Journal of the Geographical Association of Tanzania, Vol. 40 No. 1: 177–196

Adaptation to Climate Change Through Urban Forestry: Perceptions and Actions of Urban Residents in the Dar es Salaam City

Magreth Bushesha*

Abstract

This paper examines perceptions and actions of urban residents on urban forestry and adaptation to climate change in Kigamboni District in the city of Dare es Salaam, Tanzania. It employs an exploratory research design to capture the perceived link between urban forestry and climate change, using a semi-structured questionnaire administered to 107 respondents obtained through a simple random sampling technique. Yielded qualitative and quantitative data were analyzed using content analysis and the Statistical Package for Social Sciences (SPSS), respectively. The findings mostly indicated perceptions inconsistency across variables among respondents, and between the current study and past studies. Also, the number of trees planted per household is relatively low considering the space available per home ground. The paper concludes that it is time for Tanzania to introduce a national forest city program to easily track developments and achievements in the urban forestry sector.

Keywords: *urban forestry, climate change, urban heat island, Kigamboni, Tanzania.*

1. Introduction

Climate change is one of the global challenges facing humanity today. The Intergovernmental Panel on Climate Change (IPCC) (2018) warns that if no action is taken to stop the current warming rate, then global warming is likely to reach 1.5°C between 2030 and 2052. Climate change increases the levels of vulnerability to heat waves in urban areas (Satterthwaite et al., 2007). Higher temperatures occur in urban areas than in outlying rural areas because of diurnal cycles of absorption and re-radiation of solar energy, and heat generation from built physical structures, which are more concentrated in urban centres than in rural areas. Paved grounds, which are a common characteristic in urban than in rural areas, also contribute to the absorption and re-radiation of solar energy. The heat stress events in urban areas can affect the health, labour productivity, and leisure activities of an urban population (McPherson, 2008). Heat waves are known in intensifying mortality levels in respective locations. In 2003, for example, heat waves in Europe led

*Department of Geography, Open University of Tanzania, Dar es Salaam, Tanzania: magreth.bushesha@out.ac.tz

to 20,000 deaths; mostly among the poor and isolated elderly. Also, in Andhra Pradesh, India, a heat wave killed more than 1,000 people in the same year. Most of those who died were labourers working outside in high temperatures in urban areas (Satterthwaite et al., 2007).

Climate change, especially with raising temperatures, leads to increased costs of cooling within buildings, formation of smog in cities, and the degradation of green environments in urban areas. Further, if cooling buildings is through fossil fuel, then that adds to the emission of the greenhouse gases. Climate change also magnifies problems associated with air pollution in urban areas. Not only that but also increased frequency of extreme weather events such as flush floods, intensive and severe flooding, prolonged droughts, intensified dry weather and excessive storm exacerbates the vulnerability of urban areas to the impacts of climate change (Satterthwaite et al., 2007). It is this kind of vulnerability of urban areas to climate change that makes adaptation an important agenda for urban areas. One of the most popular adaptation strategies to climate change option in urban areas is urban forestry.

The concept 'urban forestry' in some literature focuses more on forest ecosystem, while in others it goes beyond forest ecosystem to encompassing street and park trees. This study adopts a definition by Konijnendijk et al. (2006), who defines urban *forestry* as "… the art, *science and technology* of managing trees and forest resources in and around urban community ecosystems for the physiological, sociological, economic, and aesthetic benefits trees provide to society" (ibid: 1). By 'urban forest', therefore, the study will be referring to both forest ecosystems as well as individual/isolated planted trees in urban areas, including trees around home grounds and the general built environment; trees around open spaces and parks; as well as trees along streets.

McPherson (2008) observed that urban forests are important for climate change mitigation, as well as adaptation in urban areas. Trees in urban areas, for example, reduce the amount of greenhouse gases in the air by sequestering carbon dioxide. Also, when trees are planted around buildings, they cool such buildings and surroundings, and as a result people use lesser energy for cooling buildings. Lesser energy use means lesser emission of greenhouse gases, especially when the source of energy is fossil fuel. Through the two functions, urban trees contribute to climate change mitigation (IPCC, 2018; McPherson, 2008).

A range of motives behind planting trees in urban areas is presented in the literature; including acquiring trees for multiple environmental and health benefits such as shade for reducing urban heat island (UHI). The National Geographic Society defines urban heat island (UHI) as a metropolitan area that is a lot warmer than the rural areas surrounding it (https://www. nationalgeographic.org/encyclopedia/urban-heat-island, accessed 28/08/2019). UHIs

are created in congested places: people, cars, industries, and trains all create heat. When buildings act as insulators, it leads to solar heat lingering around; and when they absorb heat, they later release it, adding to the heat in their vicinity. Other environmental and health benefits of trees in urban areas include improving air quality, carbon sequestration, enhancing health by fostering walking and providing a connection with nature; beautifying neighborhoods; and reducing storm water runoff (Pincetl et al.,2013). Trees also provide wood fuel (be it charcoal or wood), food, animal fodder, grazing, timber and poles, spices, fiber, and medicines (FAO, 2016a).

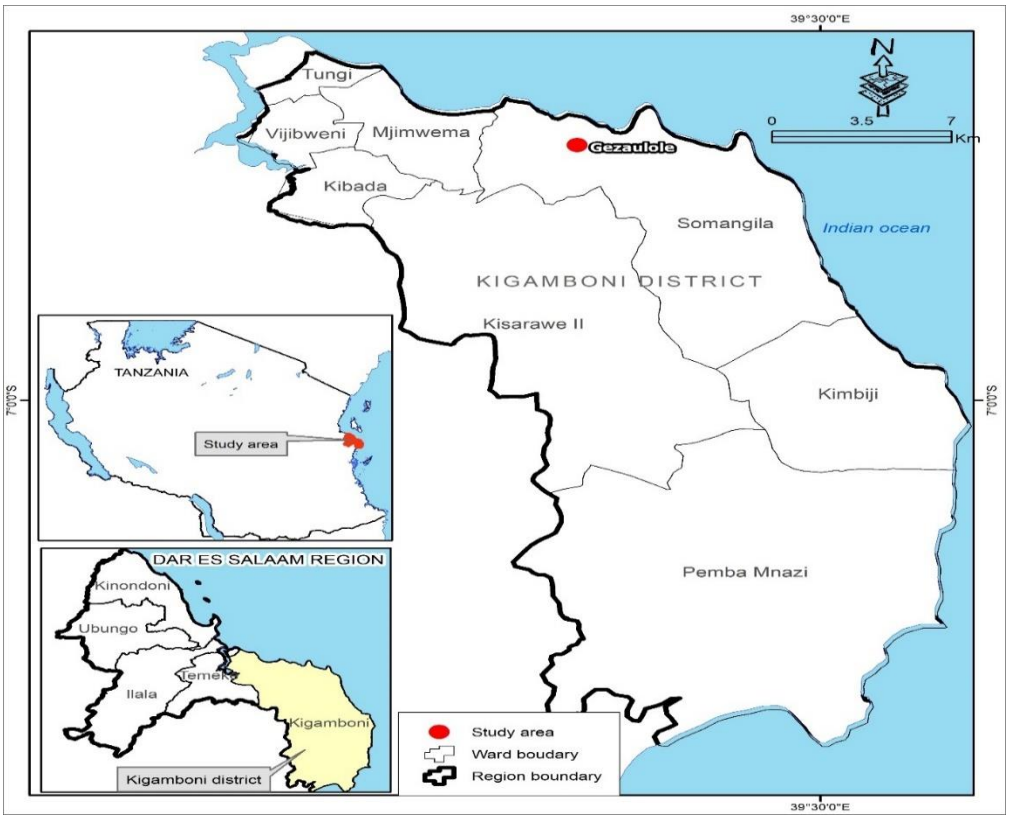
Trees in urban areas of Tanzania are commonly planted around homesteads, along streets, as well as in parks and open spaces. Unfortunately, so far there is no literature explaining peoples' perceptions of the role of urban forestry in adaptation to climate change in Tanzania despite the fact that perceptions play an important role in peoples' responses to climate change (Bushesha, 2014). In fact, perceptions determine adaptation (responses) choices (Waibel et al., 2017). Živojinović and Wolfslehner (2015) noted that stakeholders in urban forestry clearly perceived the role of urban trees in adaptation to climate change, but adaptation actions were hindered by such factors as the lack of coordination and communication between stakeholders, scale-relevant technical and scientific data, and the lack of specific regulations and financial means.

The protection motivation theory (PMT) describes how individuals are motivated to react in a self-protective way towards a perceived threat. The theory asserts that "...people protect themselves based on four factors: the perceived severity of a threatening event, the perceived probability of the occurrence or vulnerability, the efficacy of the recommended preventive behaviour, and the perceived *self efficacy* (https:// en. wikipedia. org/ wiki/ Protection motivation theory. Accessed 24/08/ 2020). In this study, PMT is used to understand how perceptions on the role of urban forestry influence adaptive actions to climate change in urban areas. Notably, as far as the PMT is concerned, the study focus is on the copping appraisal. The study intends to addresses the following specific objectives: (i) identify the importance of planting trees in urban areas; (ii) examine the roles of urban trees in adaptation to climate change; (iii) explore priority actions towards conservation of urban trees; (iv) identify aspects considered when selecting tree species; and (v) determine challenges facing tree-planting in the study area.

2. Context and Methods

2.1 Study Area

The study was conducted in Kigamboni district of Dar es Salaam region in Tanzania. The Kigamboni district is located south-east of Dar es Salaam (Map 1). It has an area of 577.86km^2. A large part of the district is flat with an elevation ranging from 20m to 50m above sea level; and consists of swampy areas in the central part and nearby sea shores.



Map 1: The Study Area

Source: Geographical Information System Lab, Institute of Resource Assessment, University of Dar es Salaam (2019)

The climatic condition of Kigamboni is tropical with high temperatures, modest winds, high humidity, and absence of a cold season. The temperature ranges from a minimum of 18°C in July, to a maximum of 32°C in February. The mean annual temperature is 26°C, with a mean daily range of ±4°C. The municipality receives moderate rainfall from November to December, and heavy rainfall between March and May. Rainfall patterns are, however, extremely variable and unpredictable (URT, 2019).

The low-lying part of Kigamboni is occupied by informal settlements, making them prone to flooding during rainy seasons. The soil cover is predominantly sandy clay, intercalated with weathered limestone. According to the Population and Housing Census of 2012, the district had a total population of 162,932; whereby 81,199 were males, and 81,733 were females. At 5.4% annual growth rate, the population projection for the year 2018 is 225,938; with 112,597 males, and 113,341 females (URT, 2019). Agriculture is an important economic activity in the district.

Due to the expansion of economic activities, the Kigamboni municipality is growing fast. Land degradation, which is partly associated with population increase and massive land clearance for settlements, is the major challenge facing the district (URT, 2019). The forecasted infrastructural developmental in the district have implications on climate change and global warming as they suggest more emissions of greenhouse gases. The population growth rate suggests more land clearance for settlements and other associated infrastructure, adding to the ongoing land degradation and associated impacts on climate change, i.e., the rainfall pattern is already reported to be highly variable and less predictable (URT 2019). That being the case, understanding urban forestry affairs in the area is important as it forms an important base for assessing the district's preparedness in adaptation to climate change.

2.2 Methods

An exploratory research design was adopted for the study. The choice of the research design was because, so far, the literature pertaining to climate change and urban forestry in Tanzania is limited. Dar es Salaam region was randomly selected for the study from the cost regions of Tanzania Mainland, which are considered to be most vulnerable areas to the impacts of climate change. The other regions include Coast, Tanga, and Mtwara. Kigamboni district was selected purposively among the five districts in Dar es Salaam—Ilala, Kinondoni, Temeke, Ubungo, and Kigamboni itself. Choosing Kigamboni was because there is much prospect of growth in the district economically and socially. The Gezaulole area was selected randomly from the rest of the surveyed areas in the district. The study involved 107 respondents who responded to a semi-structured questionnaire. These were selected using a simple random sampling technique. Qualitative data were analysed using content analysis, whereas numerical data were analysed using simple descriptive statistical analysis with the help of the IBM Statistical Package for Social Sciences (SPSS) computer software.

3. Results

3.1 Importance of Planting Trees in Urban Areas

One of the questions that the respondents were asked was on what they considered to be the importance of planting trees in urban areas. Most of the respondents (85%) were of the perception that trees in the study area improve air quality; only 15% were not in agreement with the statement (Table 1).Table 1 also indicates that 50.5% of all the respondents voted 'Yes' to the statement that trees in Kigamboni area are a source of rainfall; while over 49% did not acknowledge it. Furthermore, only 49.5% of the respondents agreed with the statement that trees in the study area cool temperatures; while 50.5% were not in agreement with the statement (Table 1).

Table1: Importance of Planting Trees in Urban Areas

Importance of Trees in Urban Areas	Yes	%	No	%
Trees in urban areas improve air quality	91	85	16	15
Trees in urban areas cool temperature	53	49.5	54	50.5
Trees in urban areas are sources of rainfall	54	50.5	53	49.5
Trees in urban areas act as wind barrier	52	48.6	55	51.4
Trees in urban areas provide sources of fuel wood	29	27.1	78	72.9
Trees in urban areas provide timber	28	26.2	79	73.8
They reduce stress	20	18.7	87	81.3
Trees in urban areas protect water sources	19	17.8	88	82.2
Trees in urban areas benefits real estate valuation	17	15.9	90	84.1
Trees in urban areas add value to urban ground	15	14	92	86
Trees in urban areas regulate micro-climate	9	8.4	98	91.6
Trees in urban areas mitigate noise pollution	8	7.5	99	92.5

Source: Field data, (2019)

Data from the FGDs indicate that tree-planting is important for freshwater availability. One of the key informants had the following to say as far as fresh-water availability and tree-planting in the study area is concerned:

> *"Freshwater is a serious challenge here. We are not connected to DAWASCO* [Dar-es-salaam Water Supply and Sanitation Authority]; [and] *we suffer a lot especially during the dry months of August and September...and sometimes even October. You can see by yourself now a twenty-liters tin of freshwater is sold at TZS500 and sometimes we pay up to TZS700, how many do you think can afford?...The situation goes worse year after year. In the past we could have freshwater in our shallow wells, even though water could diminish during the dry months, still there could be some; but not nowadays.... Rains are erratic and very unpredictable; sometimes we experience too long dry weather.... Yes, we are being told to plant trees, I have planted some here as you can see.... Yes, I think if everyone plants trees, we may restore the rainfall we used to have in the 1970s"* (Key Informant 07/08/2018).

3.2 Roles of Urban Trees in Adaptation to Climate Change

Respondents were asked to vote for or against five statements that were specifically directed to assess people's perception on the roles of trees in the adaptation to climate change in urban areas. Table 2 shows that 78% of all the respondents voted 'Yes' to a statement that trees in urban areas cool the local environment during hot seasons through evapotranspiration. This is surprising since, as can be seen in Table 1, only 49.5% of the respondents agreed to the statement that trees in urban areas cool temperature. Also, Table 2 shows that only 52.3% of the respondents voted 'Yes' to the statement that trees mitigate global warming by sequestering the greenhouse gas carbon dioxide. However, as indicated earlier in Table 1, 85% of all respondents voted 'Yes' to the statement that trees in urban areas improve air quality.

Table 2: Percent Roles of Urban Trees on Adaptation to Climate Change

Role of urban trees on adaptation to climate change	Yes	No	Total
Cool the local environment during hotter seasons through evapotranspiration	78	22	109
Mitigate global warming by sequestering the greenhouse gas carbon dioxide	52.3	47.7	109
Reduce demand for air conditioning and refrigerators, which is mostly powered by greenhouse-gas-emitting fossil fuels, e.g. natural gas, or coal	18.3	81.7	109
Add on greenhouse gas emission through respiration and litter decomposition	20	89	109

Source: Field data, (2019)

When asked whether trees play any role in the adaptation to climate change, one key informant had the following to say:

> *"As far as I am concerned, nowadays it is too hot. Now, these trees that we are planting provides us with some shade, and when they sway, we get even more fresh air"* (Key Informant 09/08/2018).

3.4 Priority Actions Towards Conservation of Urban Trees

When respondents were asked on the kind of actions they would give priority to in efforts to conserve urban forests, most (90.8%) indicated that they would give priority to environmental education vs. police surveillance, passive protection, and others (Table 3).

Table 3: Percent Priority Action for Conservation of Urban Forests

Priority action	Yes	No	Total
Police surveillance	11.9	88.1	109
Passive protection (e.g. fences, etc).	18.3	81.7	109
Environmental education	90.8	9.2	109
Others (specify)	0.9	108.1	109

Source: Field data, (2019)

One key informant had the following to say:

> *"I think more education is needed here on the importance of tree-planting in our area. Most of us take trees for granted, some people don't even know that trees are important for us to get freshwater.... You can see people cutting trees for different uses but never think of replacing them, and you wonder what they will cut tomorrow to meet their whatever needs when all trees will be gone. Charcoal makers are very troublesome: they just know how to cut trees and not how to plant trees... We used to have plenty of trees here...now we are suffering with unpredictable wet seasons. The weather is also too hot...err...it is just chaos I may say… We need to be educated more for us to save the environment. After all, it is for our own benefits" (*Key Informant, 09/02/2019).

On the other hand, however, the study findings indicate that most people grow between 1-10 trees around home compounds (Table 4). Very few people grow over 20 trees around home compounds.

Table 4: Number of Trees Planted Around Homestead

Number of Trees	Respondents	%
01-10	71	65.1
11-20	22	20.2
21-30	8	7.3
31-40	5	4.6
41-50	3	2.8
Total	**109**	**100.0**

Source: Field data, (2019)

3.5 Aspects Considered When Selecting Tree Species

Respondents were asked to indicate aspects they considered when selecting tree species to plant. Table 5 presents the results. It should be noted that there was no mention of specific tree species; rather the author intended to capture perceptions on tree qualities that respondents would consider important for planting in their area. The results indicate that trees with a high ability to provide shade are a choice of the majority of the respondents (89%).

Table 5: Aspects Considered When Selecting Tree Species N=109

Aspects	Respondents	%
Trees with high ability to provide shade	97	89
Trees that can protect water sources	22	21
Trees that are highly resistant to pollution	22	21
Trees that are resistant to drought	14	13
Trees that are resistant to flooding	37	35
Trees that make good wind barrier	39	36
Trees that can make good fence for my home	44	41
Trees that can give good timber for building material	9	8
Trees that can make good wood fuel	15	14
Trees that can provide good building materials	41	38
Trees that are resistant to pest and pathogens (general damages)	4	4
The space available necessary for its adequate development	6	6
Maintenance cost	4	4
Trees that can make good aesthetics	5	5

Source: Field data, (2019)

Fencing received second priority among respondents (41%), although they were less than 50% approval. Therefore, this is to say that more than 50% of the respondents indicated that they do not consider fencing as an important aspect when selecting tree species to plant.

Trees that can give good timber for building materials captured the attention of 38% of the respondents as a factor they would consider if they were to select tree species to plant around their homes (Table 5). This is to say that the majority did not consider it as an important factor in selecting trees for planting around home in urban areas. Trees that can protect water sources and those that are highly resistant to pollution received the attention of 21% each. Only 13% of all respondents thought that trees that are resistant to drought would be a priority to them (Table 5). The findings further show that only 36% of the respondents would consider wind barrier as an important factor when selecting tree species to plant around homes (Table 5). Reasons behind this low rate of agreement on this factor are not clear; further studies may consider making a follow-up on this.

3.6 Challenges Facing Tree Growing

Most of the respondents (60.6%) voted 'Yes' to the statement that limited space is a hindrance towards tree-planting in the study area (Table 6). Also, the perception that the lack of education is a challenge facing the community towards planting trees was voted 'Yes' by more than a half (52%) of the respondents. Although less than half of the respondents (42.2%) voted 'Yes' on the lack of water for irrigation as a hindrance to tree growing, the percentages indicates that it captured the attention of a large number of respondents. The remaining factors—i.e., poverty, poor weather, lack of manure and fertilizers, lack of seedlings, lack of appropriate tree species, and lack of clear urban forestry policy—were voted 'No' by most of the respondents (Table 6). This is to say, based on perceptions, the study area faces three major problems pertaining to tree-planting: limited space, inadequate education, and the lack of water for irrigation.

Table 6: Percentage of Perceived Challenges on Tree Growing in the Study Area (N=109)

Sn.	Challenges	Yes	No
1	Limited space	60.6	39.4
2	Lack of education	52.3	47.7
3	Poverty (explain)	4.6	95.4
4	Poor weather	21.1	78.9
5	Lack of water for irrigation	42.2	57.8
6	Lack of manure and fertilizers	17.4	82.6
7	Lack of seedlings	21.1	78.9
8	Lack of appropriate tree species	12.8	87.2
9	Lack of clear urban forestry policy	22.0	78

Source: Field data, (2019)

4. Discussion

4.1 Importance of Planting Trees in Urban Areas

The findings in Table 1 imply that most of the respondents are aware of the functions of trees in the urban environment—i.e., improving air quality as in McPherson (2008). With these findings, one may assert that the people in

Kigamboni district in Dar es Salaam experience poor air quality (i.e., air pollution); and that, it is from this experience that they came to realise that tree-planting improves the quality of air (through carbon sequestration, as well as through trapping the finest particles from the air).

But the findings also suggest that climate change is happening in Kigamboni. This is so because air pollution is a major driver of climate change, and trees improve air quality through carbon sequestration. Hence, the perceptions here imply that without trees. carbon and other pollutants are a big deal in Kigamboni district; which may also mean that there are great chances that climate change is happening in the district. As pointed out earlier, the literature indicates that rainfall patterns are extremely variable and unpredictable (URT 2019). Rainfall variability is one form of climate change.

The few respondents who did not perceive that trees improve the quality of air in the study area are more likely not aware of the function of trees on air quality improvement: such people are not expected to plant trees in view of curbing air pollution and climate change. Hence, it is important to raise awareness on the importance of tree-planting vis a vis adapting to climate change in the study area.

The study findings in Table 1 suggests that almost half of the study population are not expected to plant and manage trees properly in view to improving rainfall in Kigamboni even though most parts of the country experiences decreasing rainfall amounts and seasonal shifts in rainfall patterns (URT, 2012). Rainfall, however, is important as it provides freshwater for a range of uses, including domestic consumption, as well as for urban agriculture (Bushesha, 2019). Almost the whole of the study area is on high demand of freshwater since borehole water in Dar es Salaam in general is too salty to drink, and people find themselves forced to pay a premium for water utility delivered by mobile vendors (UNDP, 2011). Shallow wells assist in freshwater supply in the Kigamboni area. Unfortunately, the existence of such shallow wells depends on rainfall availability.

In quote 1, one may note that the key informant perceives diminishing freshwater resources as partly due to increased dry weather. Also, the informant perceives that tree-planting may play an important role in improving rainfall pattern and freshwater availability. The bad news, however, is that although areas along the coast in the country—including Dar es Salaam—are projected to experience an annual average increase in rainfall, it is also projected that rainfall will more likely fall in 'heavy' events than in the current climate, and so may not contribute to year-round water availability (REITIA, 2017).

Therefore, basing on the study findings, one may say that although there is a good number of people who are aware of the importance of tree-planting in urban areas in the adaptation to climate change, yet there is a need to increase awareness on the link between climate change, rainfall, freshwater, and trees for sustainable adaptation to climate change in the study area.

Through evapotranspiration, trees usually cool areas around (McPherson, 2008). Hence, the findings in Table 1—which show that most of the respondents did not agree with the statement that trees cool the environment—suggest that there is a larger number of people in the study area who are not aware of the role of trees in cooling respective surroundings. This is surprising though, because, since 85% of all respondents agreed with the statement that trees improve the quality of air in the study area, one would expect that the same percentage would have agreed with the statement that trees cool the air; especially because the study area is usually warmer with daily maximum temperatures ranging between 29˚C–32˚C (REITIA, 2017). Therefore, by 'improving the quality of air' one is expected to mean, among other things, 'cooling the usually warmer weather'. But also, one may assume that the usually warmer temperatures in the study area obscures the cooling functions of trees, hence the findings that show only 49.5% of all respondents are in agreement with the statement that trees cool temperature. Therefore, more studies should follow up on what people mean by 'improving the quality of air' to avoid generalisations that, by such a phrase, people mean cooling of the air around, which can lead to misinforming policy.

Around 48.6% of the respondents agreed with the statement that trees act as wind barriers in the study area, while over 50% did not agree with the statement. The reasons why most of the respondents did not agree with the statement are not clear since usually trees act as wind barriers wherever they are (Lo et al. 2017). But one may hypothesize that wind is not a concern in the study area because of the supposedly many buildings, which are likely to obscure the functions of trees as wind barriers.

The literature indicates that deforestation is rampant in urban areas of Tanzania, particularly in forests located in Dar es Salaam and Coast regions. Such deforestation is associated with fuel wood supply in the city (Bushesha, 2015; Mngumiet al., 2013). This being the case, one would conclude that urban forests are a good source of fuel wood: be it in the form of charcoal or firewood. In this study, however, only 27.1% of the respondents acknowledged that trees provide sources of fuel wood: a majority (72.9%) voted 'No' to the statement despite the fact that most of the residents in the city of Dar es Salaam use charcoal for cooking (Ishengoma & Abdallah, 2016; Bushesha, 2015; Mungumi et al., 2013). The findings are also contrary to Salbitano (2016) who noted that fuel wood supply is

one of the most valued urban forestry provisioning services in cities of developing countries. Also, Tavares (2016) noted that 19% of the energy used by urbanities in Cape Verde comes from woody biomass. This may be attributed to the fact that most respondents are not charcoal-makers but buyers, hence they do not think of tree-planting for charcoal making or any wood fuel related production.

Most of the respondents (73.8%) did not agree with the assertion that urban trees provide sources of timber. This is contrary to the existing literature, which presents that trees are known to provide timber (see, e.g., Dwyer, 1992; FAO, 2016b). Furthermore, very few respondents agreed with statements that urban forests reduce stress, protect water sources, benefits real estate valuation, add value to urban ground, regulate micro-climate, and mitigate noise pollution (Table 1). But the literature shows that these are the key benefits that urbanities can have from planting trees (Dwyer, 1992; FAO, 2016b; Tidwell, 2016; Xiao, 2016; Endreny et al., 2017; and Lo et al., 2017). Tidwell (2016), for example, noted that urban forests can improve human health by reducing levels of stress, as also observed by Dandy et al. (2012). Likewise, Xiao (2016) noted that urban forestry improves public's well-being through the provision of key goods and services. He added that urban forests are also important for the protection of water sources. Endreny et al. (2017) noted that urban trees can add value to urban grounds. According to the City of Burlington UFMP 2011-2030 (2010), physical and psychological well-being, noise reduction, and property value-addition are among the key socio-economic benefits of urban forests.

The findings in this study, therefore, means that most people in the study area are not aware of most of the functions of urban forests. This lack of awareness of the importance of trees in the study area is likely to affect any attempts by individuals, groups, or governments to plant trees in urban areas. Dwyer. (1992), for example, noted that the lack of understanding of the potential benefits that urban trees and forests can provide may seriously harm tree-planting plans and management efforts needed to provide those benefits. Hence, the creation of awareness on the benefits that urban dwellers can enjoy from urban trees is important if sustainable tree-planting and management is to happen.

4.2 Roles of Urban Trees in Adaptation to Climate Change

As mentioned earlier, most respondents were of the view that trees in urban areas cool the local environment in hot seasons through evapotranspiration, although in Table 1 just a few respondents perceived that trees in urban areas cool temperature. Also, few (52.3%) perceived trees as agents of global warming mitigation through carbon sequestration, compared to those who perceived trees as agents of improving air (85%). Trees obviously improve air quality through sequestering greenhouse gases, especially carbon dioxide. Unless by 'improving air quality' respondents were strictly referring to trees

capturing the finest particle in the air, as in McDonald et al. (2016), one may wonder why this discrepancy in votes between the two statements. However, generally the mismatch in perceptions in these findings may suggest that there is a lack of a clear understanding of the role of urban trees in the adaptation to climate change. Also, as pointed out earlier, this might be a failure on the part of climate scientists to communicate the different aspects of climate change. Findings from key informants indicate that respondents are aware of the role of trees in cooling the environment, but they are not much aware on the technicalities as to how that happens (i.e., photosynthesis and carbon sequestration processes).

Findings presented in quote 2 indicate that the informant appreciates trees as cooling agents as they provide sheds: there is no mention of photosynthesis or carbon sequestration. This means, yes, trees are important for climate change adaptation, but not in the sense of cleaning the air (carbon sinking), which is not only adaptation but also mitigation to climate change. If so, then it is justifiable to call for the creation of more awareness as far as regards the role of trees in the adaptation to climate change in urban areas.

Furthermore, a very small number of respondents voted 'Yes' to a statement that urban trees reduce the demand for air conditioning and refrigeration, which is mostly powered by greenhouse-gas-emitting fossil fuels, e.g., natural gas or coal. The same was also the response to the statement that urban trees add on greenhouse gas emission through respiration and litter decomposition. All this means that most respondents were not aware of these urban forestry functions (Table 2), contrary to the literature (as in McDonald et al., 2016; Tidwell, 2016; and Endreny et al., 2017). These findings are also contrary to the findings by Lo et al. (2017) who indicated that people had a clear perception on the functions of trees in the adaptation to climate change in urban areas. Lo et al. (ibid.) concluded that perceptions that trees may cushion people from the multiple threats of climate change can positively re-shape urban dweller's interactions with nature. Therefore, there is a need to follow up on the status on environmental education, particularly on the role of trees in urban areas on the adaptation to climate change in the study area.

4.3 Priority Actions Towards Conservation of Urban Trees

Findings indicate that most people in the study area acknowledge that environmental education is low, and that most people are not aware of the benefits of trees. Therefore, related policies need to prioritize environmental education in Kigamboni. It is not clear, however, why most of the respondents could not prioritize police surveillance and passive protection for conservation of urban forests. In quote 3, the informant confirms the need for raising awareness on the role of urban forestry in the adaptation to climate change.

From the findings presented in Table 4, one may ask whether having between 1-10 trees around homesteads may entice people to perceive that the area has adequate trees. Most studied households were within plots of between 500m^2 and 1000m^2. Usually space between trees depends on several factors—including trees species—but, on average, trees can be planted at least 5m apart. Also, common house sizes in the Kigamboni area cover about 150m^2. So, if the smallest land size is assumed to be 500m^2, then 350m^2 of land remains after excluding the built area. But also, it is common for homesteads to have kind of storey buildings at backyards, which are typically of about 30m^2. That make 180m^2 of built ground. Under this scenario, 320m^2 remain free from built area. Since it is advised not to plant trees too close to buildings, we can assume that 100m^2 are excluded on such grounds; and thus, the area that will remain for trees will be 200m^2. From the 200m^2, one may exclude 50m^2 for vegetable gardening, which is also common in the study area. Hence 150m^2 can remain unoccupied. As such, basing on the 5m spacing at the minimum, each household could accommodate a minimum of 30 trees and a maximum of 60 trees. This raises questions as to why most respondents indicated that they grow between 1-10 trees, an issue that merits further investigations.

4.4 Aspects Considered When Selecting Tree Species

The results in this study indicate that trees with the high ability to provide shade are a choice of the majority of the respondents (89%). One may ask why respondents choose tree shade as one of the important aspects they consider when choosing tree species to plant, and also how that relates to climate change (as findings indicate in Table 5). To answer this question, one may need to go back into examining the functions of trees shades on the environment. Through shading, trees reduce temperatures in a given surrounding. There is also a process known as water transpiration that adds to cooling. Lay people may not tell precisely of such technical processes as water transpiration, yet they can clearly and objectively perceive its outcome (i.e., the cooling effect) through experience.

With climate change, where most parts of the world are getting warmer, the need to cool the environment becomes of paramount importance to most communities. According to McPherson et al. (2003), trees can save up to 10% of local energy consumption through shade and water transpiration. FAO (2016a) also commented that when a tree is positioned strategically, it can cool the air between 2˚C and 8˚C. Therefore, trees improve microclimate through their cooling effect. Studies have even proven that one mature tree can produce the same cooling effect as 10 room-sized air conditioners (https:// www. greenblue. com/na/green-infrastructure/benefits-urban-trees). Therefore, the findings suggest that perceptions in the study area are in agreement with the assertion that trees in urban areas are an effective means of reducing urban heat islands and hot spots.

As presented earlier in the findings, a majority of the respondents indicated that they do not consider fencing as an important aspect when selecting tree species to plant. Most home fences in the city of Dar es Salaam, as in most urban areas of Tanzania, are of brick walls. Fencing using trees is mostly common in rural areas of the country (Hines & Eckman, 1993). However, tree-fencing is considered important for greening cities in view of improving air quality, mitigating and adapting to climate change, reducing soil compaction for improving water percolation, and improving aesthetic views (FAO, 2016a). There is a need, therefore, to revisit related policies to see ways in which home-fencing using trees in urban areas can be re-emphasized to harness the multiple benefits that can be acquired from tree fences. The Tanzania Forestry Policy of 2008 is silent on urban forestry, hence there is no clear country direction regarding urban forestry (URT, 2008). Likewise, the Tanzania National Climate Change Strategy does not state categorically the role of urban forestry in mitigation, adaptation, and resilience to climate change (see URT, 2012).

Only a few respondents (38%) agreed that trees that can give good timber for building materials is a factor they would consider if they were to select tree species to plant around their homesteads (Table 5). However, in other previous studies, timber provision is one of the important services provided by urban forests (see, e.g., Lo et al., 2017; and FAO, 2016b).

The findings in Table 5 suggest that the protection of water sources through tree-planting is not a concern for the majority in the study area. This is not good news as far as climate change is concerned. With climate change, freshwater resources will be scarce in the country. As mentioned earlier, most people in the study area depend on deep and shallow wells for freshwater, hence preserving sources of freshwater would be a priority to the majority.

Extension (2019) explains that people in urban areas need to select tree species that are resistant to pests and diseases, especially where they plan to plant trees for wind-breaking. This is important because in most cases such trees will be planted close to the homestead, hence if these trees happen to be damaged by pathogens and pests, then they are likely to cause disastrous environment and human damages especially during storms. In this study, however, although 36% of the respondents agreed that they would consider wind barrier as an important factor when selecting tree species to plant around homesteads, yet only 4% of the respondents were in agreement that they would consider resistance to pest and pathogens as an important factor as far as the selection of tree species is concerned. The findings imply that there is a likelihood that people in the study area may suffer from damages caused by tree falls, especially during storms. This calls for the raising of awareness among community members to ensure sustainable urban forestry. Similarly, the findings that only 35% of all respondents considered

resistance to flooding as an important factor for tree species to be selected implies that if people are not sensitive to the type of tree species to plant in flood-prone areas, then such people may become vulnerable to flooding events.

Very few respondents (6%) would consider space as an important factor in the selection of tree species. However, this is contrary to studies which indicate that home-owners need to ensure that trees are planted on a reasonable distance to avoid roots causing cracks on floors and walls (McPherson et al., 2008; Dwyer et al., 1992; Salbitano, 2016). Also, tree branches should not be too close to houses since they are likely to cause noises on the roof. Maintenance costs got the attention of only 4% of all respondents; meaning that maintenance costs are not an issue of concern among most respondents when it comes to tree-planting.

All in all, the observations made on the aspects that drive the choice of tree species suggest preference on climate-related aspects—i.e., pollution-tolerant, shading ability, water sources, flooding, and wind barrier—suggest the existence of an awareness of the potential roles of urban forestry in the adaptation to climate changes among the respondents.

4.5 Challenges Facing Tree Growing

Basing on the study results, the study area faces three major problems pertaining tree-planting: limited space, inadequate education, and the lack of water for irrigation. All these call for policy interventions to foster tree-planting for sustainable climate change adaptation in Kigamboni.

5. Conclusion

This study set out to examine perceptions and actions on urban forestry and adaptation to climate change in Kigamboni district, in Dare es Salaam, Tanzania. To a large extent the findings have indicated inconsistencies in perceptions across variables among respondents, and between the current and past studies. For example, while about 85% of the respondents agreed that urban trees improve air quality (Table 1), the percentage of those who agreed with the statement that urban trees mitigate global warming by sequestering the greenhouse gas carbon dioxide fell down significantly (52.3%); while those who thought that urban trees cools the local environment during hot seasons through evapotranspiration were 78% (Table 2). These kinds of inconsistencies invite skepticism on whether the respondents have a clear understanding of the functions of trees in urban areas, particularly in relation to the adaptation to climate change. There is a need, therefore, for follow-up studies on the sources of the inconstancies.

It is likely that factors other than those related to climate change also played a significant role in actions taken against tree-planting in urban areas. Risks of trees falling and causing damage may be one of such factors that discourage tree-planting in urban areas given that urban areas tend to be highly populated

with congested buildings. However, findings by Borelli et al (2018) in their study on urban forests in the global context indicate an implied understanding of the importance of urban trees in the adaptation to climate change since they prioritized aspects that, in a way, reflect real adaptation options to climate change. Improving the quality of air, cooling the local environment during hot seasons, and providing shed, for example, all counted with the highest number of the 'Yes' responses in their respective list of options. Most of the respondents were of the view that environmental education is important for conservation of urban forests. Their study concludes that it is important to ensure the raising of awareness on urban forestry and adaptation to climate change in Kigamboni area, and equally all over the country, if it is to properly address climate change issues in urban areas.

People prioritize trees species that can make good shade, resist flooding, make good wind barriers, and those that can make good fences. It would be more advisable for the government to ensure that such preferred tree species are available. In addition, it is also important to provide education on the importance of planting trees that are good protector to water resources, trees that are resistant to pollution, and also trees that are resistant to drought to enhance adaptation to climate change.

The study also found that freshwater is a scarce resource in the study area during dry spells. This finding adds on the need for the government to prioritize climate-change-related policy interventions. The study also found three major challenges facing tree-planting: limited space, the lack of education, and the lack of water for irrigation. The study recommends clear policy directives to address these challenges.

The assessment in this study, however, lacked benchmarks as there is no clear urban forestry policy for the country, unlike in countries such as China that has introduced a national forest city program since 2004; a program that sets out clear criteria for measuring success in the sector. Therefore, it is time for Tanzania to also have a similar program so as to easily track developments and achievements in the urban forestry sector.

References

Borelli, S., Conigliaro, S.B.M. and Pineda, F. (2018). Urban forests in the global context. *Forestry, and Forest Industries* 69(1)3–10.

Bushesha, M.S. (2014). Assessing perceptions of climate variability and change among farmers in Tanzania: – A quant-qualitative approach. *Huria,* 17(1), 122–142.

Bushesha, M.S. (2015). Examining sustainable resources management for reserved forests in Tanzania: A case of Pugu and Kazimzumbwi. *International Journal of Innovative Studies*, 14(7), 36–59.

Bushesha, M.S. (2019). Examining the role of urban agriculture in improving household income in Bariadi township. *Huria,* 25(2), 96–117.

City of Burlington UFMP 2011–2030. (2010). Management and implementation community engagement and stewardship protection and preservation replenishment and enhancement tree health and risk management. City of Burlington.

Climate-woodlands, (2019). Urban forests and climate change. https://climate-woodlands.extension.org/urban-forests-and-climate-change. Accessed 12/07/2019.

Dandy, N., Marzano, M., Moseley, D., Stewart, A. and Lawrence, A. (2012). Exploring the role of street trees in the improvement and expansion of green networks. In: Johnston, M., and Percival, G. (2012). *Trees, people and the built environment*. Proceedings of the Urban Trees Research Conference 13–14, April 2011, The Institute of Chartered Foresters Birmingham.

Dwyer, J.F., McPherson, E. G., Schroeder, H.W. and Rowntree, R. A. (1992). Assessing the benefits and costs of the urban forest. *Arboriculture,* 18(5), 227–234.

Endreny, T., Santagata, R., Perna. A., DeStefano, C., Rallo, R.F. and Ulgiati, S. (2017). Implementing and managing urban forests: A much needed conservation strategy to increase ecosystem services and urban wellbeing, *Ecological Modelling* 360 (24).

EXTENSION. (2019). Tree-planting for lower power bills. https://trees-energy-conservation.extension.org/tree-planting accessed on 20.09.2019**.**

Food and Agriculture Organization (FAO). (2016a). Benefits of urban trees. http:// www.fao.org/resources accessed on 01/01/2019.

Food and Agriculture Organization (FAO). (2016b). Building greener cities: nine benefits of urban trees. http://www.fao.org/zhc/detail-events/en/c/454543/ accessed on 06.06.2019**.**

Hines, D.A. and Eckman, K. (1993). *Indigenous multipurpose trees of Tanzania: Uses and economic benefits for people*. FAO Rome, FO: Misc/93/9 Working Paper FO:Misc/93/9.

Intergovernmental Panel on Climate Change (IPCC). (2018). *Summary for policymakers*. Cambridge University Press. doi: https://doi.org/10.1017/ CBO9781 107415416.005.

Ishengoma, R.C. and Abdallah, J.M. (2016). Charcoal market conditions in 2016 in Dar es Salaam and Morogoro, Tanzania. Transforming Tanzania's charcoal sector project. Technical Report 4. College of Forestry, Wildlife and Tourism Sokoine University of Agriculture, Morogoro.

Konijnendijk, C.C., Ricard, R.M., Thomas, A. K., and Randrup, B. (2006). Defining urban forestry – A comparative perspective of north America and Europe. *Urban Forestry & Urban Greening,* 4(3–4), 93–103.

Lo, A.Y., Byrne, J.A. and Jim, C.Y. (2017). How climate change perception is reshaping attitudes towards the functional benefits of urban greenery: Lessons from Hong Kong. *Urban Forestry & Urban Greening*, 23, 74–83.

McDonald, R., Kroeger, T., Boucher, T., Longzhu, W., Salem, R., Adams, J., …, Garg, S. (2016). Planting healthy air: A global analysis of the role of urban trees in addressing particulate matter pollution and extreme heat. The Nature Conservancy.

McPherson, E.G., Simpson, J.R. Peper, P.J. and Aguaron. E. (2008). Urban forestry and climate change. Albany, CA: USDA Forest Service, Pacific Southwest Research Station. http://www.fs.fed.us/ccrc/topics/urban-forests accessed on 25.02.2019.

McPherson, E. G., Simpson, J. R., Peper, P. J., Xiao, Q., Maco, S.E. and Hoefer, P.J. (2003). *Northern Mountain and Prairie community tree guide: Benefits, costs and strategic planting*. Center for Urban Forest Research USDA Forest Service, Pacific Southwest Research Station Davis, CA.

Mnguni, L., Shemdoe, R. S. and Liwenga, E. (2013). Community perceptions and willingness to accept and execute REDD+ initiative: The case of Pugu and Kazimzumbwi Forest Reserve. *Tanzania Cross-cultural Communication*, 9(3), 48–54.

Pincetl, S., Gillespie, T., Pataki, D.E., Saatchi, S. and Saphores, J. (2013). Urban tree-planting programs, function or fashion? Los Angeles and urban tree-planting campaigns. *GeoJournal,* 78: 475. Available from: https://doi.org/10.1007/s10708-012-9446-x. Accessed on 21.06.2017.

Pincetl, S. (2010). Implementing municipal tree-planting: Los Angeles million-tree initiative 45: 227. Available from: https://doi.org/10.1007/s00267-009-9412-7. Accessed on 03.04.2018.

Resilience and Economic Inclusion Team and Irish Aid. (2017). Tanzania climate action report for 2016, Available from: https://www.irishaid.ie/media/irishaid/ allweb site media. Accessed on 07/01/2019.

Salbitano, F. (2016). Trees, cities and people: urban forestry supporting quality of life, Report COFO 23 side event on "Urban Forests for Sustainable Cities – FAO, Rome, 20 July 2016.

Satterthwaite, D., Huq, S., Pelling, M., Reid, H. and Lankao, P.R. (2007). Adapting to climate change in urban areas: The possibilities and constraints in low- and middle-income nations. Available from: www.iied.org/ pubs/display. php?o= 10549IIED. Accessed on 02/2/2019.

Tavares, J. (2016). The Cape Verdean approach to the successful establishment of urban forests in semiarid lands. Report COFO 23 side event on 'Urban Forests for Sustainable Cities' – FAO, Rome, 20 July 2016.

Tidwell, T. (2016). Green infrastructure: Key to livable cities in the United States. Report COFO 23 side event on ;Urban Forests for Sustainable Cities' – FAO, Rome, 20 July 2016.

United Nations Development Program (UNDP). (2011). *Services and supply chains: The role of the domestic private sector in water service delivery in Tanzania*. New York, NY 10017 USA.

United Republic of Tanzania (URT). (2019) *Kigamboni municipal council socio-economic profile, 2019*. Dar es Salaam: Government Printer.

United Republic of Tanzania (URT). (2019). *National climate change strategy, 2012.* Dar es Salaam: Government Printer.

United Republic of Tanzania (URT). (2019). *Tanzania national forestry policy.* Dar es Salaam: Government Printer.

Xiao, W. (2016). Development of the 'National Forest City' programme in China. Report COFO 23 side event on 'Urban Forests for Sustainable Cities' – FAO, Rome.

Živojinović, I. and Wolfslehner, B. (2015). Perceptions of urban forestry stakeholders about climate change adaptation – A Q-method application in Serbia, *Urban Forestry & Urban Greening,* 14(4): 1079–1087.

Waibel, H., Pahlisch, T. H., Völker, M. (2017) Farmers' perceptions of and adaptations to climate change in Southeast Asia: The case study from Thailand and Vietnam. *Climate Smart Agriculture,* 137–160.