Utilization of Green Spaces as a Cost-Effective Strategy for Environmental and Health Risks Control in Residential Plots in Dar es Salaam City, Tanzania

Nicholaus Fabian Mwageni,
Lecturer School of Engineering and Environmental Studies, Ardhi University, Dar es Salaam, Tanzania
E-mail address: nicholausmwageni2012@gmail.com/nicholaus.mwageni@aru.ac.tz

Abstract
The main objective of this study was to determine the cost-effectiveness of green spaces in controlling environmental and health risks in residential areas. The study aimed at comparing the costs of using green spaces and the costs of conventional infrastructure in controlling environmental and health risks. Many scholars have qualitatively reported that residential home greenery is recognized as an important component for the control of environmental and health risks. However, the cost-effectiveness of green spaces relative to man-made solutions for the same is not documented with certainty. The study deployed a questionnaire, field observation and measurement methods for data collection. The study revealed that, depending on location, residents face five major environmental and health risks; fugitive dust, violent wind, runoffs, animal habitat deterioration, soil erosion and flood water. The percentage of households using green spaces as a strategy for controlling the aforementioned risks is still minimal despite the high monetary saving. The majority of the respondents' home greeneries are incorrectly orientated and home entrances appear to be more of a factor in determining where green space is located. With exception of risks of run-offs, utilization of green spaces in controlling environmental and health risks saves more than 90% of costs compared to costs for a man-made solution and 61% for run-off control. Results imply that there is a need for advocacy for greater realization of green space as a cost-effective strategy in controlling environmental and health risks among residents, environmentalists, planners and disaster risk practitioners in Dar e salaam City, Tanzania.

Keywords: Flood, Soil erosion, Stormwater, Wind, Fugitive dust.

1. Background
Urban green spaces include vegetable gardens, parks, household trees, cemeteries, vacant lots, gardens, campus areas, landfill, streams, rivers, ponds, wetlands and stormwater retention ponds. Urban green spaces provide services like climate regulation (heat and Carbon dioxide), safe water provision and sewage and stormwater control [1, 2, 3]. These make the urban green spaces increasingly recognized as an alternative ameliorative method to technical solutions abating cities' environmental problems like fugitive dust emissions, poor cooling, Carbon dioxide emissions, animal habitat deterioration, erosion, storm floods, pollution, parasites and diseases, inadequate stormwater drainage and sewage management [4, 5, 6, 7].

Despite the big role played by green spaces to improve the quality of life in cities, green space ecosystems are taken for granted. Green space ecosystems are replaced by impervious surfaces due to rapid urbanization, industrialization and rural-urban migration [8, 9]. Urbanization processes affect green spaces through the reduction in the size of open space patches and the habitat value of the core habitat area [10]. It increases the isolation of open spaces resulting from habitat fragmentation implying that open spaces patches become very far apart; and destruction of physical links among patches of open spaces such that flora and fauna get locked into specific locations causing failure of populations to travel from one open space to another [11, 12].

Residents have been using various strategies to get similar ecosystem services which could be supplied by green spaces. In that regard, residents incur a cost for conventional infrastructures as alternatives to green spaces' ecosystem services to control dust, temperature, runoff from rains, pollution and erosion [13, 14]. These include the use of green roofs and use of air conditioning [1]. Others use hybrid solutions to abate environmental and health risks [15, 16]. However, the comparison between the costs of green space investment and the alternative man-made solutions is not yet clearly known by both residents and decision-makers. The lack of information on costs required to replace ecosystem services provided by green spaces to control environmental and health risks has been contributing to inappropriate strategies for improving the quality of life through green space investment. It also leads to the irrational official decision on green space protection at the place of domicile and the city.

The existing studies on green spaces in residential areas in Dar es Salaam City have been providing information on types, use and coverage; but none has reported the cost-effectiveness of the same. The residential plots are dominated by woody plants at 27% followed by ornamental gardens at 26% and plot farms at 23% [17]. However, 2/3 of the households had more than one type of green space. Others had one and some none. Green space coverage in residential plots ranges from $5m^2$ to $1400m^2$. Green spaces in Dar es Salaam City have been used for shade and temperature regulation [18]. This study has used four sampled wards to highlight different mechanisms used by residents to control the major environmental and health risks. It also compares the costs of using green spaces and the costs of conventional infrastructure in controlling environmental and health risks.

2. Methodology

2.1. Selection of Case Study Area

This study was done in Dar es Salaam City because it is the most urbanised city in Tanzania. It faces poor housing and road infrastructures in residential settlements, consequently, soil erosion on sloping land and flood damage to houses constructed along rivers is a common practice. Residential houses are exposed to fugitive dust due to unpaved roads. Due to the clearance of vegetation, residential settlements have been facing stormwater problems, violent wind, and biodiversity deterioration. Dar es Salaam City is located in the Eastern side of Tanzania, along the Indian Ocean having five (5) Districts (Ilala, Temeke, Kinondoni, Kigamboni and Ubungo) with ninety (90) wards. This study was done in four wards namely: Makumbusho, Kawe, Mburahati and Yombo Vituka. The wards represented four (4) classes of wards based on green space abundance and building density. Class one was Makumbusho ward representing wards with very high building density (3,601-4,800 buildings/sq.km)- implying low green space coverage; class two was Mburahati representing wards with high building density (2,401-3,600 buildings/sq.km) -implying medium green space coverage; class three was Yombo Vituka ward representing wards with medium building density (1,201-2,400 buildings/sq.km))- implying high green space coverage, and class four was Kawe ward representing wards with low building density (<1,200 buildings/sq.km)) –implying very high green space coverage. Figure 1 shows the location of the study areas.

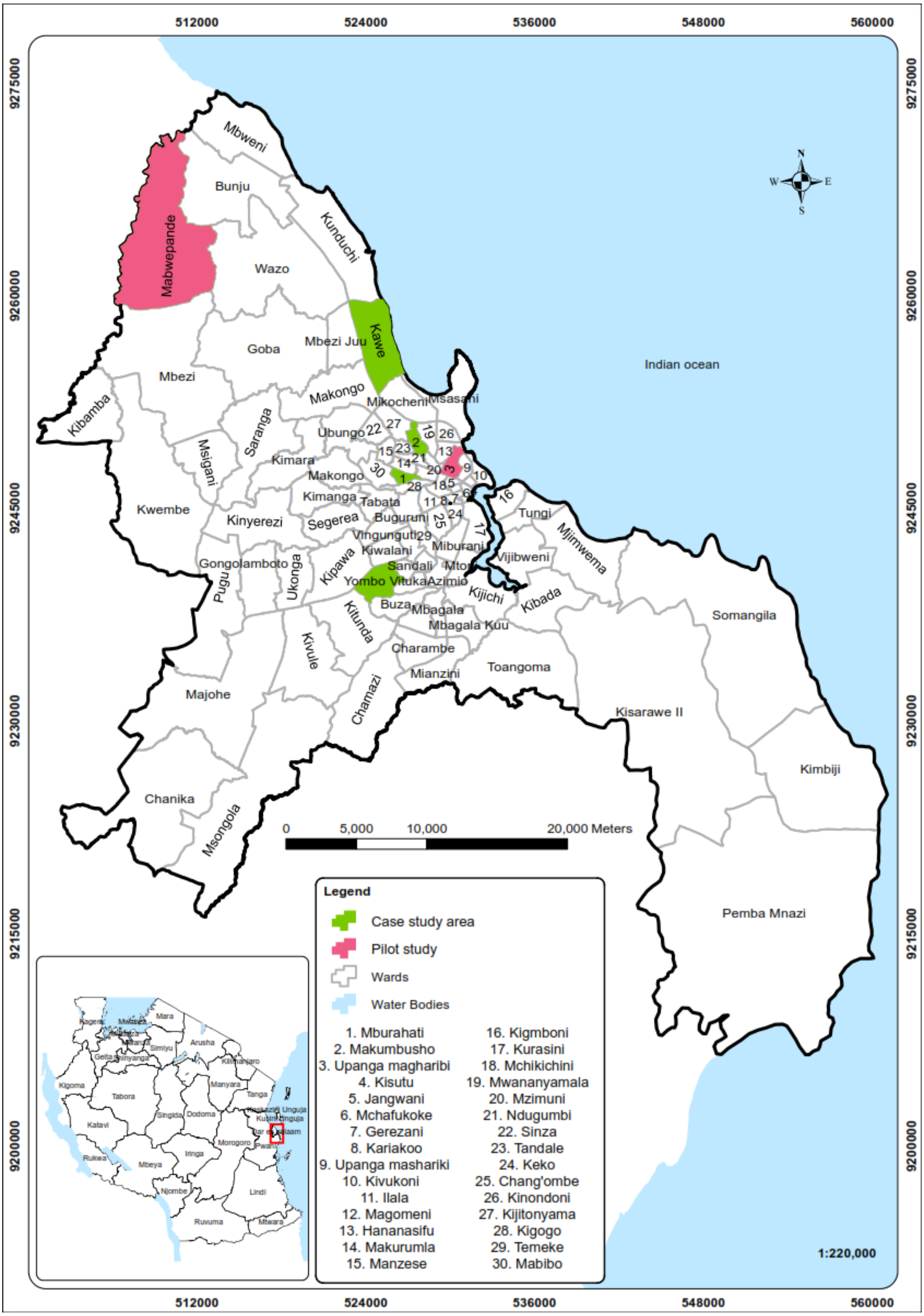

Fig. 1. Location of study areas within Dar es Salaam

2.3. Sampling of households

Residential houses were selected through a purposive sampling technique. Households were selected based on three criteria: an abundance of green spaces, topographic location within the settlement, and closeness to streams and street roads. Remote sensing technique using ortho-rectified aerial imagery of 2017 was used to identify households which meet the aforementioned criteria. Digital Elevation Model was used to determine the topography of the settlement in which high land areas were defined to have a slope greater than 6% while the low land area with a slope lower than 6%. The sampling procedure came up with 511 households distributed in four wards.

2.4. Data Collection Methods

Data were collected through focus group discussions, questionnaires and field measurements. Three focus group discussions were done, and each group consisted of 5-6 people. Participants in the focus group discussion were chosen by considering their residence depending on the topographic nature of the settlement and their proximity to open spaces and streams. Closed and open-ended Questionnaires and field measurements were used to get information on how residents use green spaces to control environmental and health risks. Questionnaires were structured after conducting focus group discussions. Data collected were used to establish the cost-effectiveness of green spaces in residential areas. A questionnaire was therefore structured to capture variables for determining the development cost of green spaces and the Cost of Man-made solution alternatives to the existing green space intervention. Other information included demographic information. Data were collected in 511 households. The distribution of the administered questionnaires was 127, 150, 100 and 134 for Makumbusho, Mbezi, Mburahati and Yombo Vituka wards respectively. This was done by administering both closed and open-ended questions to households. Table 1 provides characteristics of the case study settlements.

Table 1. Key characteristics of case study settlements

Key information/source		Sample Settlement			
		Kawe	Makumbusho	Mburahati	Yombo Vituka
Population (NBS)		67,115	68,093	34,123	76,999
Number of Household (NBS)		16,778	18,403	9,749	19,249
Household size(NBS)		4	3.7	3.9	4
Number of buildings as of 2017		7,962	6,591	3,445	9,342
Area of a ward (Square kilometre) (NBS)		15.477	1.113	1.7368	5.5453
Building density as of 2017		514	3794	3,095	1,684
Modified Density type as per urban planning space standards of Tanzania, 2018		Super low density	Very high density	High density	Medium density
Planning status	% of planned and built-up area	72.38	45.72	28.35	30.39
	% of unplanned and built-up area	9.64	54.28	71.65	60.05
	% of unbuilt-up area	17.98	0.0	0.0	9.55

Key information/source	Sample Settlement			
	Kawe	Makumbusho	Mburahati	Yombo Vituka
The dominant type of buildings	Double storey	Single storey	Single storey	Single storey
Green space coverage(square meter)	6,627,540	226,065	281,496	1,330,670
Average slope	2.4	2.1	2.5	2.73

Source: Fieldwork

2.5. Determination of cost-effectiveness of green spaces in environmental and Health Risk Control

The cost of environmental and Health Risks control was determined through an approach called the cost of alternatives. To determine the cost-effectiveness of green spaces, the development cost of green spaces was compared with the Cost of man-made solution alternatives to green space. However, the determination of the cost of man-made solution alternatives to green spaces was done in two approaches. Those who used green spaces for environmental and health risks control were asked about the man-made solution alternative to the existing green space intervention and its cost. Those who were not using green spaces or who did not have green spaces were asked about the cost of the man-made solution opted for due to the absence of green space. Table 2 shows the procedure for the determination of the cost-effectiveness of green spaces.

Table 2. Quantification procedure for determining the cost-effectiveness of green space

Cost item	Qualitative and Quantitative variables/ measurements	Letter	Quantification procedure
Development Cost			
Material	Year of development		X4+Y4+Z4+D5
	Materials needed for development		
	Total material cost (TZS)	X4	
	Transport cost (TZS)	Y4	
Labour	Labour cost (TZS)	Z4	
	Time (hours)XTime value (TZS)	D5	
	Total development cost as of 2019	E5	
Cost-effectiveness of green spaces in Stormwater control			
Cost of Man-made solution alternative to the existing green space intervention	Square footage of the home greenery (ft)	R	R×S×U×V×W
	Percentage of respondents enjoying service (%)		
	Average annual precipitation data (in inches) for the site	S	
	% retained	U	
	144 sq. inches/SF X 0.00433 gal/cubic inch	V	
	Cost of containment per gallon (TZS/ft^3)	W	
Cost of Man-made solution opted due to absence of green space	Total Size of structure needed or in use (M^2)	X	(X×Y)+Z+(Z1×Y1)
	Cost per unit size (TZS/ M^2)	Y	
	Labour cost (if hiring manpower) (TZS)	Z	
	Time spent per week (HR)	Z1	
	Value of time if a household is in charge (TZS/HR)	Y1	
Cost-effectiveness of green spaces in dust control			
Cost of Man-made solution	The alternative dust control mechanisms in absence of tree		(C2×D2)+E2+(F2×G2)

Cost item	Qualitative and Quantitative variables/ measurements	Letter	Quantification procedure
alternative to the existing green space intervention	Quantity of alternatives you may need or in use (Units)	C2	
	Percentage of respondents enjoying service (%)		
	Price per unit quantity (TZS/Unit)	D2	
	Labour cost (if any) (TZS)	E2	
	Time spent per week if a household is in charge (HR)	F2	
	Value of time (TZS/HR)	G2	
Cost of Man-made solution opted in absence of green space	The current dust control mechanisms used		(H2×I2)+J2+(K2×l2)
	Quantity of mechanism used (Units)	H2	
	Price per unit quantity (TZS/Unit)	I2	
	Labour cost (if any) (TZS)	J2	
	Time spent per week if a household is in charge (HR)	K2	
	Value of time (TZS/HR)	L2	
Cost-effectiveness of green spaces in wind control			
Cost of Man-made solution alternative to the existing green space intervention	The alternative dust control mechanisms in absence of tree		M2×N2)+O2+(P2×Q2)
	Quantity of alternative you may need (Units)	M2	
	Percentage of respondents enjoying service (%)		
	Price per unit quantity (TZS/Unit)	N2	
	Labour cost (if any) (TZS)	O2	
	Time spent per week if a household is in charge (HR)	P2	
	Value of time (TZS/HR)	Q2	
Cost of Man-made solution opted in absence of green space	The current dust control mechanisms used		(R2×S2)+T2+(U2×V2)
	Quantity of mechanism used (Units)	R2	
	Price per unit quantity (TZS/Unit)	S2	
	Labour cost (if any) (TZS)	T2	
	Time spent per week if a household is in charge(HR)	U2	
	Value of time (TZS/HR)	V2	
Cost-effectiveness of green spaces in biodiversity protection			
Cost of Man-made solution alternative to the existing green space intervention	Alternative domestic animals' hibernation and protection mechanisms in absence of home greener		(H3×I3)+J3+(K3×L3)
	The quantity you may need (Units)	H3	
	Percentage of respondents enjoying service (%)		
	Price per unit quantity (TZS/Unit)	I3	
	Labour cost if hiring manpower (TZS)	J3	
	Time spent per week if a household member is in charge for (HR)	K3	
	Value of time(TZS/HR)	L3	
Cost of Man-made solution opted in absence of green space	Domestic animal's hibernation and protection mechanisms in place		(M3×N3)+O3+(P3×Q3)
	Quantity available (Units)	M3	
	Price per unit quantity (TZS/Unit)	N3	
	Labour cost if hiring manpower(TZS)	O3	
	Time spent per week if a household member is in charge for (HR)	P3	
	Value of time(TZS/HR)	Q3	
Cost-effectiveness of green spaces in erosion and flood control			

Cost item	Qualitative and Quantitative variables/ measurements	Letter	Quantification procedure
Cost of Man-made solution alternative to the existing green space intervention	Alternative mechanisms in absence of home greenery		R3+S3+T3+(U3×V3)+(R5×S5)+T5+(U5×V3)
	Percentage of respondents enjoying service (%)		
	Physical damage is likely to occur if there could be no home greenery		
	Property damage could occur if there could be no home greenery		
	Recovery cost for physical damage (TZS)	R3	
	Recovery cost for property damages (TZS)	S3	
	Quantity of structures available (Units)	R5	
	Price per unit quantity of available structure (TZS/Unit)	S5	
	Expected labour cost for recovery if hired	T3	
	Time spent per week if a household member is in charge in recovery activities	U3	
	Labour cost for fixing the structure if hired	T5	
	Time spent per week if a household member is in charge in fixing the structure	U5	
	Value of time	V3	

3. Results and Discussion

Survey results and field observations showed that households in case study areas have different types of green spaces such as shade trees, fruit trees, allotments, and house gardens. Apart from other benefits at a household level, green spaces have been used for environmental and health risk control. The major environmental and health risks in residential areas were fugitive dust, stormwater, soil erosion, floodwater damage, and biodiversity deterioration. Green spaces have been used for the control of the aforementioned risks as explained hereunder.

3.1. Cost-effectiveness of green spaces in fugitive dust control

The study revealed that the average percentage of respondents using green spaces for dust control only was 10.8%. This implies that 89.2% use green spaces for other uses. The percentage of the households admitting the use of home greeneries for dust control might be those located along the street roads which all of them were unpaved. A high percentage (60%) of households admitting the use of home greeneries for dust control was found in Kawe followed by Makumbusho (24%), Yombo Vituka (10%) and Mburahati (6%). This might be due to the presence of vehicles on busy street roads compared to other settlements. Shade trees were the only home greenery used mostly in dust control followed by fruit trees. The percentages of households that used shade trees and fruit trees for dust control were 41.2 and 5.2 respectively. Other households used more than one type of home greenery. A combination of shade and fruit trees was predominantly used by households followed by shade trees, fruit trees and house gardens at 65% and 25% respectively.

Transect walks revealed that trees (notably ashoak *(Saraca asoca)*) were strategically planted along the road to block dust emitted by vehicles moving along the houses while other home greeneries were found in front of residential buildings (Figure 2). Green spaces particularly trees have been reducing dust from reaching residential houses by two mechanisms. Firstly, trees have been intercepting particulate matter ($PM_{2.5}$ & PM_{10}) by dry deposition on leaf surfaces. And once, intercepted, some are adsorbed, some fall on the ground and some are taken by the wind into the atmosphere and thereafter they get washed out by rainfall to the soil surface. Secondly, trees have been slowing down the speed of particulate matter such that they lose momentum to reach indoor environments or other structures[19, 20]. This impact might be bigger with an increase in tree density and distance of buildings or structures from the tree line. Thus, harmful microbes are blocked from entering residential buildings by green spaces.

Fig. 2. Ashoak trees planted to protect houses against dust
Source: Kawe ward, December 2018

Moreover, respondents reported different dust control mechanisms that were in place and that could be used if there would be no home greeneries. These include raising building fences, using aluminium windows, using windows shields, building gates, improving roads, using water for dust suppression, and regular mopping and sweeping. Using or adapting the aforementioned mechanisms for dust control has been having cost implications in terms of materials, labour and opportunity cost of time. Survey data showed that households incurred TZS 136,579 (59USD) for developing green spaces for dust control; and in absence of green spaces, households incurred or would have incurred on the average one-time cost of TZS 1,456,244 (633USD) on using the aforementioned mechanisms for dust control. Thus, households that use home greenery for dust control avoid this cost just because they opt to capitalize on home greeneries. Since the investment cost for home greenery was TZS 136,579 (59USD), then households can save a lifetime cost by 90% by for opting home greenery for dust control in residential plots.

3.2. Cost-effectiveness of green spaces in wind control

Home greeneries planted in aerial paths reduce the strength of the wind and block particulate matter and harmful microbes from entering residential buildings [21]. In all settlements, the dominant wind direction is from the ocean (Eastern side) to the Western side. Survey data shows that 30.0% of households planted trees on the Western side of the buildings, followed by the northern side (27.2%) while the rest planted on the Eastern side (26.6%) and Southern side (16.2%). This implies that the majority (73.4%) of households might not get the maximum benefits of trees for wind control. Field observations indicated that trees were planted based on the location of the entrance to the house. They were found along the road while other home greeneries were found in front of residential buildings.

Despite of wrong placement of home greeneries for wind control, Survey and field observation revealed that 7.6% of the respondents admitted to using green spaces for wind prevention/control in the case study areas. The high percentage of households using home greenery for wind control is found in Kawe ward (55%) followed by Makumbusho (31%), Mburahatati (8%) and Yombo Vituka (6%). The high percentage in Kawe might be due to the closeness to the beach where the wind originates. Trees were the single-home greenery type used the most in wind control followed by allotments. The percentages of households that used trees and allotments for wind control were 28.6 and 2.7 respectively.

Moreover, respondents reported different wind control mechanisms that were in place and that could be used if there would be no home greeneries. These included building a wall, constructing a fence and using windbreakers. Survey data shows that households incurred and or would have incurred an average one-time cost of TZS 2,957,300 (1,286USD) on using the aforementioned mechanisms for wind control. Thus, households that use home greenery for wind control avoid this cost just because they opt to capitalize on home greeneries. Based on the average investment cost for home greenery-TZS 136,579 (59USD), households can save a lifetime cost of TZS 2,820,721 (1,226USD), equivalent to 95% for opting for home greenery for wind control in residential plots.

3.3. Cost-effectiveness of green spaces in stormwater control

Apart from other services that home greeneries provide to households, home greeneries have been regulating the runoff of rainwater by containing it in plot areas. The study revealed that the use of home greenery for stormwater control was reported by 1% of the respondents in case study areas. The percentage of the households that didn't admit to using home greeneries for stormwater control might be those located in highland areas of the settlement where problems of stormwater are not experienced. According to surveyed data, 60.7% of the respondents were found to live in highland areas of the settlements while 16.8% were on sloping land and 22.5% were along the stream.

Further, out of 1% of households using green spaces for stormwater control, the percentages of households which use trees and allotments for stormwater control were 18.4% and 4.9% respectively. In addition to that, 76.7% of the households have been using a combination of home greeneries for stormwater control. Green spaces help to regulate stormwater flow and reduce runoff by slowing water movement and hence allowing more time for infiltration to groundwater [22]. Stormwater can effectively be controlled more by grasses than trees. Grasses slow down water more than trees. This implies that the presence of trees might have less impact on stormwater management in case study settlements and cities at large. This calls for a need to promote the use of grasses to control stormwater from residential areas and hence solving the problem of flood and increasing groundwater recharge in the City.

Respondents reported that there were other mechanisms which were used and or would be used to control stormwater if there were no home greeneries in residential plots. These include investing in simple rainwater harvesting and construction of drainage systems to direct stormwater outside residential plots. Using or adapting the aforementioned mechanisms for stormwater control has cost implications for households. This cost was more compared to the development and operation cost of home greeneries. Based on the square footage of home greenery, average annual rainfall, percentage of water retained during rain and cost of containment, the study showed that households incurred and or would have incurred an average one-time cost of TZS 352,800 (153USD) on using the aforementioned mechanisms for stormwater control in residential plots. Thus, households that use home greeneries for stormwater control avoid this cost (TZS 352,800 (153USD)) to capitalize on home greeneries. Also based on the average investment cost of residential green space which was TZS 136,579 (59USD), households save TZS 216,221 (94USD) for capitalizing on green spaces for stormwater control. This implies that households save 61% of the costs for using home greeneries to control stormwater through containment mechanisms.

3.4. Cost-effectiveness of green spaces in soil erosion and flood water control

Survey data and field observation revealed that households have been using home greeneries in their residential plots to prevent soil erosion and flood damage. The percentage of households which were found to use green spaces for soil erosion and flood damage was 8.8. The percentage of households using home greeneries for controlling soil erosion and flood water damage is small because it is a service enjoyed by those whose houses are located along streams and on sloping land. For instance, the settlement that lead to using green spaces for erosion control was Yombo Vituka (57%) followed by Mburahati (32%), Makumbusho (9%) and Kawe (2%). This is due to the topographical nature of the settlements. Based on the digital elevation model (DEM), Yombo Vituka and Mburahati were the settlements which have the average slope which is 2.73 and 2.5 respectively. The smallest percentage of households in Kawe and Makumbusho might also be due to having the lowest slopes which were 2.4 and 2.1 respectively. On the other hand, Mburahati was the settlement with the highest number of households using green spaces for flood control compared to other case study areas. This is due to its proximity to Msimbazi valley.

Field observation revealed that households planted trees strategically to control soil erosion. This happens to residential houses found in sloping lands and along stream banks and drains. On other hand, trees were planted along the stream to stabilize soil to prevent soil erosion that might be caused by a flood. This was seen in residential plots found near or along streams (Figure 3).

Fig. 3. Picture showing trees being used to control stream bank erosion
Source: Fieldwork, Makumbusho ward, January 2019

Despite using green spaces, households reported different disaster prevention mechanisms that are in place and that could be used if there would be no home greeneries. These include building block walls, building concrete walls, constructing a fence, and planting trees and grasses. Using or adapting the aforementioned mechanisms has been having cost implications This cost is more compared to the development and operation cost of home greeneries. Survey data shows that households incurred and or would have incurred an average one-time cost of TZS 2,304,166 (1,002USD) on using the aforementioned mechanisms for disaster prevention. Based on investment cost for home greenery (TZS 136,579 (59USD)), households can save an average lifetime cost of TZS 2,167,587 (942USD), equivalent to 94% for soil erosion and flood water control.

3.5. Cost-effectiveness of green spaces in animal habitat protection

Green spaces (including home greeneries) protect biodiversity and preserve historic landscape features [23]. It matters a lot for one single tree to animals. The presence of home greeneries connects households to nature. Field observations showed that the presence of home greeneries is not only used for domestic animals but also provides habitat to other organisms. They help to connect households to the rest of the city's green spaces network. They help to attract other birds with pleasant sounds. They attract animals like lizards which act as biological controls in homes. This implies that increasing home greeneries coverage in settlements and the City at large will attract more animals and hence more biodiversity.

Survey data showed that households have been domesticating several animals in their residential plots. These include chickens, ducks, dogs, goats, and cows. Biodiversity protection (hibernation service) is the service which is enjoyed by more than 20% of households in the case study areas. This implies that the minority have either not realized yet the importance of home greeneries for domestic animals such as hibernation or they are not domesticating animals.

The high percentage of respondents who domesticate animals were found in the Kawe settlement followed by Yombo Vituka. The reason might be due to having bigger size of residential plots compared to other settlements like Mburahati and Makumbusho. Field observations showed that shade trees were the single-home greenery types used the most in domestic animal hibernation followed by fruit trees (Figure 4). The percentages of households whose domestic animals use trees and allotments for hibernation were 11.7 and 2.0 respectively. This implies that domestic animals have been using more than one type of home greeneries for hibernation. This constitutes 86.3% of the households which domestic animals.

Fig. 4. Typical use of green spaces for animal domestication
Source: Fieldwork at Yombo and Kawe wards, January 2019

Moreover, respondents who declared the importance of home greeneries for domestic animals' hibernation reported different mechanisms that could be used if there would be no home greeneries. These include constructing huts and balconies. This implies those using home greeneries for protecting domestic animals might need to construct huts. Those with huts for domestic animals might need to construct a balcony for protecting domestic animals against the sun and bad animals during day time.

The use of the stated options for domestic animal protection/hibernation has been having c ost implications in terms of materials, labour and opportunity cost of time. This cost is mo re compared to the development and operation cost of home greeneries. Survey data show s that households would have incurred an average one-time cost of TZS 2,309,091 (1,004) on using the aforementioned options for domestic animal protection. Thus, households wh ich use home greenery for domestic animals' hibernation/protection avoid this cost TZS 2, 309,091 (1,004USD) maximum) just because they opt to capitalize on home greeneries. T he investment cost for home greenery is TZS 136,579 (59 USD). This implies that househ olds can save a cost of TZS TZS 2,172,512 (945USD) amounting to 94% by opting for ho me greenery for biodiversity protection in residential plots.

4. Conclusion

Residential home greenery is recognized as an important component in residents' lives. The study has revealed that the utilization of green spaces to control environmental and health risks is cost-effective compared to man-made solutions. Households using green spaces have been saving more than 90% of costs for man-made solutions. Moreover, the majority of the respondents' home greeneries are incorrectly orientated hence undermining the effectiveness of environmental and health risks control. The orientation of building and home entrances appears to be more of a factor in determining where green space is located, and therefore beautification is the key driving factor. The study recommends the need to capitalize on home greenery and stormwater harvesting technology at a household level. This could contribute to the collective reduction in erosion propensity and persistent flooding problems experienced in Dar es Salaam City. In addition to those, green spaces which are unedible should be planted in polluted areas. By doing that, pollution from households will be contained in trees through the phytoremediation process in a way that it does not spread into the nearby environment.

Acknowledgement

This publication could be impossible without the help of the Almighty God for the ability given to me. I am also honoured to extend my sincere gratitude to Prof. Gabriel Kassenga, Prof. Robert Kiunsi and Dr. Patrick O'Farrell for their guidance during the preparation of the manuscript.

References

[1] Benedict, M. A, McMahon, E. T. (2002), *Green infrastructure: smart conservation for the 21st century*, Renewable resources journal, 20(3), pp. 12-17, https://www.merseyforest.org.uk/files/documents/1365/2002+Green+Infrastructure+Smart+Conservation+for+the+21st+Century..pdf.

[2] Bauer, L., DeBenedictis, M., Giangrave, D., Vaughan, Z. (2017), *Measuring Green Space Efficacy in Hangzhou, China*, no. December, p. 128, https://web.wpi.edu/Pubs/E-project/Available/E-project-011018-173805/unrestricted/Smart_City_Final_IQP_Report.pdf.

[3] Livesley, S. J., McPherson, E. G., Calfapietra, C. (2016), *The Urban Forest and Ecosystem Services: Impacts on Urban Water, Heat, and Pollution Cycles at the Tree, Street, and City Scale*, J. Environ. Qual., vol. 45, no. 1, pp. 119–124, doi: 10.2134/jeq2015.11.0567.

[4] Livesley, S. J., McPherson, E. G., Calfapietra, C. (2016), *The Urban Forest and Ecosystem Services: Impacts on Urban Water, Heat, and Pollution Cycles at the Tree, Street, and City Scale*, J. Environ. Qual., vol. 45, no. 1, pp. 119–124, doi: 10.2134/jeq2015.11.0567.

[5] Yoong, H. Q., Lim, K. Y., Lee, L. K., Zakaria, N. A., & Foo, K. Y. (2017), *Sustainable Urban Green Space Management Practice*, Sic, vol. 2, no. January, pp. 1–4.

[6] Green, C. H., Parker, D. J., Tunstall, S. M. (2000), *Assessment of Flood Control and Management Options*, Secr. World Comm. Dams P.O. Box, vol. 16002, no. November, pp. 27–48.

[7] Coder, D., Biology, T., Care, H. (2011), *Identified Benefits of Community Trees & Forests*, vol. 7912, no. January, pp. 1–6.

[8] Rowe, D.B., Getter, K.L. (2006), *The role of extensive green roofs in sustainable development*, HortScience, vol. 41, no. 5, pp. 1276–1285, 2006.

[9] Kang, C., Lu, Q., Zhang, Z., Zhao, Q., Nan, H. (2019), *Study on the Construction Mode of Ecological and Sustainable Rain Flood in New Urban Area of China*, E3S Web Conf., vol. 101, doi:

10.1051/e3sconf/201910101002.
[10] Li, F., Zheng, W., Wang, Y., Liang, J., Xie, S., Guo, S., ..., Yu, C. (2019)., *Urban Green Space Fragmentation and urbanization: A spatiotemporal perspective*, Forests, vol. 10, no. 4, doi: 10.3390/f10040333.
[11] Esbah, H.,. Cook, E. A, Ewan, J., E*ffects of increasing urbanization on the ecological integrity of open space preserves*, Environ. Manage., vol. 43, no. 5, pp. 846–862, 2009.
[12] Idilfitri, S., Mohamad, N. H. N. (2012), *Role of Ornamental Vegetation for Birds' Habitats in Urban Parks: Case Study FRIM, Malaysia*, Procedia - Soc. Behav. Sci., vol. 68, pp. 894–909, doi: 10.1016/j.sbspro.2012.12.275.
[13] Killicoat, P., Puzio E. (2002), t*he Economic Value of Trees in Urban Areas : Estimating the Benefits of Adelaide ' S Street*, USDA For. Serv. Gen. Tech. Rep., no. September.
[14] Mell, I. (2018), *Establishing the costs of poor green space management: mistrust, financing and future development options in the UK*, People, Place and Policy Online, vol. 12, no. 2, pp. 137–157, doi: 10.3351/ppp.2018.7698488596.
[15] Benedict, M. A, McMahon, E. T. (2002), *Green infrastructure: smart conservation for the 21st century*, Renewable resources journal, 20(3), pp. 12-17, https://www.merseyforest.org.uk/files/documents/1365/2002+Green+Infrastructure+Smart+Conservation+for+the+21st+Century..pdf.
[16] Jongman, B. (2018), *Effective adaptation to rising flood risk*, Nat. Commun., vol. 9, no. 1, pp. 9–11, doi: 10.1038/s41467-018-04396-1.
[17] Schebella, M., Weber, D., Brown G., ... (2014), *The importance of irrigated urban green space: health and recreational benefits perspectives,* Goyder Inst. Water *Res. Tech. Rep. Ser.*, no. 14, http://greenspacealliance.com.au/wp-content/uploads/2020/01/The-importance-of-irrigated-urban-green-space-health-and-recreational-benefits-perspectives-Sth-Australia-doc.pdf.
[18] Mwageni, N., Kiunsi, R. (2021), *Green Spaces in Residential Areas of Dar es Salaam City: Types, Coverage and Use*s, vol. 14, no. 3, pp. 121–135, doi: 10.5539/jsd.v14n3p121.
[19] Roy, M., Shemdoe ,R., Hulme, D., Mwageni, N., Gough, A. (2016), *Climate change and declining levels of green structures: Life in informal settlements of Dar es Salaam, Tanzania*, Landsc. Urban Plan., vol. 180, no. February, pp. 282–293, 2018, doi: 10.1016/j.landurbplan.2017.11.011.
[20] Di Nardo, F., Saulle, R., La Torre, G. (2010), *Green areas and health outcomes: A systematic review of the scientific literature,* Ital. J. Public Healt*h*, vol. 7, no. 4, pp. 402–413.
[21] Bauer, L., DeBenedictis, M., Giangrave, D., Vaughan, Z. (2017), *Measuring Green Space Efficacy in Hangzhou, China*, no. December, p. 128, https://web.wpi.edu/Pubs/E-project/Available/E-project-011018-173805/unrestricted/Smart_City_Final_IQP_Report.pdf.
[22] Tan, Z., Lau, K.K.L., Ng, E. (2016), *Urban tree design approaches for mitigating daytime urban heat island effects in a high-density urban environment*, Energy Build., vol. 114, pp. 265–274, doi: 10.1016/j.enbuild.2015.06.031.
[23] Dodman, D., Kibona, E., Kiluma, L. (2011), *Tomorrow is too Late : Responding to Social and Climate Vulnerability in Dar es Salaam, Tanzania*, Cities Clim. Chang. Glob. Rep. Hum. Settlements, no. February, pp. 1–14, http://www.unhabitat.org/grhs/2011.
[24] Vatseva, R., Kopecka, M., Otahel, J., Rosina, K., Kitev, A., Genchev, S. (2016), *Mapping urban green spaces based on remote sensing data: Case studies in Bulgaria and Slovakia*, in Proceedings of 6th International Conference on Cartography and GIS, pp. 569–578.