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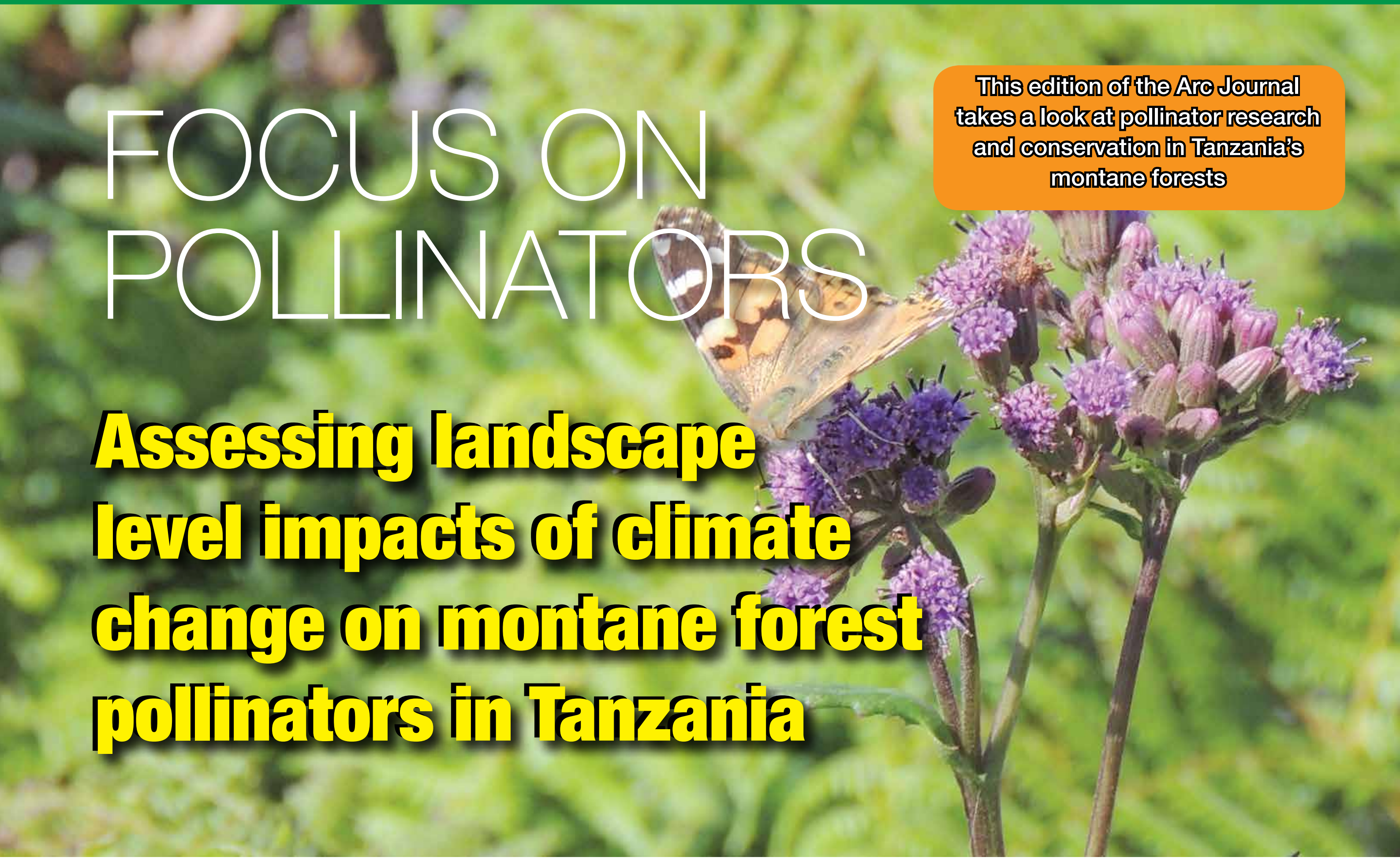


This edition of the Arc Journal takes a look at pollinator research and conservation in Tanzania's montane forests

FOCUS ON POLLINATORS

Assessing landscape level impacts of climate change on montane forest pollinators in Tanzania

Devolent Mtui *(Tanzania Wildlife Research Institute, Arusha)* and William Newmark *(Natural History Museum of Utah, USA)*

Birds and butterflies are two of the more important flower-pollinating taxa in montane forests in Africa. However, little is known of the impact of climate on pollinators in Africa. In August 2018, the Tanzania Wildlife Research Institute received a three-year grant from the JRS Biodiversity Foundation to assess landscape level impacts of climate on montane forest pollinators. Institutional collaborators included: Amani Friends of Nature; University of Dar es Salaam; Tanzania Commission for Science and Technology; College of African Wildlife Management, Mweka; Tanzania Forest Conservation Group; and the Natural History Museum of Utah.

Representatives of collaborating partners in the project 'Assessing landscape level impacts of climate change on montane forest pollinators'.

The objectives of this project are to:

1. Develop an open-access database to assess the effects of climate change on pollinators;
2. Enhance capacity in the design, management and use of the database; and
3. Educate project beneficiaries and future partners about the impact of climate change on pollinators.

The results of the project to date include:

1. Establishment of an open-access database http://bionuwai.tawiri.or.tz/ and the uploading of approximately 2,000 historical and current species occurrence records for butterflies and birds in the Uluguru and East and West Usambara Mountains (Fig. 1.)

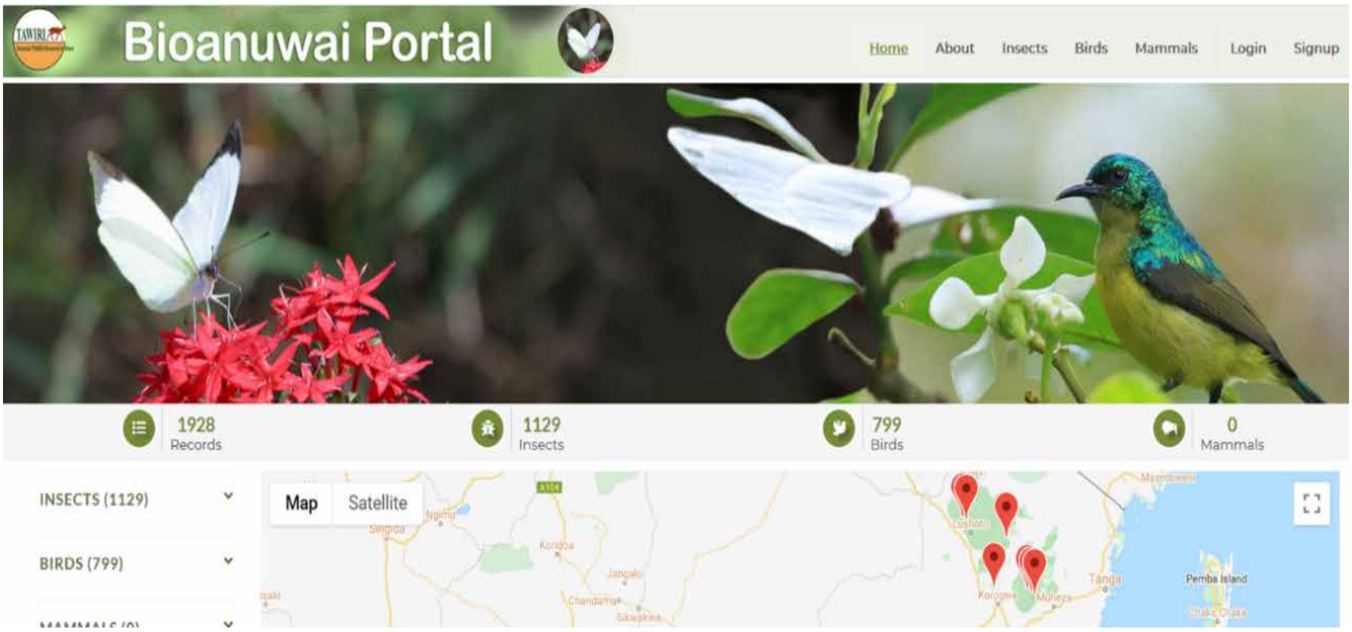


Figure 1. Tanzania Wildlife Research Institute open-access species occurrence database.

2. Nearly 7,000 survey-hours of butterflies and more than 26,400 mist net survey-hours of understory birds, in the Uluguru and East and West Usambara Mountains respectively, between 2018 – 2020 (Fig. 2).

a)  b)

Figure 2. (a) Tanzania Wildlife Research Institute and (b) Amani Friends of Nature staff conducting field surveys of butterflies and understory birds, respectively.

3. Training 33 senior staff and technicians on (a) database management; (b) digitization and uploading occurrence records; and (c) field survey techniques, and data recording and analysis (Fig. 3).

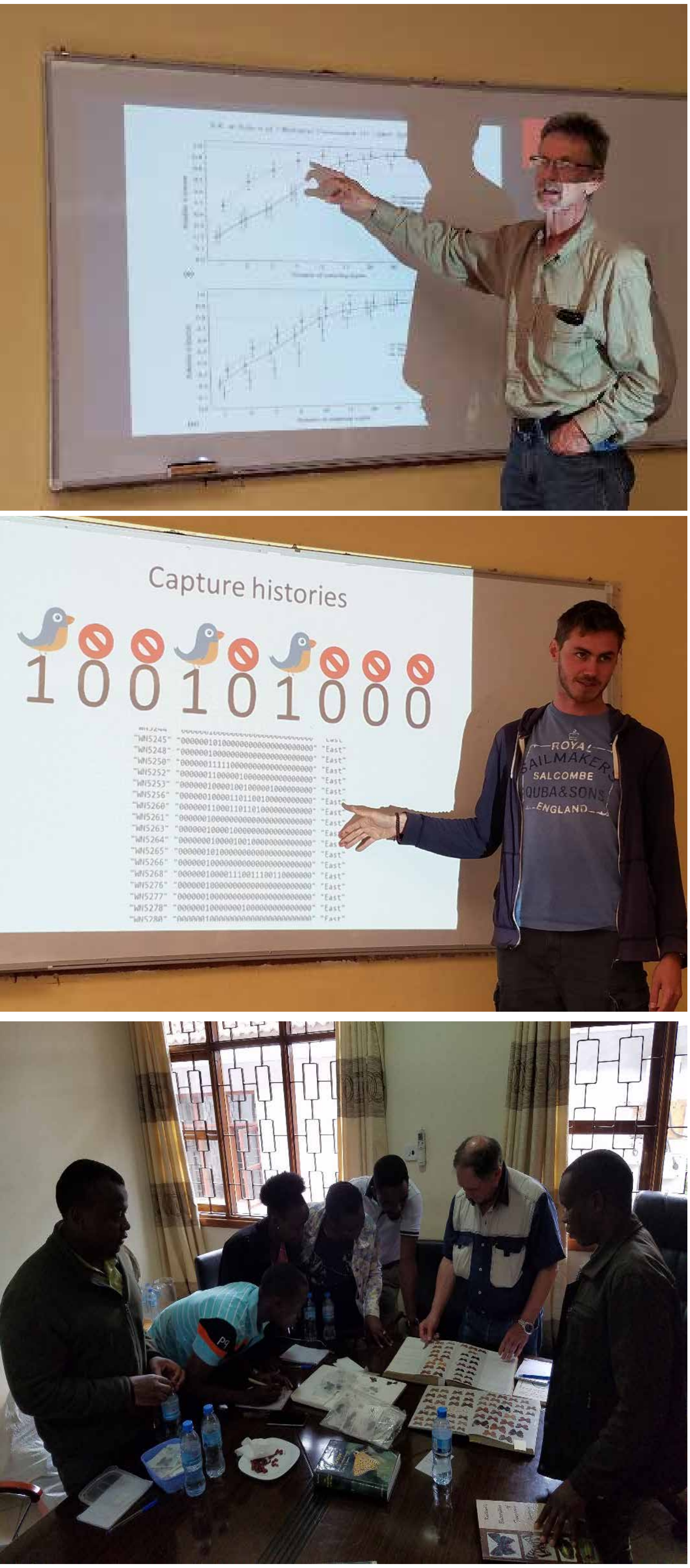
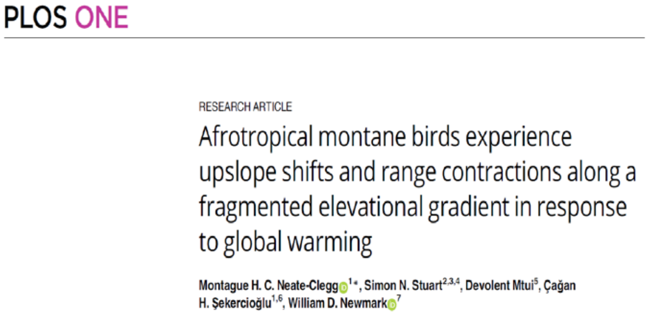


Figure 3. Training workshops conducted by the Natural History Museum of Utah and the African Butterfly Research Institute for project partner organizations senior staff and technicians.

4. Five peer-reviewed scientific publications and an additional manuscript that is *in review* (Fig. 4).


PLOS ONE

RESEARCH ARTICLE

Afrotropical montane birds experience upslope shifts and range contractions along a fragmented elevational gradient in response to global warming

Montague H. C. Neate-Clegg[1*], Simon N. Stuart[2,3,4], Devolent Mtui[5], Çağan H. Şekercioğlu[1,6], William D. Newmark[7]

Figure 4. One of five peer-reviewed publications produced between August 2018 and February 2020 assessing the impact of climate change on pollinators in the Eastern Arc Mountains.

5. Identification of an additional partner to support the creation of a corridor in the Magamba Nature Reserve, West Usambara Mountains to permit species to shift upslope more readily, in response to climate change (Fig. 5).

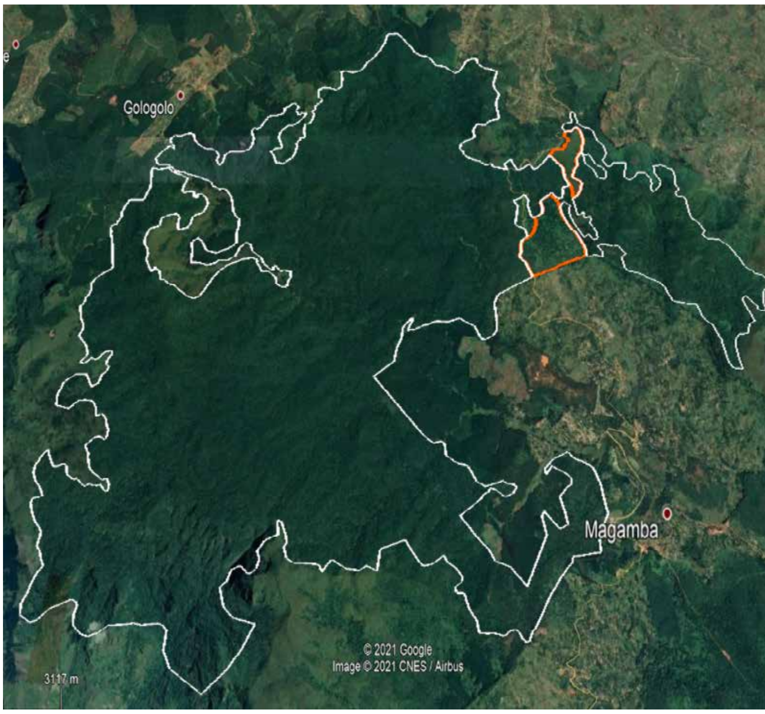
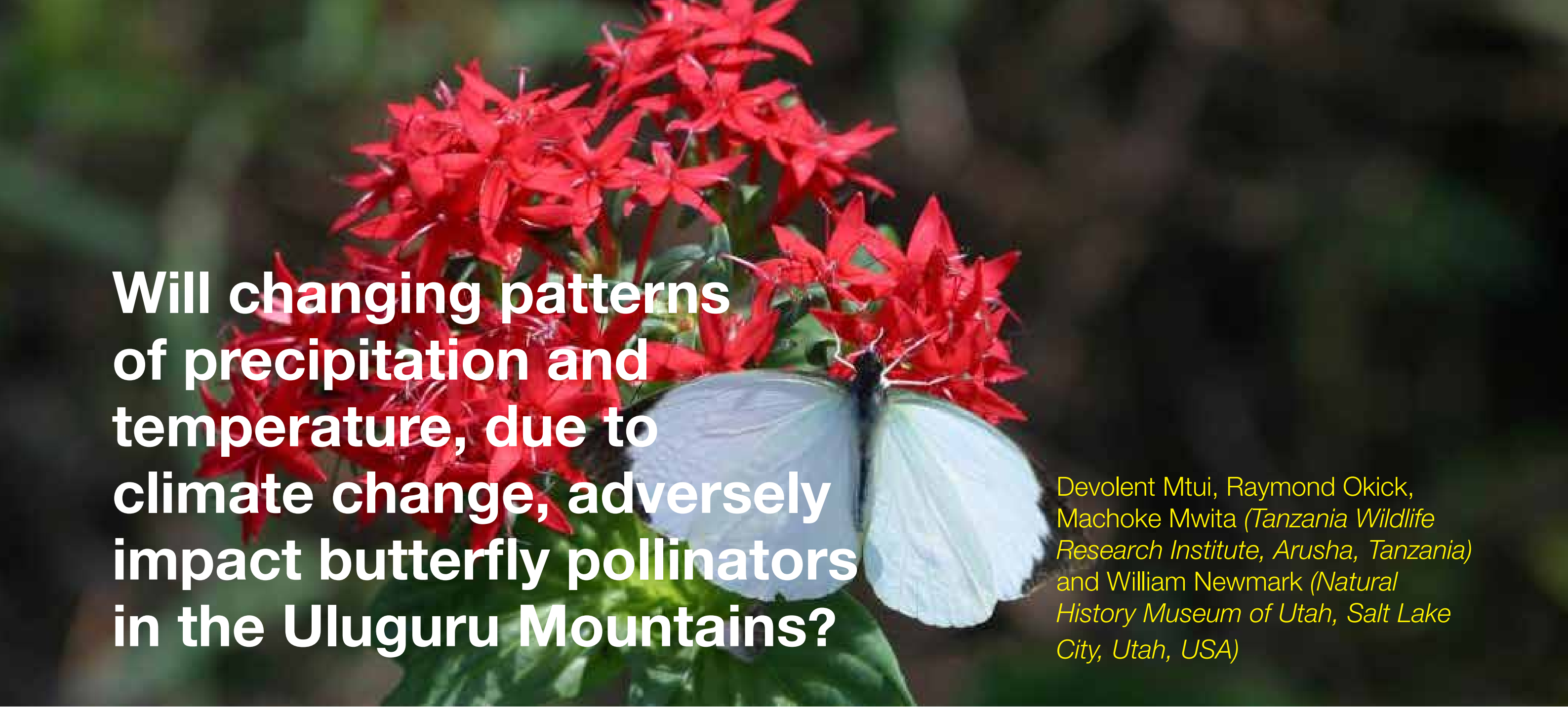


Figure 5. Location of a proposed corridor, shown in orange, in the Magamba Nature Reserve in the West Usambara Mountains.

In this special issue of the Arc Journal, we highlight the policy implications of this project.



Will changing patterns of precipitation and temperature, due to climate change, adversely impact butterfly pollinators in the Uluguru Mountains?

Devolent Mtui, Raymond Okick, Machoke Mwita *(Tanzania Wildlife Research Institute, Arusha, Tanzania)* and William Newmark *(Natural History Museum of Utah, Salt Lake City, Utah, USA)*

Importance of pollinators

Globally, 87.5% of all wild flowering-plants depend on pollination by insects and other animals, and 91 of the 107 most important food crops require, or benefit from, pollinators. Yet, this service is one of the 15 ecosystem services that are in decline. In recent years, there has been evidence of the decline, and even extinction, of pollinator species in parallel with the plants they pollinate. This is due to climate change exacerbated by habitat degradation and loss (1). The decline in pollinators suggests loss of pollination services with a consequent negative impact on ecological and economic systems, ecosystem stability, crop security and human welfare.

How climate change impacts butterfly pollinators

Butterfly seasonal activity patterns are largely driven by precipitation, particularly rainfall. Unfortunately, because of global climate change, seasonal patterns of precipitation are predicted to change. Excessive rainfall may cause flowers to drop in fruit plants and phenological shifts in flowering plants. These changes can desynchronize the plant-pollinator interactions. This can result in decreases in the amounts of flowers available for pollinators, leading to the extinction of both the plant and the pollinator. In North America and Europe, declines and extinctions of butterfly pollinator species have been associated with climate change.

Climate change effects on butterflies in the Uluguru Mountains, Tanzania

The Uluguru Mountains are part of the Eastern Arc Mountains, a global biodiversity hotspot defined as sites with unusually high numbers of endemic species of plants and animals, and which have lost greater than 70% of their original habitat. The Uluguru Mountains are among the most important sites in the Eastern Arc Mountains for endemic species, and contain 13 known endemic plant and animals species, including eight highly endemic butterfly species. Despite the richness in biodiversity, human-caused fires (Fig. 1) – which will only increase with global warming -- are currently threatening upper elevation forests.

Figure 1. Wildfires observed at Lukwangule plateau in the Uluguru Nature Reserve in September 2020.

Scientists have predicted increases in precipitation in most regions of Tanzania by the year 2100, although, over the western and southwestern regions precipitation is projected to decrease. Temperatures are predicted to increase across the country (2). The impacts of climate change on biodiversity are currently evident in the Usambara Mountains, a part of the Eastern Arc Mountains, where increases in temperature over the past three decades have been associated with upslope shifts, range contractions and reduced recruitment rates of understory birds (3).

Predicted increases in precipitation and temperature over the next 30 years are expected to impact activity patterns of insect pollinators, including butterflies, in the Uluguru Mountains. Yet, a rigorous assessment of the impact of climate change on pollinators requires standardized long-term data. Unfortunately, such data are not available for the Uluguru ecosystem.

With funding from JRS-Biodiversity Foundation, we established a standardized baseline for assessing future impacts of climate change on pollinating butterflies in the Uluguru mountains. Along an elevational transect we established 26 permanent sampling sites distanced approximately 40 m apart in elevation, from 1,540 m through 2,639 m. At each site we recorded all butterfly species including pollinators, in the Papilionidae and Pieridae families, which are easily observed and identified in the field, and therefore can serve as indicators of change. Sampling was conducted over 40 days during the months of February and September in 2019 and 2020.

Preliminary data indicate that the total number of butterfly species: (1) decrease with increasing elevation; (2) is higher during the short to long rains transition (February) than during the wet to short rains transition (September); and (3) is higher in open than in closed habitats. The abundance of butterflies display similar patterns and trends. Preliminary data also indicate that elevational distribution of butterfly species numbers and abundance vary among families. Within the family Papilionidae, species number and abundance peak at mid-elevations, while for species in the family Pieridae, species number and abundance increase with elevation.

A database is being established on the TAWIRI website http://bionuwai.tawiri.or.tz/ which will be available for public use to support assessment of the effects of climate change on butterfly and bird pollinators in the future.

Conclusion and Recommendations

Butterflies are among the group of insects that pollinate plants, a service that is underscored in the United Nation's Sustainable Development Goal (SDG) 15: to Protect Life on Land, because of its vital importance for maintaining biodiversity and ecosystems. Unfortunately, this service in the Uluguru mountains is threatened by human-caused wildfires.

On Mount Kilimanjaro, climate change-induced fires have caused changes in species composition and have resulted in a downward shift in the upper forest line (4) which leads to a downward shift of the upper forest line by several hundred meters as a result of a drier, warmer environment. Similar climate-induced changes in vegetation and fire dynamics could very well occur overtime in the Uluguru Mountains, impacting butterfly species diversity and abundance. Wildfire control measures need to be enforced in the Uluguru Mountains because the frequency and scale of fires are predicted to increase with increasing global temperatures. Many fires at upper elevations in the Uluguru Mountains are caused by people traveling between villages and to local markets, who stop at night to make a fire to keep warm and cook. The government needs to find alternative routes for villagers traveling overnight to other villages and markets.

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Bird pollinators face climate change in the Usambara Mountains

Monte Neate-Clegg (*The University of Utah, 257 South 1400 East, Salt Lake City, USA*)

The Usambara Mountains, in northeast Tanzania, are rich in flora and fauna, with many species found nowhere else on Earth. Over the past two centuries, the forests of the Usambara Mountains have been heavily fragmented, with large amounts of land converted to agriculture, especially tea. But a more recent and pressing issue facing the biodiversity of these mountains is global climate change. Temperatures are rising across the world and impacting biodiversity in many ways. The central goal of the Butterfly and Bird Pollinators Project has been to understand the effects of climate change on the pollinators of the Eastern Arc Mountains.

In Africa, most bird pollinators are nectar-eating birds in the sunbird family (Nectariniidae). In the Usambara Mountains there are as many as 13 sunbird species. These include the Usambara Double-collared Sunbird (*Cinnyris usambaricus*) and Amani Sunbird (*Hedydipna pallidigaster*) which are only found in the Usambara Mountains plus a few other nearby ranges. Sunbirds can be seen flitting between the foliage, feeding on nectar from flowers. These little gems are often brightly coloured and highly sought-after by birdwatchers. As large nectar-eaters, sunbirds perform important ecosystem functions. As they move from flower to flower, they spread pollen, allowing plants to cross-fertilise. Many plants specifically advertise their nectar to sunbirds, with large red flowers. Complex ecosystems such as the forests of the Usambara Mountains can only remain healthy if they maintain their ecosystem functions, and that includes the important bird pollinators.

Over 35 years, Dr Bill Newmark from the Natural History Museum of Utah has been surveying the forest understory bird community of the Usambara Mountains. He and his team, led by Victor Mkongewa, use delicate "mist nets" to safely and harmlessly capture birds, then mark them with small metal leg rings. After many years, they were able to build up "capture histories" for every individual bird. These capture histories can be used to assess changes in the demographic rates of birds over time. As part of my PhD at the University of Utah, I used these data to model the effects of climate change on the demographic rates of 21 understory birds in the Usambara mountains (Neate-Clegg *et al.* 2021a). For each species, we estimated survival, recruitment, and population growth rates in relation to annual temperature and precipitation.

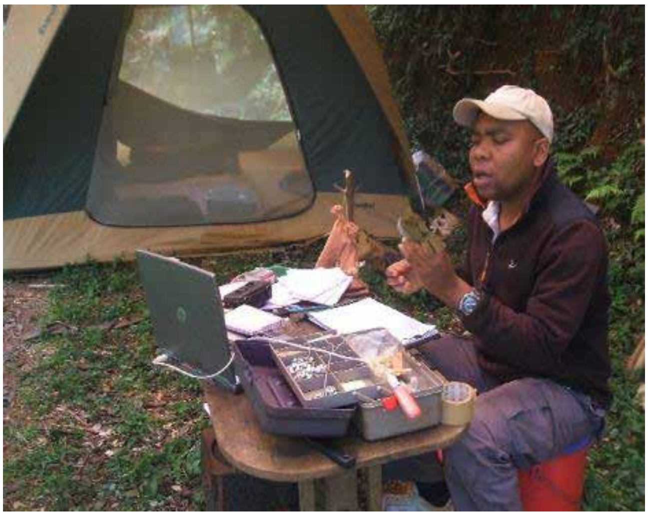

Figure 1. Mr. Victor Mkongewa recording field data for understory birds in the Usambara Mountains.

In this study, published in *Global Change Biology*, we found that, for over one-half of focal bird species, temperature was negatively associated with population growth rates. This means that populations tended to decline more in hotter years. As temperatures have increased in the Usambara Mountains over the last three decades, population growth rates have consequently decreased. In fact, most focal species have shown declining population sizes over the course of the study. In addition, when we compared the effects of temperature with the effects of time, we found that temperature was a more important predictor of demographic change for over one-quarter of focal species. Among the focal species, we found that demographic rates were negatively related to temperature for two sunbirds: the Olive Sunbird (*Cyanomitra olivacea*) (Fig. 2a) and the Usambara Double-collared Sunbird (Fig. 2b). These changes in population growth rates were driven largely by changes in recruitment rates i.e., the rate at which new individuals join the population. Compared to temperature, precipitation had little effect on the demographic rates of these species.

Climate change is also affecting the distribution of understory birds in the Usambara Mountains.

Between 1979 and 1981, Dr. Simon Stuart carried out his PhD research in the Usambaras. He used mist nets to survey seven sites across an elevational gradient, ranging from ~300 m to ~2100 m in elevation. In order to assess changes in the elevational distribution of bird species, I led a resurvey of the same sites in 2019. Together, Mr Mkongewa (Fig. 1) and I surveyed the seven sites, capturing 44 species of bird. I then compared the mean elevation and upper and lower range limits for each species between the historic survey and the resurvey, controlling for differences in sample size between surveys. In this study, published in *PLoS ONE*, we found that, of 29 species, 19 shifted upslope, eight shifted downslope, and two did not shift at all (Neate-Clegg *et al.* 2021b). On average, species' lower elevational range limits shifted upslope much more than their upper elevational range limits, and, as a result, their elevational ranges contracted. We believe that climate change is driving bird species to higher elevations. As temperatures increase, birds are shifting their distributions upslope in order to avoid hotter environments. However, forest fragmentation is interacting with the effects of climate change. There are gaps of many kilometres between forest fragments, and forest understory birds are reluctant to cross gaps of even 50 m. As a result, these bird species are unable to colonise forest fragments at higher elevations. This explains why species' elevational ranges are contracting.

Between these two studies, Dr Newmark and I have shown that climate change, particularly increasing temperature, is having a negative impact on both the demographic rates and elevational ranges of forest understory birds in the Usambara Mountains. Because these effects are occurring across the bird community, they are almost certainly affecting bird pollinators, as we have seen for the Olive Sunbird (Fig. 2a) and Usambara Double-collared Sunbird (Fig. 2b). Other sunbirds that have been captured in these studies include the Collared Sunbird (*Hedydipna collaris*), but there is not enough data to analyse the effects of climate change on these species. However, we expect that climate change will have a negative effect on many of the Usambara's pollinator species.

Climate change is a global issue which will require international agreements to stop. However, there are things that the people of Tanzania can do to help bird pollinators, and other species, in the Eastern Arc Mountains. One of the best remedies would be to reconnect the forest fragments of the Usambara Mountains. We have seen that fragmentation is an impediment to range shifts in understory birds. Bridging the gaps between forest fragments could help populations to move more easily in response to climate change. In addition, increasing the area of forest fragments will buffer species more against the effects of climate change. The Usambara Mountains, and the Eastern Arc Mountains in general, contain high levels of important biodiversity including bird pollinators. Reconnecting forest fragments and stopping climate change are needed in order to safeguard this diversity for future generations.

Figure Captions:

a)

b)

Figure 2. The (a) Olive Sunbird and (b) Usambara Double-collared Sunbird are examples of flower-pollinating bird species whose demographic rates have been adversely impacted by increasing temperature over the last 30 years.

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Ecological linkages: their importance to conserving biodiversity in the Eastern Arc Mountains

William D. Newmark, Natural History Museum of Utah, University of Utah, Salt Lake City, UT 84103

Biologists have recognized for over 120 years that the Eastern Arc Mountains (EAM) contain unusually high numbers of endemic and rare plant and animal species. This recognition was highlighted in 2000, when Norman Myers and colleagues identified the EAM as one of 24 global biodiversity hotspots, which are defined as sites that have lost greater than 70% of their original forest cover and contain unusually high numbers of endemic plant and animal species – species that are restricted to a given region.

Over the last half-century many individuals and institutions have greatly expanded our knowledge about the distribution and abundance of plant and animal species in the EAM, and this work is continuing. However, ensuring the long-term conservation of the many geographically-restricted and rare plant and animal species in the EAM over the next half century will be challenging for a number of reasons. Firstly, over the last 200 – 300 years (Fig 1) the EAM have lost 77% of their original forest cover (*2*). Secondly, the remaining forests in the 13 EAM are highly fragmented (*2*). And thirdly climate change is posing an additional and significant threat to many plant and animal species (3,4).

Figure 1. Small scale agricultural expansion has been the dominant cause of forest loss in the Eastern Arc Mountains over the last 200 – 300 years.

Impact of forest fragmentation on species persistence

The total forest area in the EAM forest is about 406,000 ha (*1*). However, the EAM forests are, unfortunately, highly fragmented. Across the 13 Eastern Arc Mountains there are 311 fragments >10 ha in size with the median fragment size of 84 ha (Table 1). The EAM's with the largest number of fragments are the Udzungwa followed by West

Usambara, Nguru, East Usambara, and Nguu Mountains. Furthermore, the average distance among remaining fragments is large. The median distance among the 311 fragments is 867 m (Table 1).

Table 1. Summary of forest cover by Eastern Arc Mountain after Newmark and McNeally (2).

Eastern Arc Mountain	Forest area (ha)	Percent of total forest	Number of fragments ≥10 ha in size	Median fragment size (ha)	Median distance to nearest fragment (m)	Median distance to nearest larger frag-ment (m)	Percent total area located <100 m from edge	Percent total area located <300 m from edge	Percent total area located <1,000 m from edge
Taita Hills	590	0.1	4	150	11,138	11,167	52.4	95.0	100.0
East Usambara	30,110	7.4	31	74	581	964	20.9	47.6	92.2
West Usambara	28,213	7.0	38	133	1387	2130	20.0	46.0	83.3
South Pare	10,749	2.6	15	33	1051	1558	17.8	39.5	70.6
North Pare	2178	0.5	10	135	5632	7213	40.7	81.6	100.0
Nguu	16,170	4.0	28	55	539	1308	23.5	64.9	88.4
Nguru	29,927	7.4	34	40	449	900	14.5	33.0	70.0
Uluguru	25,963	6.4	18	149	1182	1917	13.5	33.7	78.8
Malundwe	1141	0.3	3	120	1862	1008	49.9	93.8	100.0
Ukaguru	17,742	4.4	15	183	544	966	16.8	39.8	82.0
Rubeho	42,274	10.4	28	115	1175	2337	11.5	27.8	60.6
Udzungwa	195,321	48.1	65	126	423	1169	10.1	25.4	58.8
Mahenge	5474	1.3	22	55	2097	3279	46.0	72.9	99.4
Total/ Overall	405,852	100.0	311	84	867	1533	13.9	32.7	68.3

Yet, why should we be concerned about the fragmented nature of the Eastern Arc forests? Very simply because habitat loss and fragmentation are the dominant causes, at least currently, of species extinctions worldwide. Furthermore, many species that occur in the EAM have very limited dispersal capability (Fig. 2).

a)

b)

Figure 2. The (a) Usambara Thrush (b) Red-capped Forest Warbler and (c) Sharpe's Akalat are understory bird species that will not cross forest gaps >15 - 50 m in width.

(c) Sharpe's Akalat are understory bird species that will not cross forest gaps >15 - 50 m in width.

Long-term (35 years) capture-recapture data for understory bird species in the East and West Usambara Mountains based on >32,600 captures and 3.6×10^6 m-mist net-hrs indicate that 21% of all species (Fig. 2) have never been captured in a fragment other than where they were originally banded (*2*). The reluctance and/or inability of these species to cross forest gaps has been further confirmed through the radio-tracking of individual species over an 8-year period as well as foraging observations in matrix habitats (*2*). In addition to understory birds, chameleons in the Usambara Mountains, as well as many arboreal primates, sloths, scarab beetles, and Euglossine bees elsewhere in the tropics have been shown also to have very limited gap-crossing abilities (*2*).

Simply documenting the current status of a species within a fragment in the EAM, however, tells you little about the long-term viability of that species within the fragment. Most species extinctions following habitat loss are delayed rather than immediate, and thus a species that is observed today within a fragment does not mean it will be there 50 to 100 years in the future. However, because most extinctions of species in habitat remnants are delayed rather than immediate there are important yet insufficiently appreciated opportunities to conserve species through habitat restoration. We now have a much clearer understanding as to how quickly species that are isolated in forest fragments will go extinct following fragment isolation. Based on species-area relationships – one of the oldest and best-defined relationships in ecology - we can predict not only the number of species that will be lost over time but also how quickly species will disappear over time. I and colleagues have recently examined how quickly tropical bird species in the EAM and in the Atlantic forests of Brazil will go extinct in forest fragments after a fragment is isolated (*2*). This analysis is based on a compilation by John Halley and colleagues of all major studies conducted to date in the tropics that have documented extinctions of bird species in habitat fragments of a known age. What this analysis reveals is that the half-life – or the time over which one-half of all understory bird species will eventually go extinct – in an 84 ha fragment (the median fragment size in the EAM) is only 67 years. On the other hand, the extinction half-life of species in a 10,000 ha fragment is 637 years. While there are only 7 fragments in the EAM >10,000 ha, by regenerating forest among the largest and closest forest fragments in the EAM it would be possible to not only dramatically increase the size of existing forest blocks within many of the EAMs but more importantly the persistence time of the many endemic and rare species that occur here. I and colleagues have estimated that by regenerating 8,134 ha of forest among the largest and closest forest fragments at nine locations in the Eastern Arc Mountains one could create >316,000 ha in total of contiguous forest (*2*). However even more importantly it would increase the persistence time for species by a factor of 6.8 per location or ~2,272 years. Finally we estimate that the cost of regenerating forest among the largest and closest forest fragments at the nine locations in the EAM would be approximately $21 million dollars and could provide one of the highest returns on investment for biodiversity conservation worldwide (*2*).

Climate change

Forest loss and fragmentation are, however, unfortunately not the only threats facing plant and animal species in the Eastern Arc mountains. Over the last 30 years temperatures in the EAM have increased by 0.58 °C (3). While this increase may appear to be small, unfortunately it has had a dramatic and adverse impact on, not only the elevational distribution of understory bird species, but also their population growth and recruitment rates.

Over the last 40 years, understory bird species in the East and West Usambara Mountains have shifted upslope on average by 93 m (3). Yet what is even more concerning is that the average elevational range of understory bird species in the East and West Usambara Mountains has contracted by 114 m (3). This contraction in the elevational range of species is due in large part to the fragmented nature of the East and West Usambara forests (Fig. 1) as well as the very limited dispersal ability of most understory bird species (Fig. 2) to cross forest gaps (*2*). Furthermore, three-quarters of the most common understory bird species over the last 30 years have had average population growth rates that are negative – meaning that most bird populations are currently under severe threat and that if these long-term trends in population growth rates continue many species will eventually go extinct (4). However, what is particularly disconcerting is that declining population growth rates and recruitment (the number of births) were documented for only the most common species in the Usambara Mountains and these declines in demographic rates were associated with increasing temperatures for nearly one-third (29%) of all common species (4). Unfortunately, most bird species in the Usambara Mountains are uncommon or rare and thus climate change clearly poses a significant threat to, most likely, a majority of bird species in the EAM.

The importance of regenerating linkages among fragments

By regenerating forested linkages among the largest and closest forests, one can effectively enlarge the remaining largest fragments in the EAM and thus increase population size of species and more importantly species persistence time (*2*). Furthermore, these linkages among fragments can permit plant and animal species to more readily shift their ranges upslope over time in response to climate change.

Over the next 30 – 50 years, temperature and precipitation are predicted to increase in Tanzania as a result of climate change. Additionally, Tanzania's population is projected to double from 61 million people to 122 million people over the next 27 years (*5*). Consequently, both climatic and human pressures on the remaining forests in the EAM will certainly increase over the next two decades.

Establishing linkages or corridors among the largest and closest forest fragments will require both governmental and local support and involvement. Yet, if we are to maximize the benefit of linkages or corridors among forest fragments on species persistence time, this must be done quickly and over the next decade.

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What drives deforestation in Tanzania?

This article is based on: Doggart, N., Morgan-Brown, T., Lyimo, E., Mbilinyi, B., Meshack, C.K., Sallu, S.M., Spracklen, D.V., 2020. Agriculture is the main driver of deforestation in Tanzania. *Environmental Research Letters* **15** Available for free download at: https://iopscience.iop.org/article/10.1088/1748-9326/ab6b35

Tanzania is undergoing a period of rapid deforestation. Every year, more than half a million hectares of forest are cleared

Deforestation involves the conversion of forest land to non-forest land. Deforestation threatens the supply of forest ecosystem services and products.

In order to reduce deforestation, it is important to understand the drivers of deforestation. Drivers of deforestation are the human activities that cause forest loss. To be effective in reducing deforestation, policies need to tackle the activities that cause the most forest loss.

In 2017, Tanzania had approximately 37.7 million hectares of forest. Of this, 41% is protected in areas such as forest reserves while 45% is on village land, managed by communities[1]. Unreserved forests on village land are the most threatened.

Putting a figure on how much deforestation is caused by different drivers

In order to generate policy-relevant information on how to reduce deforestation, a study was carried out in 2018/19 to measure the relative importance of different deforestation drivers[2].

The study mapped the area of land that was deforested between 2010 to 2017, across Tanzania, and then surveyed 120 random sampling points from the deforested area. Each sampling point was assessed in order to identify the activities that had contributed to the clearance of the forest. All activities were measured including both drivers of deforestation and drivers of forest degradation. The surveys used a combination of satellite images, field visits and interviews with local people.

Deforestation driver: an activity that causes the conversion of forest land to non-forest land e.g. agriculture.

Forest degradation driver: an activity that causes loss of forest quality, such as reduced tree density, in areas that remain forest e.g. charcoal production, firewood collection.

Which activities cause most deforestation?

Key findings of the survey

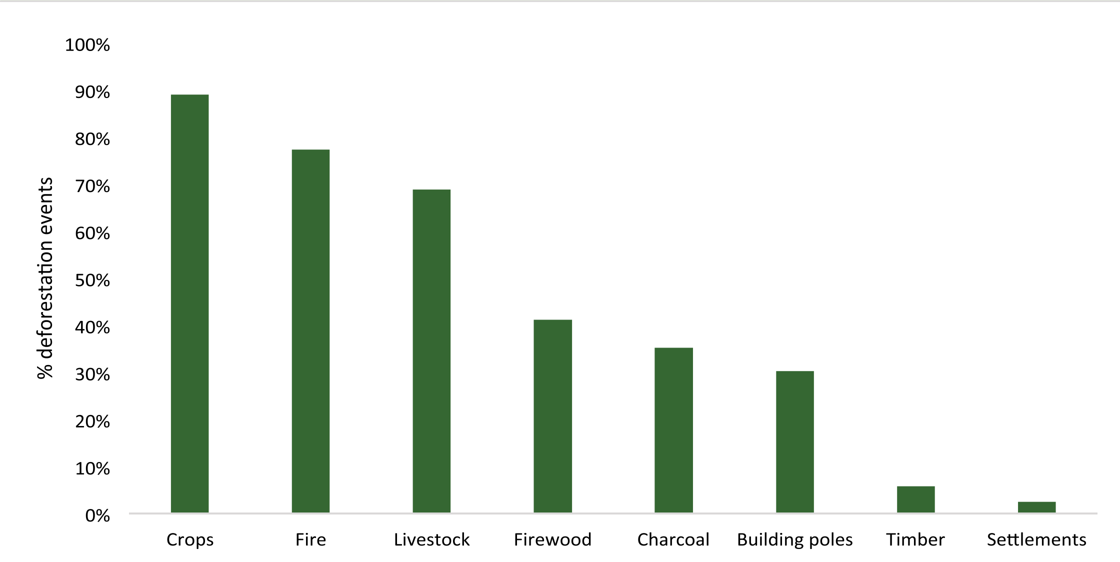
1. Small-scale agriculture is the main driver of deforestation in Tanzania and was recorded in 89% of the deforested areas (Figure 1).
2. Over half of all deforestation events (57%) involve maize cultivation. Sesame is also associated with deforestation (20% of events).
3. Most deforestation events involve multiple drivers, most frequently a combination of crops and livestock.
4. Firewood collection, charcoal production and pole-cutting contributed to 30% - 40% of deforestation events, always in combination with either crops, or livestock grazing.

1 Source: MNRT, 2015 National Forest Resources Monitoring and Assessment of Mainland Tanzania: main report.

2 Doggart *et al.* 2020 doi.org/10.1088/1748-9326/ab6b35

5. Charcoal was never found to drive deforestation separately from crops or livestock.
6. Fire is frequently used to clear forest, with signs of fire evident in 77% of deforested areas.
7. More deforestation occurs on village land than in forest reserves and other protected areas

Figure 1. Percentage of deforestation events where drivers of deforestation and forest degradation were present.



Source: Doggart et al. 2020

Recommendations

Given that most deforestation is caused by agriculture, there is a need to focus on changing the relationship between farmers and forests.

In the agriculture sector, change is needed to:

- reduce farmers' dependence on expanding farms into intact forest areas;
- avoid policies that encourage farmers to clear intact natural forest;
- provide support and incentives for communities and other land owners to retain natural forest, rather than converting land to agriculture.

Given that most deforestation involves more than one activity, reducing deforestation requires strong inter-sectoral coordination between the land, agriculture, livestock and forest sectors.

In forestry, community-based forest management (CBFM) is the main policy tool to protect forests on village land. CBFM empowers communities to establish and manage village forest reserves. With less than ten percent of village land forests under CBFM, the opportunity exists to expand CBFM. In 2021, the Ministry for Natural Resources and Tourism published the National Forest Policy Implementation Strategy (NFP IS) for 2021 – 31. The NFP IS sets a national target to '*increase the area under CBFM from 2.7 million ha to 16 million ha by June, 2031*'. If combined with technical and governance support for communities, the expansion of CBFM could play an important role in limiting the conversion of the remaining forest land, to other land uses.

Are there gaps in Tanzania's Forest Nature Reserve network?

By Claire Ract, Master student in Biology - University of Copenhagen, Denmark and University of Uppsala, Sweden

Amani Nature Forest Reserve, established in 1997, was Tanzania's first Nature Reserve. *Photo by Andrew Perkin*

Tanzania has a wide range of different environments with a high level of biodiversity. This makes the country one of the twelve mega-diverse countries of the world. A network of 22 Forest Nature Reserves (FNRs) has been established in the country. The network is categorized with the highest level of protection under the Forest Act of 2002; is state-owned; and managed by the Tanzania Forest Services (TFS) Agency.

Goal of the analysis

An analytic study was performed to assess the network, and to generate recommendations on how to improve its impact on biodiversity conservation. To evaluate the network, the number of species endemic to Tanzania, and to the sites themselves, was determined using datasets provided by experts on the different taxa. The number of threatened species in each reserve was determined using IUCN Red List categories: Vu (Vulnerable), CR (Critically Endangered) and EN (Endangered). The study used data on amphibians, reptiles, birds, mammals, and plants.

Assessing the network of Forest Nature Reserves

The biodiversity value of the reserves, based on the number of endemic or threatened species, was compared across the sites. Results were compared with different characteristics of the nature reserves including forest type, management effectiveness, date of declaration, available finance, and the threat level of each reserve. The parameters are described below (Table 1).

The nature reserves include seven different forest types including Coastal, Eastern Arc Mountain and Guinea Congolian forests. The analysis found that nature reserves in the Eastern Arc Mountains had the highest biodiversity values.

The effectiveness of the management of the reserves was evaluated using the Management Effectiveness Tracking Tool (METT). This tool consists of a set of questions about reserve management, that are answered by the managers of the reserves. The higher a reserve's METT score, the more effectively the site is managed. The analysis showed that the reserves with the most effective management tended to have a higher number of endemic and threatened species.

Focusing on the date of declaration of a reserve, the results show that the earliest reserves, such as Amani, Uluguru and Kilombero, contain the most endemic and threatened species. Indeed, with the addition of the most recent reserves, the number of endemic or threatened species present across the network of reserves, has not increased (Figure 1).
However, the analysis showed that the total finance available, threat level and size of each reserve, did not impact their biodiversity values.

Forest Nature Reserve	Endemic species to Tanzania	Forest type	Date of establishment	Management effectiveness (in %)	Size (in km2)	Total finance available (in US$)	Threat level (in %)
Amani	174	Eastern Arc	1997	59	83.8	125,668	47
Kilombero	164	Eastern Arc	2007	50	1345.11	122,975	19
Nilo	81	Eastern Arc	2007	61	60.25	78,737	22
Uluguru	250	Eastern Arc	2008	73	241.15	133,892	28
Mkingu	129	Eastern Arc	2016	76	264.33	87,202	28
Magamba	65	Eastern Arc	2019	74	92.83	70,628	42
Chome	65	Eastern Arc	2016	70	142.83	219,797	22
Uzungwa	124	Eastern Arc	2016	67	327.63	56,596	17
Minziro	0	Guinea Congolian	2019	67	257.17	93,118	22
Mount Hanang	18	Northern Volcanics	2016	58,5	58.37	83,817	25
Rondo	72	CoastalForests	2017	59	117.42	75,675	28
Magombera	12	CoastalForests	2019	88	26,15	572,183	42
Mt Rungwe	100	Southern Highlands	2019	78	136.52	137,092	28
Mwambesi	0	Miombo	2019	44	1129.01	74,891	42
Itulu Hills	2	Miombo	2019	46	4036.26	52,000	33
Pindiro	5	Coastal Forests	2019	67	122.49	577,468	64
Kambo River	1	Miombo Acacia	2019	44	433.34	127,688	47
Pugu	32	Coastal Forests	2020	No data available	89.65	No data available	No data available
Uzigua	0	Miombo	2020	No data available	276.55	No data available	No data available
Hassama Hill	0	NorthernVolcanics	2020	No data available	49.01	No data available	No data available
Essimingor	1	NorthernVolcanics	2021	No data available	60.7	No data available	No data available
Nou	6	NorthernVolcanics	2021	No data available	289.36	No data available	No data available

Table 1: Forest Nature Reserve and their characteristics

To understand whether the reserves' characteristics impact the species composition of the sites, a non-metric multidimensional scaling analysis was done using the statistical software R. This analysis includes all the species present in each site (both endemic, and non-endemic) and was done for all the taxa (amphibian, reptile, bird, mammal, and plant). The protected areas were grouped depending on the characteristics described above. For example, they were grouped based on their management effectiveness (classified from poor to highly efficient), their available finance (small to large budget), their size (small to large), their threat level (as a percentage for each site), their date of establishment (recent or old sites) and their forest type (corresponding to the seven different forest type).

The results showed that the grouping factors corresponding to management effectiveness and forest type contribute to a significant variation in species composition for all taxa (amphibians, reptiles, birds, mammals, and plants). Basically, this means that management effectiveness and forest type have the strongest impact on a reserve's species composition.

Improving the network of FNRs

To improve the network of nature forest reserves in Tanzania, a gap analysis was performed using the software QGIS (a freely available Geographical Information System program) and global species distribution datasets developed by IUCN and other agencies.

The main goal of the analysis was to identify the presence of gap(s) in parts of Tanzania where there are a lot of endemic species present but no Nature Forest Reserves. Therefore, those part(s) of the country might need to be protected in the future. To identify those gap(s), the proportion of species endemic to Tanzania which have part of their range inside the reserves was computed. The analysis was done for amphibians, reptiles, birds, and mammals. The proportion of each endemic species' range (extent of occurrence) inside and outside of the nature reserve network, was calculated. This ranged from endemic species for whom 0% of their range occurs in the Nature Reserve network (gap species), to species whose range is found entirely (100%) within the Nature Reserve network.

By plotting the change over time in the proportion of endemic species occurring in the nature reserve network, the results showed that, as more reserves were established so there was a decline in the number of endemic species not protected by the network of nature reserves. Therefore, as more FNRs are added to the network over time more of the endemic species' area of occurrence is being covered by the reserves (Figure 1). However, there remain many endemic species whose ranges are poorly protect by the nature reserve network. This is highest among amphibians where more than 10 percent of endemic amphibian species are not protected by any of the 22 Nature Forest Reserves (Fig. 1).

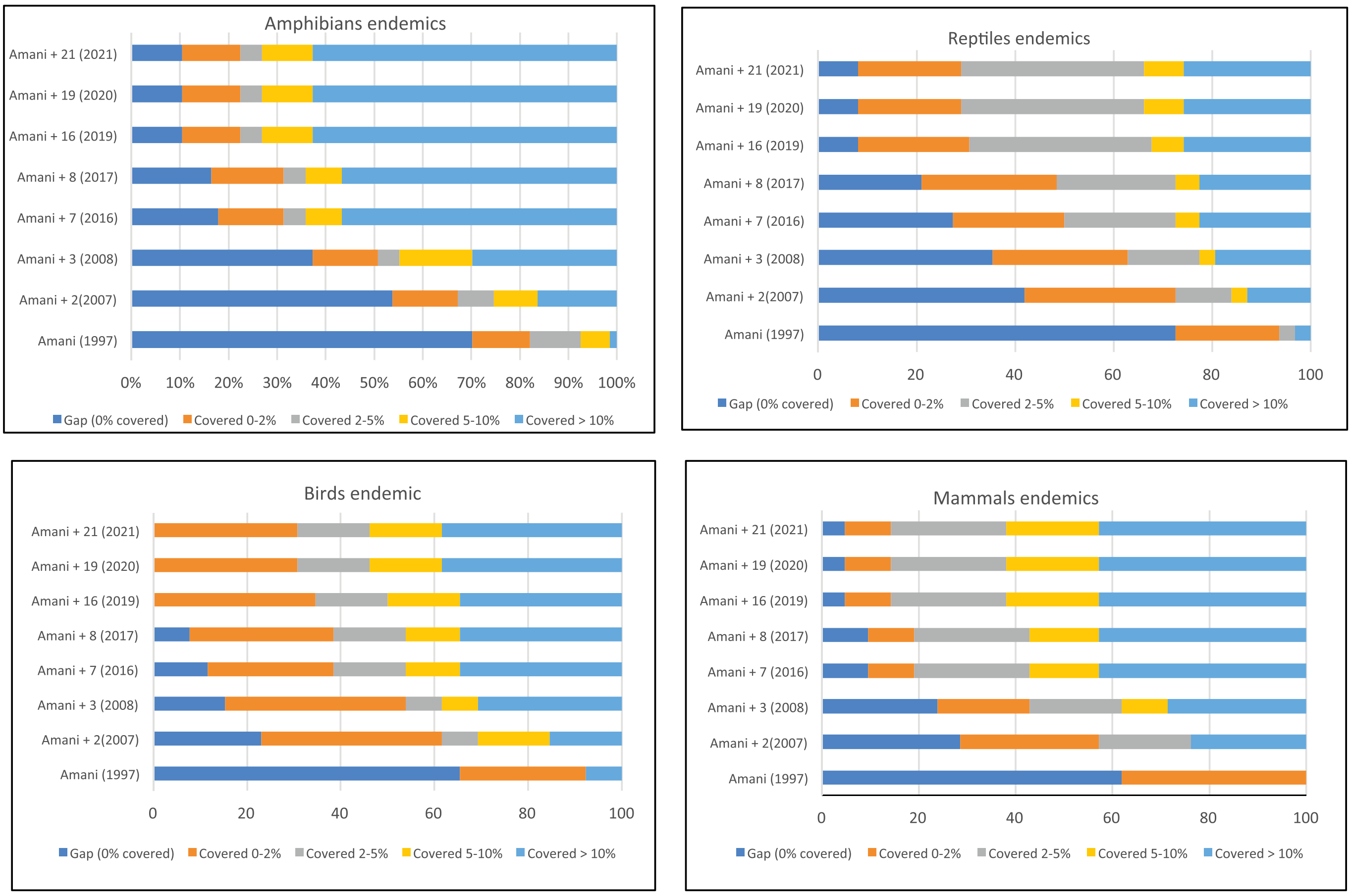


Figure 1: Gap analysis based on the proportion of endemic species in Tanzania with their range coverage' percentage in the reserves

Finally, to better visualize the outcome from the above analysis, species richness maps with the range of gap, or poorly covered, endemic species were produced to visualize their distribution in Tanzania and compared with the geographical position of the reserves using QGIS (Figure 2). The maps below show the endemic gap species and poorly covered species (defined as species with their range covered between 0 and 2 percent by the reserves). The Forest Nature Reserves are the dark green shapes.

From these maps, it seems that the gap endemic amphibian species are located mostly within the Eastern Arc Mountains (EAM) and the Coastal Forests (Figure A). There were only a few endemic gap amphibian species, in contrast, to endemic gap reptiles which would need more protection. Most endemic poorly-covered bird species are located within the EAM (Figure C). Endemic gap mammals are the best covered species by the reserves and the few gap/poorly covered species were mostly located within the Eastern Arc Mountains and the coastal Forests (Figure D).

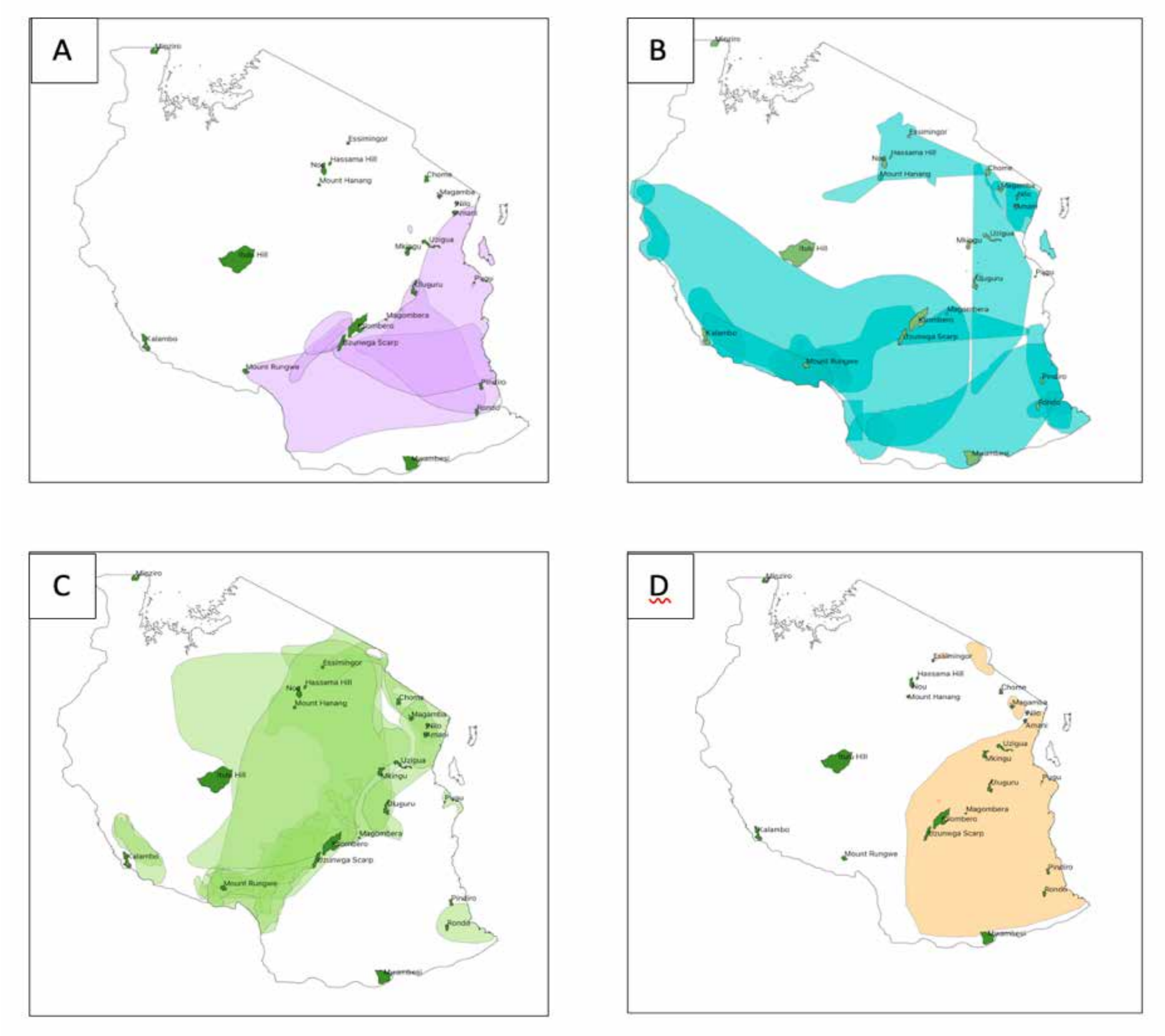


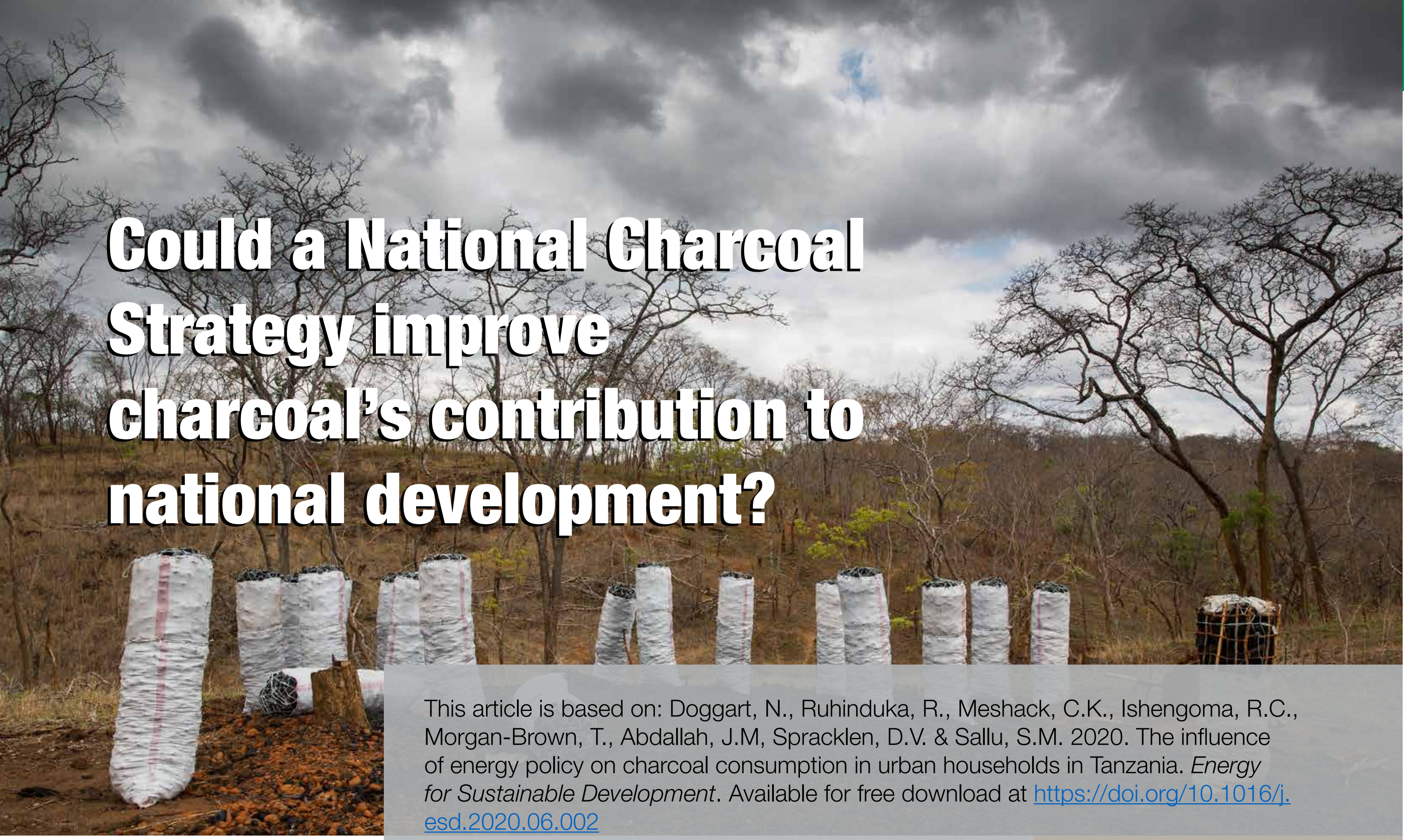
Figure 2: Endemic species range maps representing gap and poorly covered species for amphibians (Figure A), reptile (Figure B), birds (Figure C) and mammals (Figure D).

Conclusion

To conclude, forest type is most significant in affecting the species composition of Forest Nature Reserves. Indeed, the Eastern Arc Mountains (EAM) are considered as a biodiversity hotspot which contain most of the endemic and threatened species present in Tanzania. Future recommendations for improving the network of reserves include performing additional distribution surveys on reptiles and amphibians and establishing a new reserve in the Eastern Arc Mountains, where several gap species overlap, such as in the Udzungwa Mountains (Figure 2). Additional studies should be conducted in other forest types to determine the presence of endemic or threatened species.

View from Kwevikoli Peak, Mkingu Nature Reserve. Photo by Rob Beechey'

Could a National Charcoal Strategy improve charcoal's contribution to national development?



This article is based on: Doggart, N., Ruhinduka, R., Meshack, C.K., Ishengoma, R.C., Morgan-Brown, T., Abdallah, J.M, Spracklen, D.V. & Sallu, S.M. 2020. The influence of energy policy on charcoal consumption in urban households in Tanzania. *Energy for Sustainable Development*. Available for free download at https://doi.org/10.1016/j.esd.2020.06.002

For decades policy-makers have sought to reduce charcoal use in Tanzania. However, it remains the most popular cooking fuel for urban households.

Charcoal's advantages are that it is affordable, reliable, and is produced in-country providing employment for tens of thousands of producers and traders. Charcoal has the potential to generate substantial government revenues. However, charcoal also has disadvantages. Charcoal causes health problems and contributes to deforestation and forest degradation. There is widespread evasion of charcoal royalty payments.

The study described in this article looks at how policies have influenced the charcoal trade and whether policy change could achieve outcomes aligned with Tanzania's development priorities.

In the energy sector, successive national energy policies have sought to transition urban households away from charcoal and into modern fuels. For example, the government has tried to encourage more households to switch from charcoal to liquefied petroleum gas (LPG), for cooking. To achieve this, the government exempted LPG from the fuel levy, in order to make LPG more affordable. On the supply side, forest policy has sought to regulate the charcoal trade and generate government revenue from royalties. Prior to 2021, policies did not promote sustainable charcoal production. However, in May 2021, the Ministry for Natural Resources and Tourism published the National Forest Policy Implementation Strategy 2021 – 31, which sets a target for '*50% of Tanzania's charcoal to be produced sustainably by June, 2031*'. This marks a significant shift in policy direction, reflecting the success of sustainable charcoal production pilot projects, such as the TFCG-led project 'Transforming Tanzania's Charcoal Sector' project (for more information, see the TFCG News section in this edition of the Arc Journal).

Understanding how national policies influence households' cooking-fuel use

In late 2018, household surveys were carried out involving 100 randomly-selected households across Dar es Salaam. Data were collected on the different types of fuel used for cooking; why households prefer different fuels; and fuel costs.

Through surveys with charcoal retailers, traders and producers, data were also collected on charcoal prices along the value chain. By comparing this information with the results of previous surveys and with information on government taxes, royalties and other fees, it was possible to link

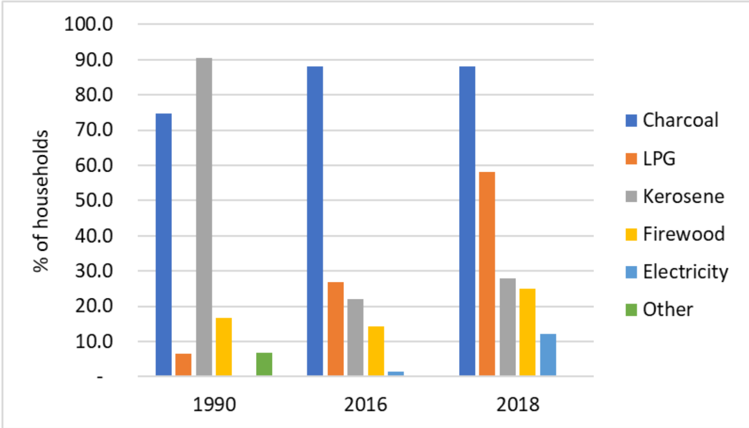


Figure 1. Changes in the percentage of households using five cooking-fuels in Dar es Salaam between 1990 and 2018. Source: Doggart et al.

fuel-use trends with policy shifts. Price data for other cooking fuels were collected and compared with charcoal prices per unit of usable energy.

Key findings of the survey

1. **Urban households have not transitioned from charcoal to modern cooking fuels**, over the last 30 years. A higher proportion of Dar es Salaam households used charcoal in 2018, than in 1990 (Fig. 1). Charcoal has remained popular despite three successive energy policies promoting a transition to modern fuels.

2. **Demand for charcoal in Dar es Salaam has quadrupled** from 0.22 million tonnes in 1990 to 0.94 million tonnes in 2018. Increased charcoal demand is largely driven by population growth and urbanisation.

3. **Charcoal is popular because it is cheaper than other fuels**, including LPG. Only firewood is cheaper, per unit of energy. Widespread non-payment of charcoal royalties contributes to the low cost of charcoal.

4. **Policy interventions have influenced cooking-fuel choices, primarily by impacting fuel cost.** For example, less households used kerosene in 2018 than in 1990, due to a fuel levy increase on kerosene in 2011, making it more expensive. In contrast, LPG's popularity increased due to a fuel levy exemption in 2015. However, more LPG use has not resulted in less charcoal use (Fig. 1).

5. **Government revenue from royalties on the charcoal used in Dar es Salaam should exceed US$ 98 million.** In practice, less than 10% of this is collected.

6. **National energy policies do not promote sustainable, efficient and safe charcoal production and use**. Charcoal is excluded from the scope of the National Energy Policy.

7. **Most households in Dar es Salaam use more than one fuel.** On average, households use 2.1 fuels for cooking. An LPG/charcoal combination is most popular.

Recommendations from the study

Embrace charcoal into national policy

Based on historical trends, charcoal will continue to be used by most urban households for the foreseeable future. A new vision is needed for charcoal that amplifies the positive outcomes of the trade, while reducing the negative impacts. Changing energy and forestry sector policies to reflect the continued popularity of charcoal, could achieve outcomes aligned with the national development vision of building a strong and resilient economy. Relevant policy options include: supporting sustainable charcoal production in community-managed woodlands; reducing the health impacts of charcoal use, through promotion of low-emission stoves and safer cooking practices; building technical expertise along the value chain; improving revenue collection; improving inter-sectoral coordination around charcoal; and working with communities and other stakeholders to improve governance along the value chain.

The issue of whether or not to adopt a National Charcoal Policy has been under consideration for several years. For example, a Charcoal Task Force was formed in 2019 with a mandate to advise the Minister for Natural Resources and Tourism on the development of a National Charcoal Policy and, in 2021, the Strategic Plan of the Ministry for Natural Resources and Tourism included the development of a National Charcoal Strategy, as a target. Whether MNRT develop a separate policy or a strategy, the important issue will be the direction that the strategy or policy takes, and the implementation commitment. Clear government support for integrating sustainable charcoal production into natural forest management, would mark an important step towards improving charcoal's economic and ecological outcomes.

Support research and monitoring of charcoal

Policy-relevant research on charcoal's contribution to the economy, sustainable production options and safer production and use options, is needed. Similarly, more systematic and transparent monitoring and reporting around charcoal production, use and revenues, is needed in order to provide a sound evidence base for policy development.

TFCG News

Hon. Dr Damas Ndumbaro (MP)- Minister for MNRT and Hon Mary Masanja Deputy Minister for MNRT (both centre) meeting with TFCG Executive Director, Charles Meshack (2nd to left) and MJUMITA Executive Director, Rahima Njaidi (2nd to right)to discuss sustainable charcoal, in March 2021.

Scaling-up sustainable charcoal production into four new districts

Since 2012, TFCG and the Community Forestry Network of Tanzania (MJUMITA) have piloted a model of community-based forest management that integrates sustainable charcoal and timber production. The model has been introduced in 39 villages in Morogoro, Lindi and Iringa Regions. Communities who have adopted the model have benefitted from improved forest management, rural employment and community-led development projects. In 2019, financed by the Swiss Agency for Development and Cooperation, the project entered its third phase with a focus on scaling-up and strengthening mechanisms to sustain the model.

Since then, the model has been expanded into villages in Liwale, Nachingwea, Ruangwa and Kilolo Districts.

The model involves the establishment of community-based forest management, providing communities with a legal mandate to manage and benefit from their forests. Management plans for the reserves include provisions for harvesting trees for charcoal production from areas designated as charcoal forest management units (FMUs). These FMUs comprise up to 20% of the total reserve area, with the remaining 80% designated for protection and other uses. Harvesting follows a 24-year rotation based on the mean annual increment for Tanzanian woodlands.

Charcoal production fees have generated substantial revenues for the forest-owning communities who have used their charcoal revenues to manage their forest reserves and to improve social services including education, health and infrastructure. Participating communities have earned more than one million US dollars.

TFCG Executive Director, Charles Meshack, receives prestigious international prize

Mr Charles K. Meshack, Executive Director of the Tanzania Forest Conservation Group (TFCG) has received the French Republic's Human Rights Prize "Liberty, Equality, Fraternity 2020" for TFCG's work on community-based forest management in Tanzania. The French Ambassador, His Excellency Frédéric Clavier, awarded the prize at a special ceremony held at the Alliance Francaise in Dar es Salaam on 10th December 2020.

The prestigious prize is awarded annually to organisations or individuals who have made a significant contribution to human rights. TFCG won the prize under the theme 'Defense of environment and biodiversity'.

Protecting Magombera Forest

Magombera Forest is a unique lowland forest located between the Nyerere and Udzungwa National Parks. The forest is home to the Endangered Udzungwa red colobus monkey, the Magombera chameleon and the Udzungwa dwarf galago. Numerous other internationally threatened species of plants and animals are present in the forest. With support from TFCG, Reforest Africa, the Ministry of Natural Resources and Tourism and the surrounding communities, the forest was formally protected as a Nature Forest Reserve in 2019. Since then, TFCG have been working with local stakeholders including communities and the Tanzania Forest Services Agency to establish joint forest management and promote ecotourism. The reserve has a well-maintained tourist trail, where visitors can see monkeys, birds, and other wildlife. The protection of the forest was made possible following major donations by the World Land Trust, Rainforest Trust, the Aage V. Jensen Charity Foundation and Flamingo Land. http://www.tfcg.org/what-we-do/conserve/magombera-forest/

Conserving Coastal Forests on the Rondo Plateau

At 900 metres, the Rondo Plateau's elevation makes it stand out from other coastal forest fragments. The plateau draws moisture and creates forests rich in endemic flora, including sixty endemic plant species. The plateau also provides habitat for the Coastal Forest-endemic and Critically Endangered primate, the Rondo dwarf galago. With support from the World Land Trust, TFCG is supporting ten village land forest reserves covering over 20,000 hectares in, and around, the Rondo Plateau. Over the last 18 months, five village land forest reserves covering 15,055 hectares have been established, and support has been provided to strengthen reserve management and improve livelihoods in the participating communities.

Scaling-up the eco-schools approach

With support from the Danish Outdoors Council, TFCG have been scaling up the eco-schools approach into 102 schools in Lindi, Morogoro and Iringa Regions. The eco-school movement is the largest global sustainable schools network, with over 50,000 schools in 70 countries. The approach involves learning and action in schools and communities. Eco-schools are designed to nurture generations of sustainably-minded and environmentally conscious people. As well as promoting learning on the environment and sustainability, schools engage in environmental sustainability projects such as tree planting and forest protection. Since 2016, TFCG has worked with the Ministry of Education and Local Government Authorities to introduce the programme in Tanzania. In 2020, thirteen schools were awarded the internationally-recognised Green Flag to mark their success in integrating sustainability and environmental education.

Promoting community-based forest management along the Standard Gauge Railway

With the ongoing modernization of the Standard Gauge Railway, the Tanzania Railway Corporation requested TFCG's assistance to support communities along the railway to implement community-based forest management. TFCG are now working with 8 communities to improve the management of their natural forests and conserve biodiversity, along the railway line.

Tree planting

In the West Usambara and Udzungwa Mountains, TFCG have been working with 25 communities to promote tree planting, through a project financed by the Yves Rocher Foundation. In its first year, the project has succeeded in supporting communities to raise 250,000 tree seedlings.

Assessing the new village land forest reserve in Nndawa Village on the edge of the Rondo Plateau, Lindi

Obituary

Peter Sumbi (1961 – 2020)

Peter Sumbi dedicated his life to conserving Tanzania's forests. Through his commitment, sense of humour and optimism, Peter succeeded in inspiring people from all walks of life to care about and protect Tanzania's Coastal and Eastern Arc Mountain Forests.

Peter began his career working with the government supporting community tree-planting in Morogoro Region. From there he was offered a place at Sokoine University of Agriculture to study forestry. After graduating, Peter went on to study forest policy at Oxford University, in the UK, and was later awarded an MSc in Protected Landscape Management from the University of Wales.

From 1993 through 2011, Peter worked with the international conservation NGO, WWF. In the early years, Peter worked closely with local communities to protect forests and plant trees. His infectious enthusiasm meant that he was quickly promoted and, by 2000, he became the head of the WWF Tanzania's National Forest Programme, a position he held until 2012. An early advocate for community-based forest management, he supported numerous communities to protect their forest and miombo woodland, including several biologically important and threatened forests in the Udzungwa and East Usambara Mountains, and in the Matumbi Hills. In 2011 he was awarded WWF's Global Staff Award for his outstanding service in championing WWF's work in community conservation. In 2015, Peter launched Tanzania Botanical Exploration Limited, working on a range of consultancies, as well as advocating for the Eastern Arc Mountain forests to be granted World Heritage Site status.

For over 25 years, Peter Sumbi served on TFCG's Committee, including as Treasurer. He generously volunteered his time to TFCG, always ready to provide advice and attend meetings.

He also mentored many young Tanzanian foresters and conservationists, and was always willing to answer questions from a long stream of expatriate advisors, students and 'experts' on matters relating to forest conservation in the country.

Peter had a gift for bringing people together. He coordinated several influential committees including the National Coastal Forests Task Force, the National Miombo Working Group, the National FSC Working Group and the Tanzania BioEnergy Forum. Peter's enthusiasm, integrity and wicked sense of humour brought out the best in those around him. Once the meetings were over, Peter loved nothing more than to share a beer and some nyama choma with colleagues.

Peter's dedication to conservation saw him constantly being driven across the country to attend meetings and visit projects. On two occasions, serious road accidents nearly cost him his life. Later in life, the injuries from those accidents made it difficult for him to walk. Despite chronic pain, leaning on his cane, he always greeted people with a big smile and a quirky 'How are you breathing?'

Peter was a giant in Tanzanian forest conservation and is greatly missed by all who worked with him.

Peter passed away on 5th July 2020.

News of the Arc

The 2021 National Forest Policy Implementation Strategy provides a road map for improving forest management and protecting biodiversity

Over several years, from 2017, careful consideration was given to a revision of Tanzania's National Forest Policy 1998. The review concluded in a decision to retain the existing policy while adopting a ten-year National Forest Policy Implementation Strategy 2021-2031 (NFP IS). The NFP IS was published in May 2021 and aims to guide the implementation of the National Forest Policy. Consistent with the 1998 National Forest Policy, the goal of the NFP IS is 'To enhance the contribution of the forest sector to the sustainable development of Tanzania and the conservation and management of her natural resources for the benefit of present and future generations. The document sets out strategies and targets and indicators for achieving the NFP's four policy objectives. Importantly, the strategy sets a target of reducing Tanzania's annual deforestation rate from 462,000 to 138,600 hectares, by 2031. For Tanzania's high biodiversity forests, the NFP IS sets a target of increasing the area of Nature Forest Reserves from 0.8 million to 2 million hectares by 2031. The strategy also seeks to improve the management of natural forests by reducing the area covered by each extension officer from 25,000 ha to 10,000 ha and increasing the area under community-based forest management to 16 million hectares by 2031.

Expanding Tanzania's Nature Forest Reserves

Since 1997, the network of Nature Forest Reserves has been expanding. On 11th January 2019, the Government announced the establishment of the 2,600-hectare Magombera Nature Forest Reserve. The announcement was the culmination of many years of advocating for the protection of this unique lowland forest at the base of the Udzungwa Mountains.

Plans to expand the network of Nature Forest Reserves in Tanzania's high-biodiversity coastal forests have progressed with the publication, in February 2020, of the government's intention to declare Pugu, Kazimzumbwi, Vikindu and Uzigua Forest Reserves as new Nature Forest Reserves. The purpose of upgrading the reserves from Forest Reserve to Nature Forest Reserve status, is to enhance the protection of the forests' threatened and endemic biodiversity. The two government notices, GN 188 for the 27,684 hectares of the Uzigua forest and GN 190 for the 8,965 hectares of the Pugu, Kazimzumbwi and Vikindu forests, set out the government's intention to establish the two Nature Forest Reserves. As the 90-day objection period has passed, it is anticipated that the process will be finalized in late 2021.

African pitta in Pugu proposed Nature Forest Reserve

Stakeholders express concern over the impact on community-based forest management of Government Notice 417

In May 2019, the Forest (sustainable utilization of logs, timber, withies, poles or charcoal) Regulations, 2019 were published, also known as Government Notice 417 (GN 417). Compared with the 2006 Forest Regulations, a key difference is that the scope of the 2019 regulations includes Village Land Forest Reserves (VLFRs). The inclusion of VLFRs in the regulations has raised a number of concerns among communities and NGOs. These centre on the transfer of rights to issue harvesting permits for harvesting in village land forest reserves away from the communities who manage the reserve, in favour of district harvesting committees. This has raised concerns that communities must bear the costs of forest management for VLFRs but are being disempowered from decision-making and constrained in their capacity to generate revenues. Meanwhile, NGOs and development partners are concerned that their support for CBFM is being undermined by the new regulations and that the new system adds costs, creates delays and limits communities' ability to attract forest-product traders. The Forestry and Beekeeping Division have requested stakeholders to share evidence on the impact of GN 417.

New research on development corridors and the Eastern Arc Mountains

By Molly Brown, Development Corridors Partnership, United Nations Environment Programme – World Conservation Monitoring Centre

Development corridors are extensive, often transnational and linear, geographical areas targeted by governments for public and private investment to spur economic growth with broad objectives to achieve national development visions. Development corridors aim to diversify and improve livelihoods by making trade, communications, and services more efficient. They must therefore protect the integrity of ecosystems and biodiversity and respect the rights and livelihoods of communities from the earliest stages of planning, through implementation, to post-project completion.

Figure 1. depicts the route of a best practice led approach to avoid and mitigate the often-irreversible negative

impacts poorly planned infrastructure projects create in the landscapes they pass through. A key example of a biodiverse ecosystem vulnerable to the impacts of development in Tanzania is found in the Udzungwa forests and woodlands in the Eastern Arc Mountains, which is flanked by the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) (see figure 2.).

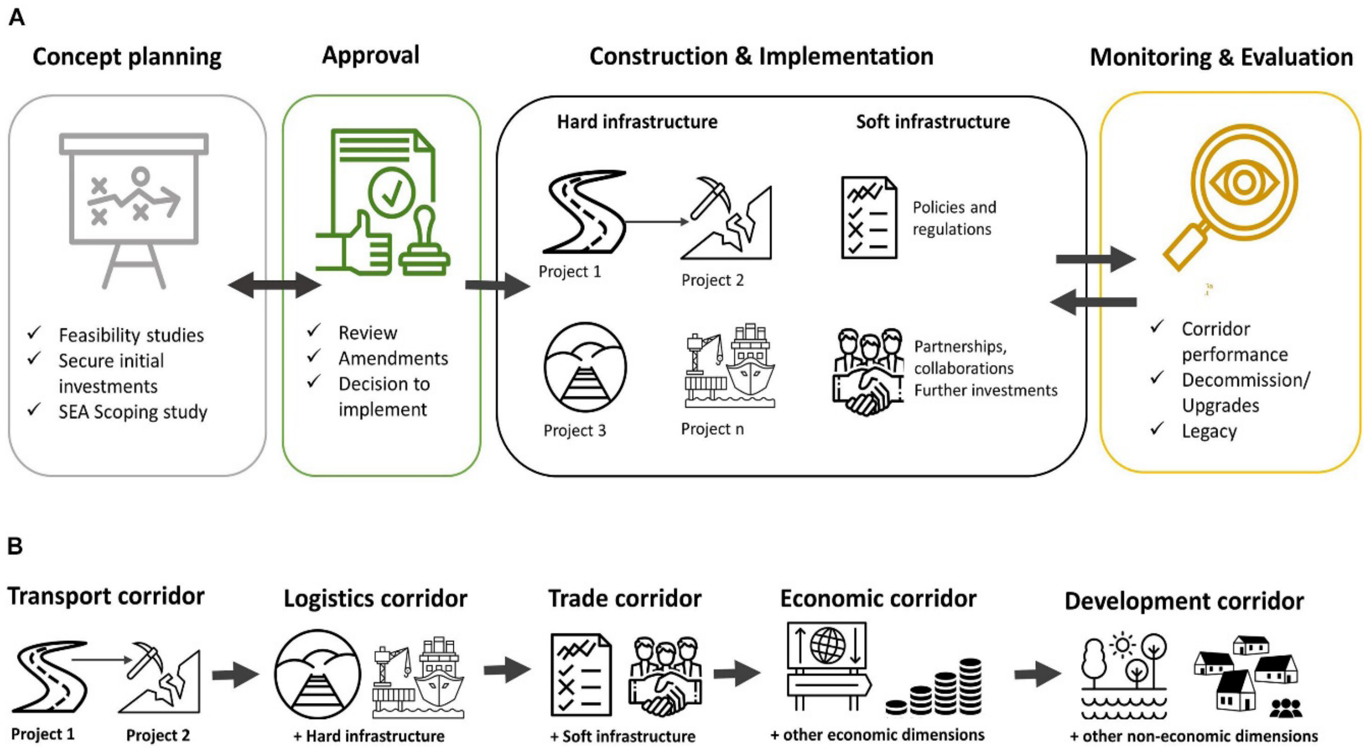


Figure 1. (A) Main phases of a development corridor. (B) A simplified example on how a transport corridor may evolve to a development corridor as hard and soft infrastructure and other economic and non-economic dimensions are incorporated. Source: Juffe-Bignoli et al., 2021[1]

Over the past four years, the Development Corridors Partnership (DCP)[2] has enhanced the scientific evidence base for development corridors across Tanzania and Kenya. This evidence is based on multidisciplinary research across natural and social science disciplines, and capacity building initiatives, which included hosting trainings, facilitating workshops and stakeholder engagement activities.

To ameliorate ongoing and future threats to natural resources and biodiversity in the SAGCOT region, DCP provide key insights into how to avoid ecosystem damage and biodiversity loss. By using such best practice tools to address direct, indirect, and cumulative impacts, SAGCOT decision-makers can incorporate further DCP evidence to improve biodiversity net-gain (or at least no net-loss) via the restoration and protection of ecological connectivity corridors that support the population survival of keystone species such as African elephants (*Loxodonta africana*) in the Kilombero catchment (see Figure 2.), which is subject to worsening habitat fragmentation due to agricultural pressure and land use change.

1 Juffe-Bignoli et al. 2021 Front. Ecol. Evol., Mitigating the Impacts of Development Corridors on Biodiversity: A Global Review. https://doi.org/10.3389/fevo.2021.683949

2 Development Corridors Partnership website available at: https://developmentcorridors.org

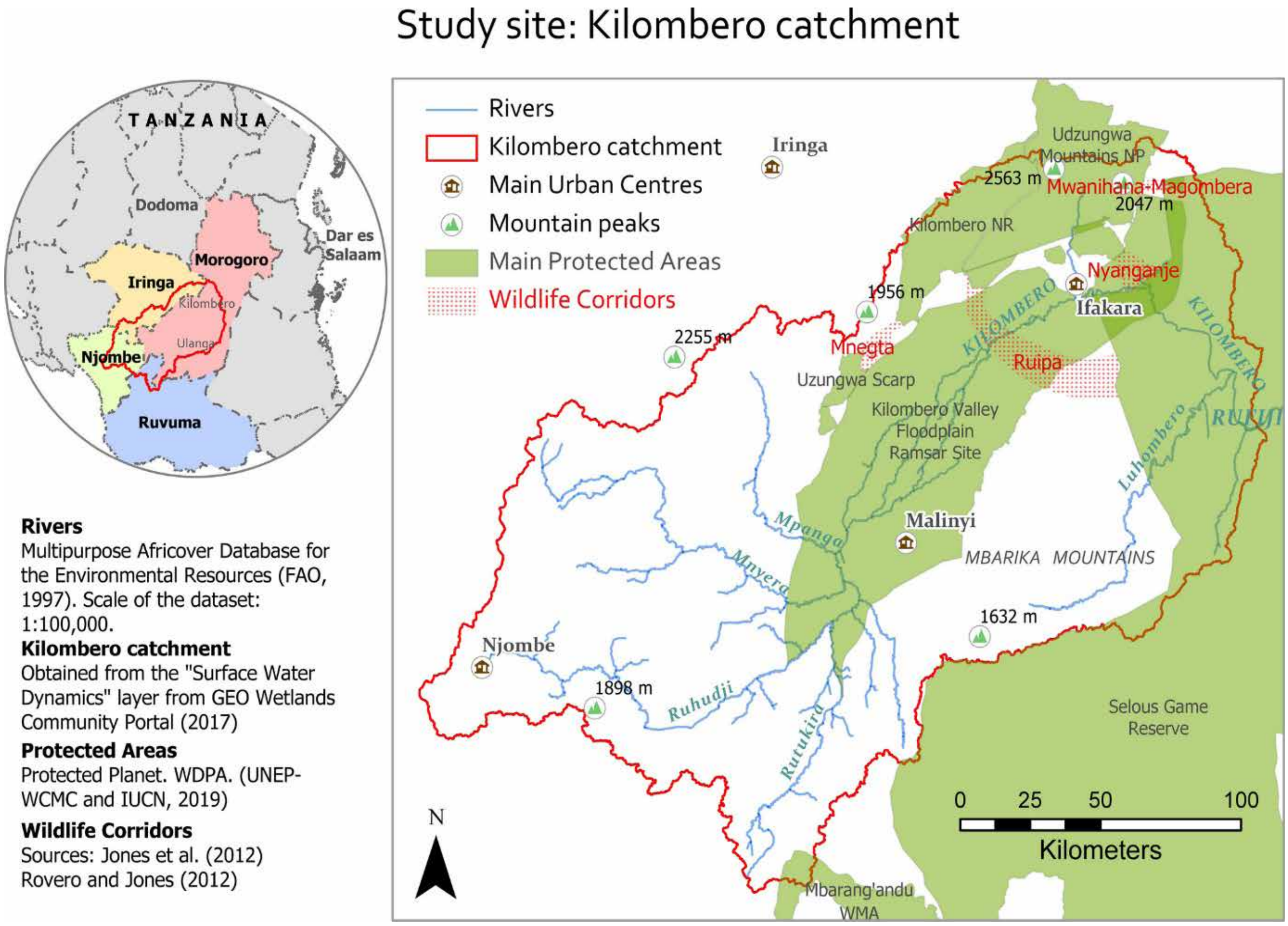


Figure 2. Kilombero catchment (study area, SM1) with its main rivers, urban centres, wildlife corridors and protected areas (UNEP-WCMC & IUCN, 2018). Source: Cisneros-Araujo et al., 2021[3]

Grounded in the work of the DCP, a key message to highlight is the critical need to improve the accessibility and practical nature of scientific evidence. Evidence created by development corridor practitioners must be targeted for decision-makers and diverse stakeholder groups from financiers, management authorities, contractors, and local communities to progress towards the realisation of sustainable development futures. The capacity building strategy of the DCP established effective routes to help bridge the science-policy gap in development corridors, directed through an impact focused lens of participatory methods. However, the importance of diverse global stakeholder engagement cannot be underestimated in development corridors. International investment commonly facilitates national development visions. Therefore, a top-down approach led by partnerships across public and private sectors continues to determine the will to follow sustainable infrastructure best practices from the earliest planning, financing, and contracting stages of a corridor's lifecycle.

3 Cisneros-Araujo et al., 2021 Remote sensing of wildlife connectivity networks and priority locations for conservation in the Southern Agricultural Growth Corridor (SAGCOT) in Tanzania. Rem. Sens. Eco. Cons. 7:3, https://doi.org/10.1002/rse2.199

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About the Tanzania Forest Conservation Group

The Arc Journal is published by the Tanzania Forest Conservation Group (TFCG). Established in 1985, TFCG is a Tanzanian Non-Governmental Organisation promoting the conservation of Tanzania's high biodiversity forests.

TFCG's Vision

We envisage a world in which Tanzanians and the rest of humanity are enjoying the diverse benefits from well conserved, high biodiversity forests.

TFCG's Mission

To conserve and restore the biodiversity of globally important forests in Tanzania for the benefit of the present and future generations. We will achieve this through capacity building, advocacy, research, community development and protected area management in ways that are sustainable and foster participation and partnership.

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Tanzania Wildlife Research Institute (TAWIRI)

Tanzania Wildlife Research Institute (TAWIRI) is a parastatal organization under the Ministry of Natural Resources and Tourism responsible for conducting and coordinating wildlife research in the United Republic of Tanzania. TAWIRI Head Office is located at Njiro Hill, Arusha.

TAWIRI was established by an Act of Parliament in 1980 to conduct, supervise and coordinate wildlife research in the United Republic of Tanzania and disseminate timely and quality scientific information that will enhance the management and utilization of wildlife resource in the country.

Mission: To facilitate an effective provision of wildlife research findings and acquisition of sufficient wildlife information in collaboration with all stakeholders.

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