areas in a matrix of agricultural land, with only the Derema Forest Corridor linking Amani Nature Reserve to other forested areas (Tropical Biology Association 2007). This fragmentation limits the movement of pollinator and dispersal species, including birds and insects, resulting in lower fertilization and dispersal and thus lower recruitment in forest plant species, ultimately leading to population extinction (Cordeiro and Howe 2003).

Land-use change has other more subtle negative effects, such as degrading soil or water quality. For example, tea cultivation in catchment areas has been found to result in significantly lower dissolved oxygen in tributary streams. This is associated with reduced species richness of more than 25% relative to streams with forest dominated catchments (Van Biervliet et al. 2009).

Similarly, the unsustainable farming practices of many small-scale agriculturalists leads to leaching and reduced soil fertility, as well as reduced ground cover, leaving the soils exposed and prone to erosion. This reduces downstream water quality and biodiversity, as well as degrades the terrestrial ecosystems in the catchment (Bullock et al. 2013).

Since 2003, small-scale alluvial gold mining operations have also become a significant threat to biodiversity due to their degrading impacts on aquatic and wetland forest ecosystems. This activity involves the excavation of open pits in riverine and wetland forest areas like the one in Fig. 12 and results in water-saturated soils with high organic matter, low pH, and low microbial activity. Nutrient recycling, especially nitrogen and phosphorus, is also negatively affected, with carbon-to-nitrogen ratios significantly higher in undisturbed forests, suggesting greater carbon sequestration capacity (Kweyunga and Senzota 2007). This degradation of water quality, soils, and wetland forest habitat significantly affects the ability of vegetation to reestablish itself, threatens amphibian and



The Source Waters of Tanga, Fig. 12 Wetland trees nicknamed Mdhahabu [gold] thanks to its fibrous roots that trap alluvial gold for miners. Photo by Fred Kihara

invertebrate aquatic fauna dependent on these habitats, and creates water quality concerns for water users in the lower catchment areas (Rural Focus Ltd. 2020; Senzota and Mbago 2009).

A further significant threat to the biodiversity of the East Usambaras is introduced species, especially *Maesopsis eminii* (Rhamnaceae) which has naturalized and begun to dominate areas of otherwise virgin forest. This tree naturally occurs throughout central Africa, including western Tanzania, and was first introduced to the East Usambaras in 1913 (Sheil 1994; Tropical Biology Association 2007). Its introduction has resulted in reduced regeneration of primary forest trees, thinner leaf litter, increased soil erosion, decreased organic matter in the topsoil, and reduced diversity in the soil microfauna. It is generally recognized that the tree's spread threatens the endemic and near-endemic tree species of the East Usambaras' primary forests (Binggeli and Hamilton 1993; Hamilton and Bensted-Smith 1989).

The final, and perhaps most significant, long-term threat to biodiversity is climate change. Projected changes for Tanzania by 2050 include (USAID 2018):

- Increased average annual temperature of 1.4–2.3 °C
- Increased duration of heat waves (by 7–22 days) and dry spells (up to 7 days)
- Likely increase in average annual rainfall, with the greatest increase in the northeast
- Increased heavy rainfall event frequency (7–40%) and intensity (2–11%)
- Rise in sea levels of 16–42 cm
- Loss of Kilimanjaro glaciers

These effects cumulatively make Tanzania the 26th most vulnerable country to climate risks (USAID 2018). Studies on greenhouse gas (GHG) emissions show that the main contributing sectors are land-use change and forestry (87.33%), energy (6.39%), and agriculture (5.68%), with deforestation being the main contributing activity (Rural Focus Ltd. 2020).

These changes are expected to cause range shifts and ecosystem composition changes that

threaten biodiversity. This is particularly true in island-like mountain ecosystems such as the East Usambaras because the potential range for expansion is limited due to altitude. This means that whereas species could ordinarily shift their ranges to compensate for environmental changes due to climate change, in a mountain-restricted species, a shift up the mountain in response to global warming results in a reduction in range area, ultimately leading to extinction. Additionally, changes to rainfall patterns and other climatic variables can result in changes in species' phenology. This can lead to dissociation of predator and prey population booms, leading to crop pest plagues and disease outbreaks, as well as reduced recruitment to populations which exacerbates the likelihood of extinction for threatened and endemic species (Post et al. 2001).

Potential Conservation Interventions

Soil and Water Conservation

Researchers identified 114 km² of agricultural land with especially high sediment loss (>10 t/ha/yr). Most of that land has slopes greater than 15%. It is recommended that terracing and agroforestry be implemented in these areas to protect against soil erosion (which helps with soil fertility and soil physical properties) and to provide ground cover. This will be crucial to protecting fragile aquatic ecosystems that harbor endemic and threatened amphibian species, as well as plant species that depend on wetland forest habitats.

Agroforestry and Woodlots for Carbon Sequestration

The Tanga Water Fund targets agroforestry and woodlots establishment on 10% of the 10,182 ha of farmland with slopes >5% within the Zigi catchment and where terracing is not targeted. Woodlots release the pressure on primary forests for firewood and construction materials, thereby helping to conserve the remaining primary forest that most species endemic to the East Usambaras depend on. Planting the targeted one million trees as part of agroforestry across these areas, as well

as protecting soils from erosion, could create a sufficiently diverse habitat to provide dispersal corridors for birds and insects instrumental in pollination and the distribution of plant seeds. Agroforestry activities like the one shown in Fig. 13 are crucial for maintaining endemic and threatened species with small populations in a fragmented habitat matrix.

Riparian Conservation

Approximately 853 km and 269 km of river length within the Zigi and Mkulumuzi catchments, respectively, should be targeted for riparian conservation efforts. Tanzanian legislation stipulates that 5 m on either side of the river is not to be cultivated and a further 55 m is to remain under perennial cover. This implies that perennial crops such as fodder grass or spice trees are permitted within the riparian area. These practices are to be encouraged, as riparian conservation protects against soil erosion and leaching. This would thereby protect water quality, with ensuing biodiversity conservation implications, as outlined above. Additionally, continuous riparian habitats

are ideal for species dispersal, as they transect all parts of an area and provide a diverse habitat with water availability. Riparian habitat conservation is therefore critical to biodiversity.

Integrated Watershed Management Plans

Integrated watershed management plans aim to address issues within a smaller (5–15 km²) watersheds that are causing erosion or water pollution. These require a communal approach and provide an opportunity to carefully manage practices, such as mining, that damage unique habitats, including wetland forests. These plans would be integrated with catchment and subcatchment plans, as well as other conservation initiatives, and are important for formalizing and implementing the necessary measures for limiting ecologically damaging behavior in the East Usambaras.

Livelihood Support

Various options to support rural livelihoods are proposed to address poverty and the unsustainable use of resources. These include high-value enterprises such as poultry, beekeeping, milk



The Source Waters of Tanga, Fig. 13 Integration of clove trees in agroforestry farming system in the Tanga watershed. Photo by John Esther

production from stall-fed livestock, and more efficient use of fuelwood through the adoption of energy-saving stoves. These practices will relieve pressure on the primary forest for food and fuel, thereby protecting these habitats for the endemic and threatened species that are wholly dependent on them.

Marketing and Value Chain Support

It is recommended that tree crops – for example, cloves – be processed, stored, and marketed after harvesting. Targeting efforts to crops that integrate agroforestry practices encourages the cultivation of those that can contribute to soil and water conservation measures in the East Usambaras. Fig. 14 shows some of the ways to increase revenue for the farmers, helping them shift from their reliance on forest products such as firewood and thus further contributing to habitat conservation.

Rural Roads, Tracks, and Pathways

Training on manual road and footpath maintenance and drainage is proposed in order to help keep roads passable and protect against soil loss. These tracks are a dominant source of erosion and turbidity in the watercourses. Managing this problem will improve water quality, which is crucial

for amphibian, fish, and aquatic invertebrate species of the East Usambaras.

Conclusion

Fig. 15 depicts the forests of the East Usambaras host unique biodiversity, with multitudes of endemic, near-endemic, and threatened species from across the tree of life. Indeed, these forests have some of the highest levels of endemism not only in Africa but across the world. However, these ecosystems are under threat from various natural and anthropogenic factors, and currently have less than 30% of the original primary forest remaining. With a growing human population, resolving these challenges requires collaboration between local communities and governing and technical authorities. TWF is one such initiative, and the interventions proposed here have the potential to expand biodiversity conservation in the East Usambara Mountains. The TWF stands as the first line of defense and helps foster the survival of forest-, wetland-, and river-dependent taxa.



The Source Waters of Tanga, Fig. 14 Spreading fresh clove spices to dry. Photo by Roshni Lodhia

Part 3. Carbon Sequestration and High Climate Impacts of Conserving the East Usambara Mountains, Tanga

Introduction

Approximately 45,137 ha of the East Usambara Mountains remain as a natural forest, with 30.6% classified as submontane rainforest and 63% as lowland forest. These amounts vary by altitude, with submontane forest generally occurring above 850 m and low-altitude forest extending to the coastal plains. This composition is similar to other East African coastal forests (Hamilton and Bensted-Smith 1989).

The soils of the East Usambaras are predominantly clay and clay loams between 1 and 5 m in depth. Generally red and well-drained, most soils at higher altitudes exhibit an acidic and leached condition. Soil conditions under primary forest cover are better (Kashindye et al. 2018).



The Source Waters of Tanga, Fig. 15 If tree and tree can live in harmony so can man and nature. By Roshni Lodhia

The potential for carbon sequestration and storage in the East Usambaras is significant, but mechanisms for quantifying and harnessing this to access global carbon markets are not in place. This would impact climate change mitigation, as well as improve local livelihoods, generate revenue, and conserve nature.

The Zigi watershed is dominated by forest, both natural primary forest and commercial teak and eucalyptus plantations. This is complemented by commercial agroforestry, primarily cardamom, cloves, and cinnamon, with an understory of black pepper and table sugarcane. Extensive tea plantations and small-scale subsistence agriculture are also prevalent, and, together, agriculture accounts for 69% of economic activities in the Zigi River catchment area (Rural Focus Ltd. 2020). These activities have devastated forests. Currently, only 18,589 ha of undisturbed primary forest remains (see Fig. 1).

Carbon: Natural Compound and Valuable Commodity

Climate Change

Climate change has become one of the leading concerns of the twenty-first century, with global warming, sea level rise, and increased variability and extremity in weather patterns all predicted as a result of anthropogenic activities since the industrial revolution. These changes are largely attributed to the release of CO₂ and other GHGs into the atmosphere. Activities contributing to this include the global transportation, agriculture, and energy sectors, as well as deforestation and forest degradation. Deforestation and forest degradation account for approximately 11% of global carbon emissions – more than the entire global transportation sector and second only to the energy sector (UNEP 2020). This makes deforestation the second leading cause of global warming (Forest Carbon Partnership Facility 2020), with tropical deforestation estimated to contribute 7–14% of global carbon dioxide emissions (Green et al. 2013).

Potential Solution: Conserving Nature, Generating Carbon Credits

With deforestation contributing so significantly to the climate change problem, afforestation and forest conservation efforts are an adaptable, effective, and cost-efficient solution that can provide up to a third of the mitigation required to keep global warming well below 2 °C; the benchmark set in 2015 (UNREDD 2020; UNFCCC 2015). To achieve this, it was recognized that creating mechanisms that provide financial incentives for afforestation and forest conservation initiatives were needed. To this end, carbon credits were formalized as a standardized means of measuring and valuing the contribution of natural habitats and areas to climate change mitigation in terms of “carbon stocks” comprising of carbon removed from the atmosphere by planted trees like in Fig. 16 (carbon sequestration) and stored (carbon storage). Trading in carbon credits allows revenue to be generated for



The Source Waters of Tanga, Fig. 16 Growing black pepper spices as climbers on planted trees. Photo by Roshni Lodhia

the conservation of natural habitats and ecosystems that sequester carbon from the atmosphere, as well as providing states, companies, and businesses an opportunity to mitigate the carbon footprint of their activities.

The international market for carbon credits has been developed through initiatives such as REDD + (reducing emissions from deforestation and forest degradation). This “creates a financial value for the carbon stored in forests by offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. Developing countries would receive results-based payments for results-based actions. REDD+ goes beyond simply deforestation and forest degradation and includes the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks” (UNREDD 2020). Fig. 17 shows tea planted at the edge of a natural forest serving as a permanent protective buffer and deterrent to encroachment.

There are many nuances and challenges in creating a globally recognized standard for calculating the carbon stocks of a given habitat or ecosystem and then converting these stocks to tradable carbon credits. Furthermore, ensuring that the sale of carbon credits is effectively reinvested in the people, institutions, and projects working to conserve and regenerate natural forest habitats for carbon sequestration and storage remains complicated. However, through systems such as REDD+ – reducing emissions from deforestation and forest degradation in developing countries and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries – these challenges have been addressed. Carbon credits are now a viable opportunity for funding conservation and climate change mitigation activities.

Saving Carbon in the East Usambara Mountains

Vegetation

Human population expansion (influenced by economic opportunities such as employment on tea



The Source Waters of Tanga, Fig. 17 Tea growing at the edge of the cloud forest in Tanga watershed. Photo by Roshni Lodhia

plantations, which can require up to 4,000 people) is increasing pressure on the remaining natural forest in the area (Tropical Biology Association 2007). Higher demand for resources and food leads to forests being cleared to make way for crops and housing. Alternative revenue-generating activities such as alluvial mining for gold and other gemstones along rivers have further exacerbated the destruction of trees and wetland ecosystems in the last decade.

The rate of forest loss varies by forest type, with closed to nearly closed-canopy deciduous vegetation, known as “miombo woodlands,” experiencing the greatest recent decline: approximately 43% between 1975 and 2000. This was partly due to this habitat existing mainly outside the network of protected areas across the Eastern Arc Mountains, which are dominated by primary closed-canopy forest as shown on Fig. 18 (Green et al. 2013).

Estimates of the carbon stocks (both vegetative and pedological) for each mountain block in the Eastern Arc Mountains are presented in Table 2, with estimated total carbon storage for the entire

watershed of the Eastern Arc Mountains at 1.3 Mton C (1.3×10^6 tons C).

Figure 20, below, spatially represents the carbon storage and sequestration across the Eastern Arc Mountains watershed.

Carbon storage and sequestration capacity also vary by habitat type. These estimates are given in Table 3:

Soil

The organic matter in healthy soils contains carbon, which is stored in the soil and referred to as soil organic carbon (SOC). SOC is crucial to the global carbon cycle, with soils representing the world’s largest terrestrial carbon stock. Tropical forests are estimated to account for about 32% of the SOC stored in the world’s soils (Kirsten et al. 2016).

Carbon stocks in the soil are dynamic, capable of long-term persistence or loss through various processes. These processes include release as CO_2 or CH_4 back into the atmosphere, loss in eroded soil material, or dissolution of organic carbon washed into rivers and oceans (FAO 2017).



The Source Waters of Tanga, Fig. 18 Tanga water fund protects millions of tons of carbon stocks from destruction. By Roshni Lodhia

According to data extrapolated from Amani Nature Reserve, in the East Usambaras, SOC stocks down to 1 m depth were 16.9–22.4 kg C m⁻² (mean 19.7 kg C m⁻²) (Kirsten et al. 2016), though some conversion of forest habitat to agricultural land use results in the depletion of SOC stock by 20–50% (Lal 2004, 2005). However, the SOC stock in secondary forest has also been found comparable to that in primary forest soils (20.2 kg C m⁻²) (Kirsten et al. 2016). A time-series analysis of forest cover done in 2020 distinguishes undisturbed from disturbed forest but does not distinguish agricultural and secondary forest within the disturbed forest areas. Therefore, using the areal degradation since 1986 shown in Fig. 1 and a 35% observed cover depletion rate for disturbed land, the net SOC stock of the East Usambaras is 8.5 million tons C, as shown in Table 4:

The SOC stock estimate for secondary forest (20.2 kg C m⁻²) given above makes the case for plantation and agroforestry as appealing options for carbon stocks and for generating credits in ways that also provide livelihood opportunities for local community members.

The estimates of SOC stock above are fixed time measurements and do not give any indication of SOC sequestration or accumulation over time. Some estimates suggest the rate of SOC sequestration in tropical forest soils is 0.1–1 ton C ha⁻¹ yr.⁻¹ (Lal 2004). Again, using area estimates given in Fig. 1, with no discounting for disturbed land and a midpoint estimate of 0.55 t C ha⁻¹ yr.⁻¹, this would equate to carbon sequestration for the East Usambaras amounting to 31,150 t C yr.⁻¹.

Financial Analysis

The price of carbon credits constantly fluctuates on the international market, and there are myriad variables that are considered in their valuation. Generally, carbon quantity estimates are first converted to CO₂ equivalents (CO₂e) (This is achieved by multiplying by 44/12 due to the molecular weight ratio of CO₂ to carbon.). Even then, the value of carbon credits varies widely depending on the nature of the project and the standard used (Gold Standard 2020). Some national price estimates are given in Table 5. For the Tanga Water Fund, the average

The Source Waters of Tanga, Table 2 Carbon storage and sequestration estimates for the individual mountain blocks of the Eastern Arc Mountains. (Adapted from Willcock et al. 2014)

Eastern Arc Mountain Bloc	Area (km ²)	Aboveground live carbon storage (million tons)	Mean carbon sequestration (t/ha/yr)
North Pare	510	1.93	2.6
South Pare	2,327	8.96	2.41
West Usambara	2,945	13.52	3.64
East Usambara	1,145	5.91	2.79
Nguu	1,562	9.34	1.89
Nguru	2,565	15.11	1.79
Ukaguru	3,243	13.39	1.42
Uluguru	3,057	15.92	1.35
Rubeho	7,984	36.84	1.06
Malundwe	33	0.29	1.8
Udzungwa	22,788	101.73	1.01
Mahenge	2,606	23.58	0.19
Total	50,765	246.52	21.95

The Source Waters of Tanga, Table 3 Mean carbon storage and sequestration by land cover type (Willcock et al. 2014)

Land cover category	Carbon storage (t/ha)	Range	Carbon sequestration (t/ha/yr)	Range
Lowland forest (<1,000 m)	182	152–360	–0.91	–7.08–4.29
Submontane forest (1,000–1,500 m)	189	95–588	–2.02	–11.06–1.29
Montane forest (1,500–2,000 m)	130	62–702	–2.03	–11.85–1.07
Upper-montane forest (>2,000 m)	166	69–533	–2.08	–10.49–1.23
Forest mosaic	121	55–485	–1.18	–6.69–2.92
Closed woodland	100	70–331	–1.24	–7.91–2.63
Open woodland	51	38–165	–1.49	–7.53–2.05

The Source Waters of Tanga, Table 4 Soil organic carbon estimate for the East Usambaras based on a per-area estimate from Lal (2004) and areas from Fig. 1, using a 35% depletion rate for disturbed forest soils

Type	Area (ha)	Estimate (t C/ha)	Discount factor (%)	Discounted Estimate (t C /ha)	Total (t C)
Undisturbed	18,589	197	100	197	3,662,033
Disturbed	38,047	197	65	128	4,871,918
Total	56,636				8,533,951

estimate of USD 11.4 per tCO₂e will be used (Fig. 19).

The valuation of the carbon stock in the East Usambaras is given in Table 6, and the per annum valuation of the carbon sequestration in the East Usambaras is given in Table 7.

The calculations in Tables 6 and 7 suggest the East Usambara carbon stocks are worth over USD 324 million, while the sequestration potential is worth a further USD 1.3 million per year. To realize this financial asset, elaborate valuation and verification by accreditation schemes are required. The final value will be arrived at based

on the verification method used and may vary slightly in final quantities. However, this estimate makes a strong case for implementing TWF as a beneficial climate mitigation project. Figure 22 below shows forest cover trends over a 35-year span. This shows the effectiveness of conservation interventions in reducing forest degradation and improving forest cover.

The Source Waters of Tanga, Table 5 Price of carbon per unit ton of CO₂ for selected countries (Kossov et al. 2014; CDP 2013; Environmental and Energy Study Institute 2012)

Country	Price (USD tCO ₂ e ⁻¹)
Australia	21.1
Canada, British Columbia	29.1
European Union	5.9
India	0.9
Japan	2.9
South Africa	12.2
The United Kingdom	7.6
Average	11.4

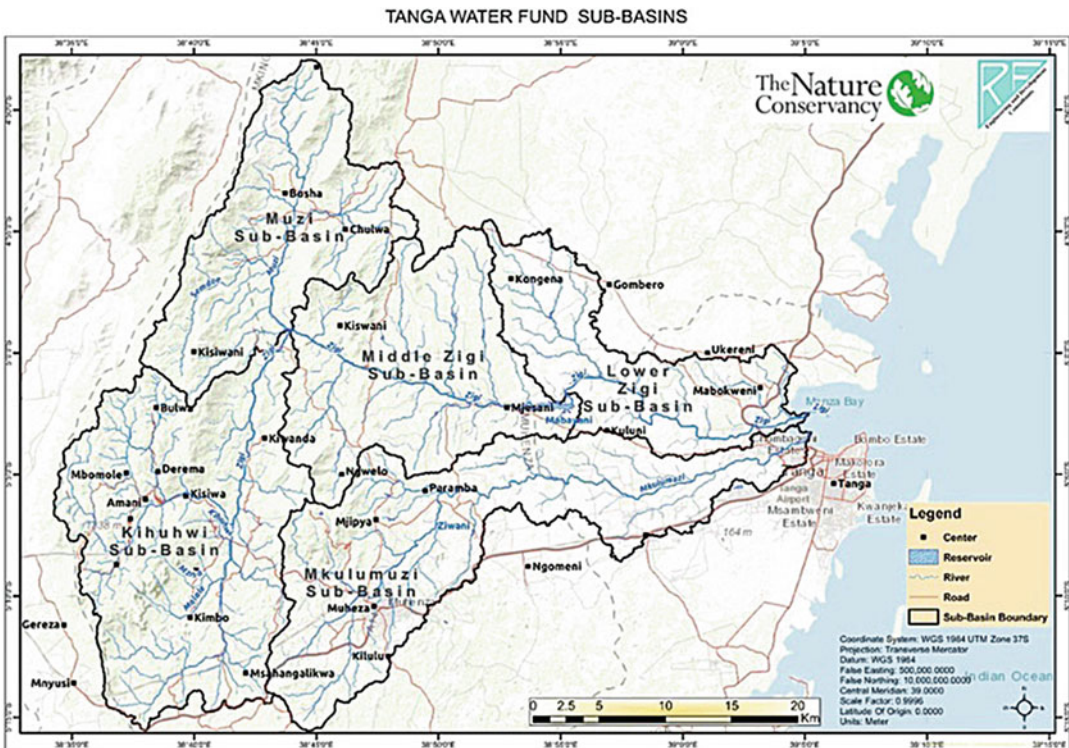
Enhancing Carbon Sequestration through Sustainable Land Management

Soil and Water Conservation

Of the 114 km² of agricultural land with especially high sediment loss (>10 t ha⁻¹ yr.⁻¹) identified, most have slopes greater than 15%. It was recommended that terracing and agroforestry be implemented in these areas to protect against soil erosion and to provide ground cover. This will result in improved soil properties, including nutrient cycling. This will conserve and increase the carbon sequestration and storage capacity of the soil, as well as protect against carbon loss through erosion.

Agroforestry and Woodlots for Carbon Sequestration

Tanzania is renowned for its participatory forest management efforts. It is proposed that agroforestry and woodlots be targeted on 10% of the 10,182 ha of farmland with slopes of >5% within



The Source Waters of Tanga, Fig. 19 Subbasins of the Tanga watershed

The Source Waters of Tanga, Table 6 Calculations of the estimated financial value of carbon stocks in the target areas of the Tanga Water Fund

Area	Altitude (m.a.s.l.)	Forested area (ha)	Aboveground carbon per unit area (t/ha)	Soil carbon per unit area (t/ha)	Combined total (t)		CO2 Equivalent (t CO2e)	Value (USD)	
Stage 1 – Kihuhwi	<1,000	25,161	182	197	9,536,106	11,484,704	34,965,722	398,609,236	480,060,617
					1,948,598	7,144,858	81,451,381		
Stage 2 – Zigi	<1,000	34,983	182	197	13,258,663	13,753,934	48,615,096	554,212,100	574,914,445
					495,271	1,815,995	20,702,346		
Stage 3 – Mkulumadzi	<1,000	8,480	182	197	3,214,019	3,214,019	11,784,737	134,345,999	134,345,999
					–	–	–	–	
Total		74,956				28,452,657		104,326,409	324,360,289

The Source Waters of Tanga, Table 7 Calculations of the estimated financial value of the annual carbon sequestration in the target areas of the Tanga Water Fund

Area	Altitude (m.a.s.l.)	Forested area (ha)	Aboveground carbon sequestration per unit area (t/ha/yr)	Soil carbon sequestration per unit area (t/ha/yr)	Combined Total (t/yr)		CO ₂ Equivalent (t CO ₂ e/yr)	Value (USD/yr)
Stage 1 – Kihuhwi	<1,000 1,000–1,500	25,161 5,048	0.91 –2.02	–0.55 –0.55	–36,735 –12,974	–49,709	–134,696 –47,571	418,784 147,902
Stage 2 – Zigi	<1,000 1,000–1,500	34,983 1,283	–0.91 –2.02	–0.55 –0.55	–51,076 –3,298	–54,373	–187,277 –12,091	582,262 37,592
Stage 3 – Mkulumadzi	<1,000 1,000–1,500	8,480 –	–0.91 –2.02	–0.55 –0.55	–12,381 –	–12,381	–45,398 –	141,145 –
Total		74,956				–116,464	–427,033	1,327,684



The Source Waters of Tanga, Fig. 20 Teak [*Tectona Grandis*] seedlings nurseries in the Tanga watershed. Photo by John Esther

the Zigi catchment and where terracing is not targeted. Woodlots can lessen the pressure on primary forest for firewood and construction materials, thereby helping to conserve the remaining primary forest. Implementing agroforestry across these areas, as well as protecting soils from erosion, can contribute to climate change mitigation by improving carbon sequestration and storage.

These agroforestry schemes will likely take the form of teak (*Tectona grandis*) plantations as shown on Fig. 20, which have been a highly successful commercial endeavor in many parts of Tanzania, including the East Usambaras (Bekker et al. 2004; Rance and Monteuuis 2004). Other agroforestry approaches with potential for success include growing sugarcane and cultivating spice tree crops, such as cardamom and cloves, with an understory of black pepper. These crops protect soil structures and create a mixed forest habitat with carbon sequestration and storage capacity. They have strong local and international market value, offering additional financial benefits. In the case of teak in the Tanga

watershed, which drains the East Usambaras, the proposed agroforestry interventions are estimated to be worth about USD 3,170 ha⁻¹ yr.⁻¹ (Rural Focus Ltd. 2020). This equates to a total of USD 48,415,410 once the interventions have been carried out over the full area for 15 years, or approximately USD 3.2 million yr.⁻¹.

The Tanzania Forest Conservation Group has successfully piloted REDD+ projects in the Tanzania districts of Kilosa and Lindi. A similar project could be extended to the Zigi catchment, providing an opportunity for additional benefits to the communities tasked with implementation and maintenance (Tanzania Forest Conservation Group 2020).

Complementary Activities

1. *Riparian protection*: 853 km of the Zigi River's riparian area will be conserved over the first 10 years, with another 269 km along the Mkulumuzi River planned to be done by the 15th year. The targeted area, which will consist mainly of cut-and-carry pasture and agroforestry, covers the 5 m from the riverbank that,



The Source Waters of Tanga, Fig. 21 Fish farming is a major source of proteins for the community in the zigi river watershed. Photo by John Esther

by Tanzania state law, cannot be cultivated, and an additional 55 m buffer either side of the river that must be under perennial. This will result in increased carbon stocks and sequestration along the length of these rivers.

2. *Livelihood support activities:* As part of the conservation interventions, additional pasture will be established on the farmlands. Further, cookstoves, which require less biomass for household energy needs, will be adopted as well as fish farming as shown in Fig. 21. These changes should coincide with the anticipated rise in livestock numbers (which provide household protein in the form of milk and meat and revenue from the sale of these products) to ensure that any additional GHG emission from the livestock is offset by the interventions.
3. *Marketing of farm produce and increased motorized activities:* Increased crop production related to population growth in the catchment areas is likely to result in marginally increased carbon emissions from produce transportation, mechanized processing, and farm operations.

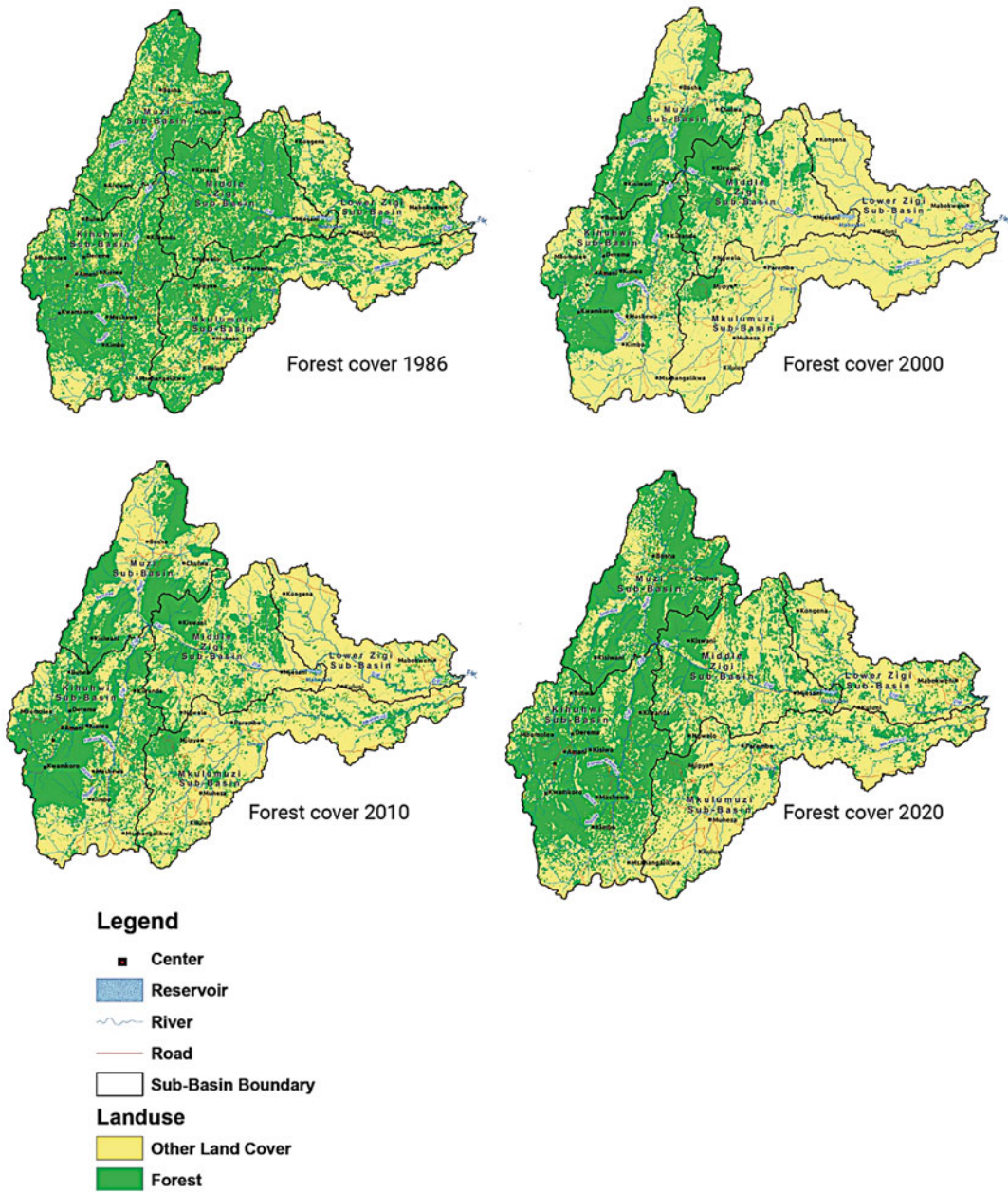
These emissions, though marginal, should be easily offset by the anticipated sequestration gains generated by the proposed interventions.

4. *Rural roads, tracks, and pathway development:* Where possible it is recommended that manual road maintenance, drainage, and foot-path maintenance be adopted to keep them passable and to protect against soil loss. Currently, the tracks are a prominent source of erosion and degradation of soil carbon stocks. The reduction of these processes will offset additional carbon from increased traffic.

Conclusion

The ecosystems of the East Usambaras are highly valuable for biodiversity and ecosystem services, including storing large stocks of aboveground soil carbon, as well as sequestering significant amounts of carbon from the atmosphere.

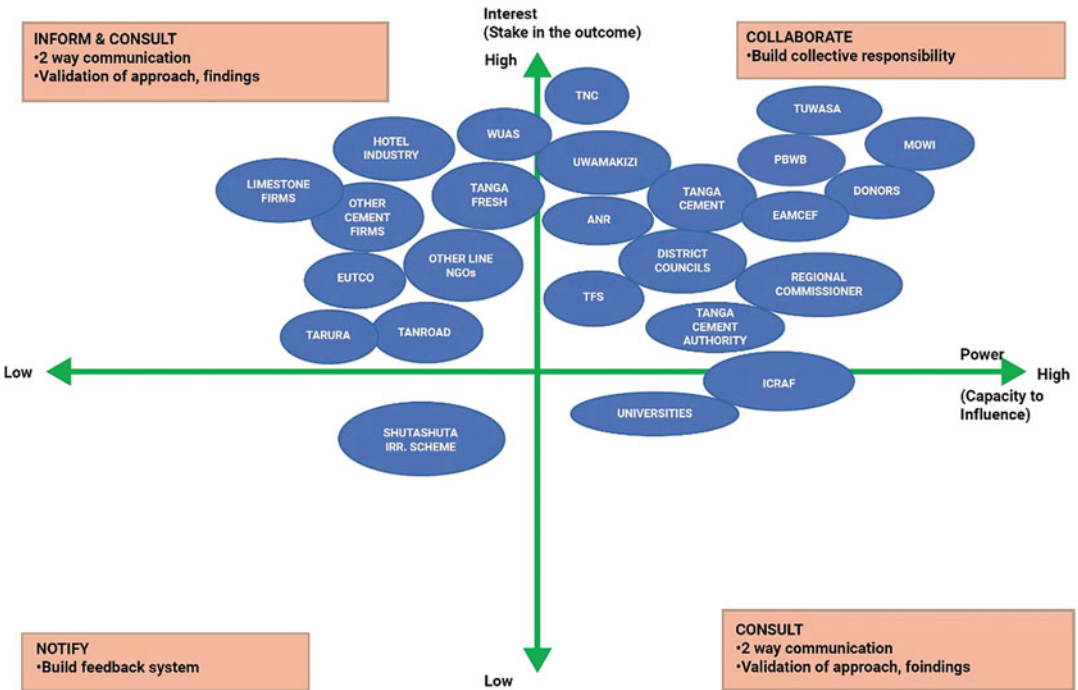
The Tanga Water Fund and its collaborating institutions should document and claim credit for the value of (i) carbon stocks being safeguarded



The Source Waters of Tanga, Fig. 22 Forest cover changes in the Tanga watershed between 1986 and 2020. Own analysis. Source: Landsat imagery

by the project, (ii) the mitigation of carbon stock degradation resulting from activities of the project, and (iii) the increase in carbon stocks and sequestration capacity resulting from investments made by the fund.

The carbon value in the East Usambaras is estimated at over USD 324 million, plus an estimated per annum value of USD 1.3 million for carbon sequestration. There is a strong case for offering some of the CO₂ equivalent credits



MAPPING OF STAKEHOLDERS AND THEIR LEVEL OF INFLUENCE TO THE TANGA WATER FUND

The Source Waters of Tanga, Fig. 23 Participatory mapping of stakeholders in the Tanga Water Fund (RFL 2020)

associated with the Zigi River watershed to TWF investors for their offset schemes or for directly trading the credits on the international carbon market to financially support the fund.

and ability to collaborate is critical to the water fund’s success.

The Tanga Water Fund feasibility study identified the following key stakeholder categories:

Part 4. Robust Governance and Stakeholders Engagement in Establishing a Lasting Water Fund in Tanga

The water fund model draws on the global payment for ecosystem services (PES) concept, in which downstream water users pay upstream watershed keepers to implement conservation activities that promote water security for the downstream users. Additionally, the water fund model incorporates a strong governance mechanism and is strengthened by the collaboration of both public and private sector stakeholders in its operation, financing, and governance. Thus, the engagement of stakeholders and their willingness

- (a) **Water Service Providers in Tanga City and Its Environs** – Tanga UWASA
- (b) **Major Water Users** – Tea plantations, sisal plantations, lime and cement manufacturers, Tanga fresh dairy processors, Tanga Port Authority, and hotels
- (c) **Catchment Managers and Users** – Pangani Basin Water Board; district councils of Korogwe, Mkinga, and Muheza; UWAMAKIZI; and Zigi Water Users Association
- (d) **Transport Infrastructure Developers** – Tanzania National Roads Agency, Tanga Port Authority, East African Crude Oil Pipeline and Tanzania Rural Roads Authority
- (e) **Regulatory Agencies** – Energy and Water Utilities Regulatory Authority

- (f) **Agencies Responsible for Protected Areas** – ANR
- (g) **Conservation Entities in the Catchment Areas** – Tanzania Forest Conservation Group, International Union for Conservation of Nature (IUCN), TNC, Worldwide Fund for Nature, CARE Tanzania, ONGAWA, and Eastern Arc Mountains Conservation Endowment Fund (EAMCEF)
- (h) **Public Funding Agencies** – United Nations Development Programme, Global Environment Facility, (Ministry of Water (MoW), USAID- RTI and GIZ
- (i) **Research Institutions** – World Agroforestry and Tanzania Agricultural Research Institute

An analysis conducted in 2020 on how these stakeholders ranked in terms of interest and influence to the water fund found that the stakeholder landscape is complex, with institutions having different mandates and interests (Fig. 8). This is to be expected, as integrated water resource management cuts across many sectors. TWF aims to work with catchment users and managers, as well as water consumers, and to engage interested private sector leaders.

The water fund will establish appropriate structures to allow for district-level coordination, as there are development programs and relevant mandates across numerous institutions. The private sector's role within TWF is a critical ingredient to the fund's sustainability in regard to local funding, engagement, and governance. The private sector will also ensure financial efficiency and implementation accountability. In this regard, TWF will need to strengthen collaboration between public, private, and civil society sectors within the fund.

A review of past development projects within the Zigi watershed and East Usambara Mountain areas indicates that future initiatives such as the Tanga Water Fund will need to incorporate the following aspects into its stakeholder engagement strategy:

- Full support by the national government and national government agencies (e.g., Ministry

of Water and Irrigation, the Pangani Basin Water Board, Tanzania Forestry Service)

- Strong and close links to regional and local government administrative and technical departments (Muheza, Tanga, Korogwe, and Mkinga districts)
- Provision of a structure that represents private sector interests and operates on principles of financial efficiency and performance accountability
- Engagement with other stakeholders for effective collaboration, governance, and implementation

Fig. 24 shows stakeholder participation and commitment, TWF must present a strong business case. This can be accomplished by ensuring that potential stakeholders understand the value that can be accrued from their investment. As explained in the previous sections, the interventions to be implemented through TWF could generate numerous environmental and financial benefits to the various stakeholders. The feasibility study commissioned by TNC concluded that from a total investment of USD 17.8 million in sustainable land management interventions, stakeholders in the Zigi and Mkulumuzi watersheds can accrue annual net benefits amounting to USD 11.2 million from the 15th year. The financial analysis of carbon potential in the watershed estimates a value of carbon stocks and sequestration potential for the targeted areas of USD 324.4 million and USD 1.3 million, respectively.

However, given that the scale of the proposed interventions is resource-intensive and to maximize on available resources, a progressive three-phase approach is proposed based on the level of risk identified and urgency for intervention.

Phase One would implement activities in the Kihuhwi River – the southern tributary of the Zigi River – and the area up to the confluence with the Muzi tributary from the north. That subbasin is 383.5 km². The area is largely covered by steeply sloping land with higher sediment yields than the other subbasins. In addition, it has extensive on-the-ground coverage by community-based



The Source Waters of Tanga, Fig. 24 Consulting Zigi river watershed communities on their conservation priorities. Photo by John Esther

operation UWAMAKIZI, a collaborator that can mobilize the implementation of proposed activities.

Phase Two covers the Muzi tributary and the mid-Zigi subbasin up to the Mabayani Dam and down to the delta, covering 1,088 km². The additional area of Muzi and the middle catchment will require the establishment and capacity development of local partners to help implement activities. The nongovernmental association ONGAWA has had experience working in this area, as has the Eastern Arc Mountains Conservation Endowment Fund (EAMCEF).

Phase Three adds Mkulumuzi River to the other two, increasing the area to 1,432 km². The Mkulumuzi area will benefit from a growing interest in the soon expanded Tanga port. The port suffers sediment deposition, which requires periodic desilting. As with Phase Two, Phase Three will require the establishment and capacity development of local partners to help implement activities. Phase Three is expected to be implemented after 10 years of work on the other two phases.

Successful execution of this strategy will require adequate financing, proper organization and management, and stakeholders' collaboration and participation. The EAMCEF and TNC, the leading organizations, share a common vision and baseline resources to steer the initial development of the Tanga Water Fund, as well as to coordinate stakeholder engagement and build on Tanga Urban Water Supply and Sanitation Authority's (UWASA) catchment conservation efforts. Two options for the water fund's establishment emerge: (1) embedding the TWF within EAMCEF and operating it as a project within EAMCEF with technical and fundraising support from TNC and peers and (2) registering TWF as a separate autonomous trust with an office in Tanga City. Regarding the first option, TNC needs to have further discussions with EAMCEF to chart the way forward and determine the TWF's governance structure.

An independent TWF would benefit from a three-tier governance structure in which (1) a board of trustees (BOT) draws in strategic government, private sector, and funding partners;

(2) a board of management (BOM) provides technical and management oversight and ensures coordination across different agencies and districts; and (3) a management unit provides implementation capacity.

Management unit functions can be outsourced to an organization with an established office, capacity, or relevant experience that can be scaled up appropriately for the TWF. TNC and EAMCEF, and to some extent Tanga UWASA, have broad organizational capability to guide TWF's establishment. In due course and with sufficient capacity, TWF could attain more autonomy. TWF would require a lean administrative and technical staff that could draw technical capacity from the district departments.

Setting up and operating costs are estimated as:

- USD 96,000 (transport, furniture, equipment)
- USD 150,000 for the monitoring system (water quality and river flow monitoring equipment)
- USD 500,000 annual operational and maintenance costs, inclusive of a 20% communication, monitoring and evaluation budget

Long-term funding options may be explored as the water fund progresses. The public sector could co-fund the proposed interventions by aligning budgets and making funding commitments to achieve the identified outputs. This lessens the reliance on public funding beyond requiring commitments to co-fund specific activities.

One promising funding option is a catchment conservation levy applied to the Tanga UWASA water tariff. This method would leverage Tanga UWASA's good standing and existing revenue collection systems to target large consumers and industrial/commercial customers that have indicated their willingness to support a TWF. This could provide a transparent source of predictable funds earmarked for the TWF. A maximum of 5% levy could generate approximately USD 27,000 annually. To grow this revenue, the water utility would need to expand its service base and demand.

Grants and donations from development partners or commercial enterprises are recommended

particularly for the initial stage. This requires strong cooperation and commitments from local private and public sector institutions to exhort external partners to invest or provide other leverage. Developing funding proposals requires continuous effort and outreach to potential donors. The MoW can play a significant role in securing high-level, national commitments to partner with development partners. Fig. 25 shows a clear case why these investments are important for people.

As discussed previously, carbon markets are another option for long-term financing. Finally, loans and endowment and blended finance could also be considered.

Conclusions

The Tanga Water Fund can deliver a numerous benefits beyond its main objective of improved water security. Through the water fund, biodiversity preservation, climate change mitigation, and improved livelihoods could also be achieved.

There exists a healthy mix of stakeholders with the capacity to accomplish the water fund's objectives. The Tanga Water Fund will continuously structure its engagement with the different stakeholders to leverage their respective interests while ensuring appropriate role and levels of involvement in the fund's decisions and activities.

The Tanga Water Fund will maintain a sound, transparent, and accountable governance and implementation structure that well represents stakeholders' interests and capitalizes on their strengths and capacities. Options for this include (1) embedding the TWF within EAMCEF with technical support from TNC, and (2) registering TWF as a separate autonomous trust in the long run.

Implementation of the water fund's activities will be best done through a phased approach. The priority being the Kihuhwi subcatchment, the area at highest risk. A phased approach will provide more realistic resource mobilization and help concentrate efforts to result in visible, tangible impacts, to the benefit of stakeholders.

The Tanga Water Fund may adopt a blended structure for resource mobilization and funding



The Source Waters of Tanga, Fig. 25 As Tanga city grows so does the clean water demand. Photo by Roshni Lodhia

that may incorporate catchment conservation levies, grants and donations, loans, endowment funds, and carbon offsets markets. While local enthusiasm is high, the reality is that with a small urban economy, the domestic contributions initially are likely to be low and insufficient to finance upscaling the project. Tanzania leadership has seen significant changes and so does external donor relationships. This may need careful navigation to identify sufficient donors or corporations willing to fully finance this public-focused work and outcomes.

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