The Role of Urban Forest in Flood Risks Management in Yaoundé VII, Centre Region of Cameroon

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Authors' contributions

This work was done with the collaboration among all authors. Author SG designed the study, wrote the protocol, the first draft of the manuscript and managed the analyses of the study. Authors ZMG and CJK performed the statistical analysis and managed the literature searches. All authors read and approved the final manuscript.

ABSTRACT

The alarming rate of flooding in urban centres continues to inflict untold suffering and placed the urban poor in precarious living conditions across most Cameroon towns and cities. In the diverse metropolis of the country's urban cities like Yaoundé, Douala, and Limbe, peoples of basic living standards are living in non-habitable flood-prone environment where their vulnerability remains to worsen at any given flooding event. The study examines the role of urban forest in preventing flood risk and management in Yaoundé VII. To achieve the aim of the study, sub-objectives where inevitably of utmost importance, the objectives included: To ascertain the causes and environmental hazards of flooding in Yaoundé VII Municipality; to identify measures put in place to control flooding; to examine the level of preparedness by the urban dwellers of Yaoundé VII to cope with increased exposure to flooding events and hazard mitigation. The primary data sources constituted direct information from structured and unstructured questionnaire, key informants interviews included most stakeholders of the municipality such as the Divisional Officer, the Mayor of the municipal council

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and those directly involved in flood hazards. A cross-sectional and descriptive research design was employed in the study. Purposive, stratified, and systematic sampling techniques were used as platform for questionnaire administration of which a sample of 400 was drawn from the population using Taro Yamane sample determination method. The data generated were analysed using descriptive and inferential statistics. A null hypothesis was formulated and stated as follow: There exist no significant measures put in place to control flooding in Yaoundé VII Municipality. The hypothesis was tested using a One Way ANOVA test at 0.05 levels of significance. The major findings showed that there is significant flood measures put in place to control flooding in Yaoundé VII Municipality and also there exist a significant level of preparedness by the urban dwellers of Yaoundé VII to cope with increased flooding events. Based on the findings, the study recommended that the Urban Municipality of Yaoundé VII should organize massive campaign to sensitize the urban populace of the study area against improper dumping of refuse in the drainage systems while severe fines should be placed on violators. The government through the municipal council should Channelized and dredge the River Mefou which has tributaries in the study area so that the river can accommodate more volume of water whenever there is excess rainfall. The government should provide more funding for studies on hazards management in Cameroon as a whole; and for disaster management bodies and agencies in order to carry out their duties when necessary.

1. INTRODUCTION

As cities continue to urbanized and expand, recent severe flooding events continue to persist alongside urbanization and highlighting the fragility of settlements in urban areas to more dominant effects of climate change phenomenon especially in the continent of Africa, Asia and South America. Daily news and media coverage around the world has spotlighted drastic images showing how urban places and rural communities are struggling to cope with flooding incidences. What comes into people and government authority's mind is the immediate recovery efforts which of course are fundamental, but pre-disaster management scheme which is fundamental for sustainable disaster management is not always put in place for a sustainable disaster management. As flood incidences increases, the risk it raises as time passes, calls for alarm for sustainable measures to be taken to avoid future casualties. How local inhabitants of flood prone zones should react during state of emergency requires tremendous government and municipal council efforts even in the area of capacity building on self-prevention and awareness of disaster occurrence especially that of flooding in Yaoundé VII municipality in the centre region of Cameroon. In this study the research team places urban forest as platform to flood risk reduction and management in Yaoundé VII Municipality, which is operationalized through green infrastructure (designing and planting of trees) at the urban scale.

Many scholars have written in many domains about floods passing through lens of urban forest. Such scholars as Hyomin and Dong-Kun [1] painted the picture of the role that urbanization has played in intensifying urban flooding in the city of Seoul in South Korea. Paloma [2], another scholar, draws readers attention that the world's population is now concentrated in urban cities more than ever before and that the already half of the world population in cities is due to increase even faster in a few decades from now. This is actually in line with UN-WUP [3], making it clear that currently, 55% of the world population live in urban areas and by 2050, 68% is projected to be urban. This urban influx, especially in African cities of Lagos, Port Harcourt, Douala and Yaoundé, is taking place in an unplanned environment where urban development control is inadequate; consequently, the environment is vulnerable to stressors such as flood, landslide, pollution and sewage disposals around cities. Borelli et al. [4], in their article described the essential role city planners need to play by introducing urban forest in their planning scheme to meet up with global commitments on sustainable city development. The UN-Habitat [5], has long predicted that unplanned urban growth do not only lead to poverty and inequality but also to social and environmental problems on a global scale. Not too long ago, the Sustainable Development Goals (SDG) clearly attempted to address the growing demand for urban development sustainability, with focus on "make cities and human settlements inclusive, safe, resilient and sustainable" of which urban forest was increasingly seen as part and parcel of the urban sustainable decision making.

Several researches have suggested many options patterning to flood hazard control and adjustment responses. To some researchers, flooding should not just be handled locally; it requires the aid of multidimensional actors since its causes are complex. For example, White and Medd [6] listed a considerable number of flood nature to include not only fluvial, tidal and coastal flooding, but also exposure to flood risk from surface water including urban run-off and local drainage failure. Highlighting the importance of building capacity to cope with flooding issues, Adedeji [7] suggested the building of spatial planning and land management measures while Ogunsote [8] suggested that sustainable landscaping could be a better option. Oshodi [9], on his part, proposes drainage infrastructure expansion within city cores, the removal of debris from main drainage facilities and demolition of homes in flood prone areas. With all these literatures on flood control, not much has been said about the role of urban forest in controlling flood in urban areas especially in African countries. This study therefore is structured to fill this gap.

Matos [10], consider urban forest consisting of a type of mosaic of trees and other vegetation, where different actors intervene in its intensive management and the rest is being affected by natural succession forces triggered by urban conditions. In this context urban forest is identified to consist of street trees, remnant and emergent forest patches, tree plantations, and vegetation in parks, yards, and highway verges were agencies such as the Ministry of Environment and Nature Protection; the City Council and Town Planning Department work together for sustainable green city development. To Matos and his colleagues, natural succession forces (landslide, severe wind throw, wildfire…) set in when forest extend beyond its municipal boundary to encompass peri-urban agro-forests or forested watersheds that provide a city's drinking water. Such forests or plantations may often require complex management to sustain the multiple social, ecological and economic services they provide for the urban public.

FAO [11] combines urban and peri-urban forest to mean a network of woodlands, group and isolated or residual trees which is found around urban areas. Urban forest is interchangeably used with green spaces to give the same meaning. In a broader sense, green spaces in cities comprises of forest parks, public spaces, plots, green corridors, street trees, private gardens, private and domestic gardens. In most urban cities, urban forests do occur in a range of belts including managed parks, protected areas along streets and around wetlands and water bodies.

Many countries around the world have recorded significant benefits from the role Urban forest play in their city's development and sustainability. Trees and forests situated in towns and cities are often recognized as an important element in the urban systems [12,13], but in most developing countries urban cities like Cameroon, deforestation, runoff, floods, and landslides, are recurrent and the measures put in place to combat these urban catastrophes is not enough. The urban forest in Yaoundé, especially in Yaoundé VII where this study is carried out has even in a small way played significant role in flood control and management. Therefore, it became necessary to carry out this piece of research work evaluating the role urban forest play in flood reduction and management.

2. STATEMENT OF THE PROBLEM

Over the centuries, local communities have learned to utilize Africa's floodplains for their benefit, not least because of the proximity of water but also because of the annual fertilization of land by flood sediments, and these areas have become of central importance to many local economics and societies [14]. According to Parker, the most tangible form of damage caused by floods is structural damage to homes, shops and public buildings and their contents and loss of crops and livestock. Depending on how well they are constructed and the severity of the event, buildings may be partially or totally destroyed by flooding.

This study seeks to assess the role urban forest play in reducing flood risk and management in Yaoundé VII in the Centre Region of Cameroon. Nearly every year the inhabitants of Yaoundé VII suffer from serious flooding disasters. Each time when heavy rain falls, inundation occurs and destroys the homes of people, even the urban streets are not safe from flooding risk as the roads are piled-up with debris tracks deposited by run-off. At times heavy downpour ends up with serious landslide and mudflow on the roads. In fact, the inhabitants of Yaoundé VII described 2009/2010 as the worst in terms of flooding that occurred that year and the level of risk involved. Many people were displaced from their dwelling places resulting into houses destruction,
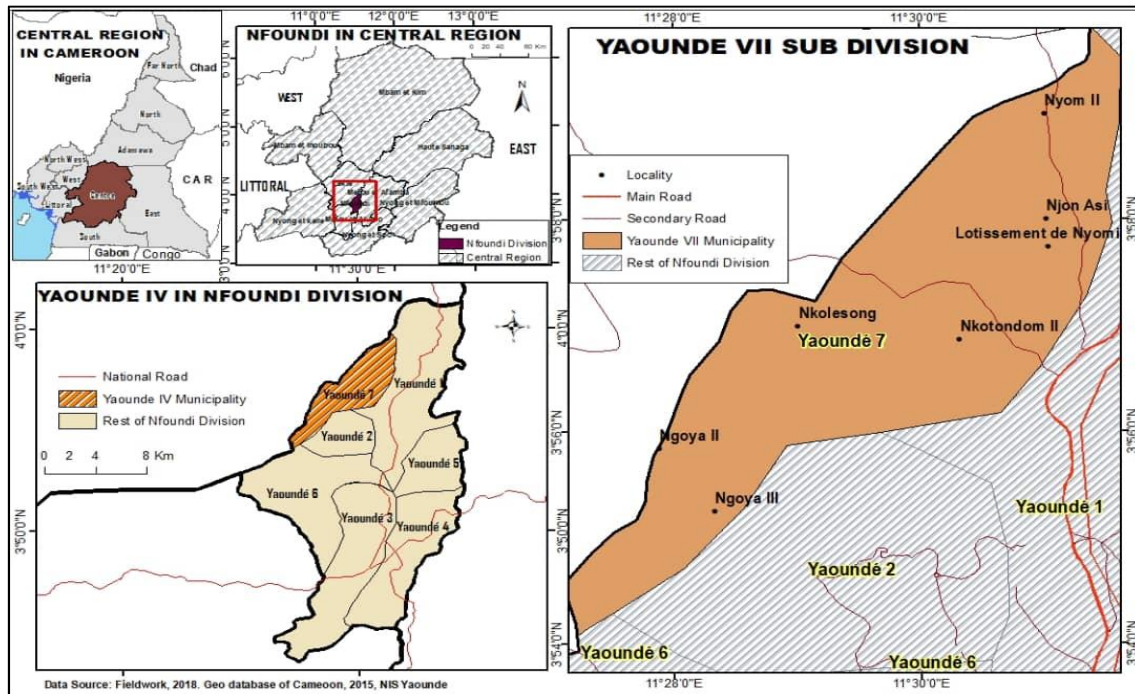
Fig. 1. Location of Yaoundé VII in the centre region of Cameroon

damaged of bridges and road slippery that could easily lead to accidents. In a bit to control flooding, the government through the Ministry of Environment and Nature Protection in 2010 promoted the planting of urban trees in Yaoundé to fight against deforestation. At individual levels, most households have resorted in planting trees in their residences to combat run-off. Green parks and communal forest reserves have been largely encouraged by the municipalities. This research work therefore sorts to assess the resident's perception on the role urban forest play in flood risk reduction and management in Yaoundé VII urban area.

2.1 Study Area

This study was undertaken at Nkolbisson within the sub-divisional council area of Yaoundé VII in the Centre Region of Cameroon. The Yaoundé VII council was created by presidential decree, N°2007/117 of 24th April 2007 in the Mfoundi Division as was the case in other regions of Cameroon. Yaoundé VII is located between latitude 3°50' and 3°53" North and longitude 11°27' and 11°30" East of the meridian. It covers a surface area of 34. 9 km², with an estimated population of 440 000 inhabitants. It is located on the western part of the Centre region. The sub-division is boarded in the west, by the council of

Mbankomo (Division of Mefou-Akono); in the north, by the councils of Okola and Lobo (Division of Lekie) and in the east, by the councils of Yaoundé 2 and Yaoundé 4.

3. METHODOLOGY

The study adopted a descriptive research design to address present prevailing conditions in the study area and also practices that are carried out by inhabitants within Yaoundé VII council area to manage flood risk events. Primary sources sorted direct information from structured and unstructured questionnaire, key informants interviews included most stakeholders of the municipality such as the Divisional Officer, the Mayor of the municipal council and those directly involved in urban forest management in the area. Secondary data came from National Institute of Cartography Yaoundé; Regional Delegation of Environment, Yaoundé, the Ministry of Environment and Wildlife, Yaoundé; interview materials; the internet and library sources as well as published and unpublished bulletins. The population of the study consisted of the inhabitants of Yaoundé VII council area. As of 2018, the population was estimated to be 440 000 inhabitants [15]. A sample of 400 was determined from the entire population using Taro Yamane (1967) sample determination method.

Purposive, stratified, and systematic samplings were the main techniques employed by the research team in the fieldwork phase.

The descriptive and inferential statistics were compiled from the raw data gathered from the field using SPSS software. The results are presented in the form of tables, charts, frequencies, percentages, graphs, diagrams, and maps for better understanding.

3.1 Test of Hypothesis

The hypothesis here was tested to confirm whether there was any significant measures put in place to control flooding in Yaoundé VII.

The hypothesis was stated as:

H_0: There exist no significant measures put in place to control flooding in Yaoundé VII Municipality.
H_1: There exist significant measures put in place to control flooding in Yaoundé VII.

3.2 The Decision Rule

Before deciding whether or not the response frequencies among the respondents were significantly effective or not, the research team decided on a "rule of the thumb" which was put in place such as: Reject the null hypothesis and accept the alternative if the critical level of significance .05 is greater than the calculated p-value otherwise, accept the null hypothesis and reject the alternative. To conduct this test, the research team used one-way ANOVA with Tukey post hoc test to show the statistical significance among the independent variables that were involved at 0.05 error margin.

4. RESULTS AND DISCUSSION

4.1 Data Presentation and Analysis

This research work sorted to examine the role of urban forest on flood risk management in Yaoundé VII Municipality. To do this successfully, it was necessary for the research team to identify the root causes of flooding in the study area. As such sample opinions of respondents were collected in the field based on the resident's level of agreement on the causes of flooding in Yaoundé VII Municipal area.

Table 1 describes respondent's level of agreement on the causes of flooding, in regards to heavy rainfall as the principal cause of flooding, 346 (86.5%) respondents strongly agreed that rainfall is a major cause of flooding in Yaoundé VII municipal, 47 (11.8%) agreed to the assertion, while 2 respondents (0.5%) were unconcerned about it. Also, 2 respondents representing 0.5% disagreed with the fact that rainfall was responsible for flooding in the study municipality. In the same light, 3 (0.8%) of the respondents strongly disagreed rainfall as a cause of flooding as well.

On the same Table 1, as to whether flood from rivers contributed to flooding, 341 (85.3%) of the sampled population strongly agreed, 33 (8.3%) agreed, 11 (2.8%) of the respondents were indifferent in the agreement level, 6 (1.5%) were in disagreement of the fact while 7 (2.3%) strongly disagreed that flood from rivers caused flooding.

More concerns by respondents about poor condition of tarred roads as one of the causes of flooding in the municipality was reacted upon by 337 (84.3%) of respondents who strongly agreed that the present state of roads in the municipality is so bad and causes flooding as against 43 (10.8) whose agreement level was agreed. The researcher recorded 5 (1.3%) responses which were indifferent, 9 (2.3%) disagreed as against 6 (1.5%) who strongly disagreed.

Map 2 indicates areas disposed to flooding in the Municipality, the researcher during fieldwork observed that most area vulnerable to flooding were swampy areas having seasonal streams passing through it.

4.2 Measures Taken to Control Flooding in Yaoundé VII Municipality

Flood victims at the Municipal Council of Yaoundé VII have developed a good number of measures or strategies to reduced flooding activities in the area. Among these measures included Street trees planting, creation of forest parks, drainage system, environmental awareness on the danger of flood, construction of bridges, growing vegetation parks, yards among others. Notwithstanding, the constant experience of flood in the study area has been very enormous in the recent years as if no action has been taken in the municipality by actors in place. The level of effectiveness of flood control measures within the study area has been explained using Liker's scale of five levels on Table 2.

Table 1. Respondents agreement level on the causes of flooding in Yaoundé VII

Causes of flooding	Rating					Effective	Percentage rating (%)				
	SA	A	I	D	SD		SA	A	I	D	SD
Heavy rain fall	346	47	2	2	3	400	86.5	11.8	0.5	0.5	**0.8**
Flood from rivers	341	33	11	6	7	400	85.3	8.3	2.8	1.5	**2.3**
Poor condition of tarred roads	337	43	5	9	6	400	84.3	10.8	1.3	2.3	**1.5**
Inadequate drainage channels	327	48	9	9	7	400	81.8	12.0	2.3	2.3	**1.8**
Failure of flood defence	304	55	12	14	15	400	76.0	13.8	3.0	3..5	**3.8**
Buildings along water channels	328	47	9	7	9	400	82.0	11.8	2.3	1.8	**2.3**
Waste disposal in water channels	304	57	12	21	6	400	76.0	14.3	3.0	5.3	**1.5**
Violation of planning regulation	363	18	2	7	10	400	90.8	4.5	0.5	1.8	**2.5**
Farming along the slopes	290	39	23	24	24	400	72.5	9.8	5.8	6.0	**6.0**
Total rating						400	100%				

Note: SA=Strongly Agree; A=Agree; I=Indifferent; D=Disagree, and SD=Strongly Disagree
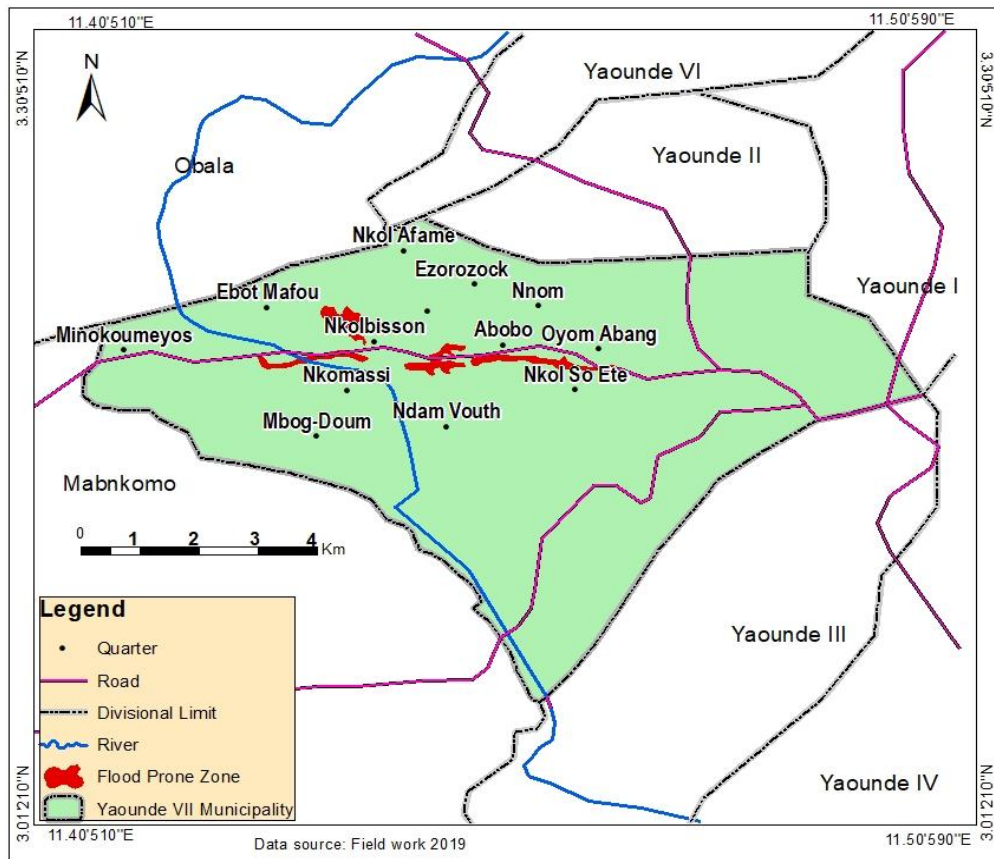*Source: Author's Field Survey, 2019*

Fig. 2. Map showing flood prone areas in Yaoundé VII
Source: Fieldwork, 2019

Table 2. Respondents agreement index on the measures to combat flooding in Yaoundé VII

Measures	Rating/Frequency					Effective	Percentage rating (%)				
	SA	A	I	D	SD		SA	A	I	D	SD
Street trees planting	338	50	8	2	2	400	84.5	12.0	2.0	0.5	0.5
Forest parks	320	63	11	3	3	400	74.8	20.8	2.0	1.5	1.0
Planting trees at residences	325	57	11	5	2	400	81.3	14.3	2.8	1.3	0.5
Community forest	312	72	10	5	1	400	78.0	18.0	2.5	1.3	0.3
Growing vegetation parks	290	83	19	6	2	400	72.5	20.8	4.8	1.5	0.5
Individual tree planting	291	88	12	7	2	400	72.8	22.0	3.0	1.8	0.5
Shrub conservation	261	99	25	13	2	400	65.3	24.8	6.3	3.3	0.5
Tree gardening	252	86	31	22	9	400	63.0	21.5	7.8	5.5	2.3
Construction of wood barriers	274	43	5	11	67	400	68.5	10.8	1.3	2.8	16.8
Total						400	100%				

Source: Author's Field Survey, 2019. Note: SA= Strongly Agree; A=Agree; I=Indifferent; D=Disagree, and SD=Strongly Disagree
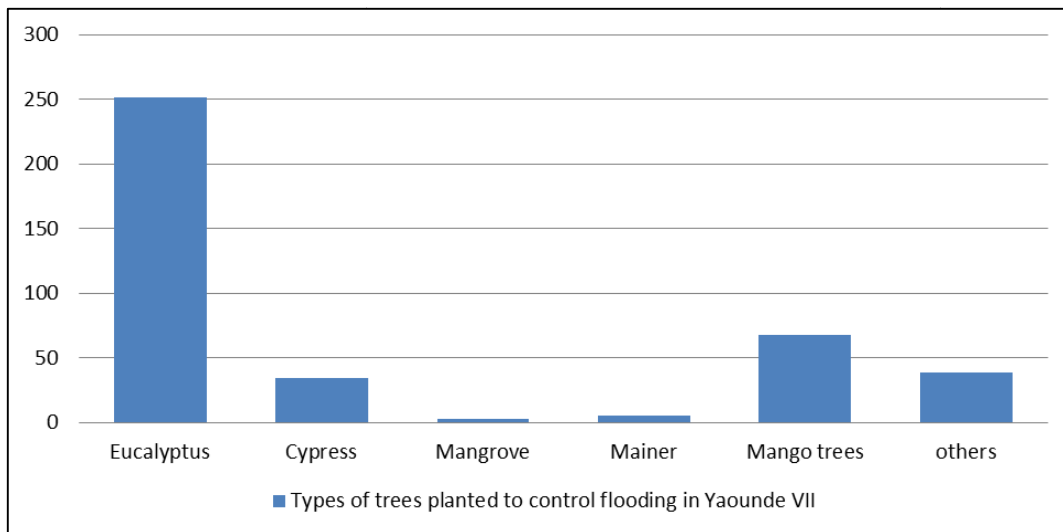

Fig. 3. Types of trees planted to control flooding in Yaoundé VII
Source: Authors fieldwork computation, 2019

Table 2 shows the agreement levels of respondents during the field administration of questionnaires, as described on the table, the control measures with highest percentage rating for those households who strongly agreed to street trees planting were 338 (84.5%) while the least in the category was tree gardening which recorded 252 (63.0) respondents. The control measure with the highest level of respondents who agreed to a particular flood control method was the conservation of shrubs at swampy areas; this was confirmed by 99 sample respondents representing 24% while the lowest figure stood at 43 (10.8) attributed to construction of wood barriers.

The study also found out that majority of trees planted to control flooding were eucalyptus (62.8%) as shown on Fig. 3, while others such as mango trees (17.0%) were planted by residences for fruits consumption. The local residences were very committed in conserving forested reserve areas especially shrubs and eucalyptus. Other tree species, 9.8%, included flower gardens, oranges, and palm tree. Others such as guava trees, avocado trees were also accepted by a good number of households interviewed.

Table 3. One way ANOVA test

**Dependent variable: Flood control
Turkey HSD

Measures	T	df	Sig.	Std. Error	95% confidence interval	
					Lower	Upper
Street trees planting	44,511	399	,000*	1,20000	1,1470	1,2530
Forest Parks	40,736	399	,000*	1,26500	1,2040	1,3260
Planting trees at residence	40,668	399	,000*	1,25500	1,1943	1,3157
Community forest planting	42,799	399	,000*	1,27750	1,2188	1,3362
Growing vegetation parks	39,532	399	,000*	1,36750	1,2995	1,4355
Individual trees that form canopy	40,129	399	,000*	1,35250	1,2862	1,4188
Conservation of shrubs at swampy areas	37,500	399	,000*	1,49000	1,4119	1,5681
Tree gardening	32,633	399	,000*	1,62500	1,5271	1,7229

*the mean difference is significant at 0.05 levels Source: Author's fieldwork computation, 2019

The result as presented on Table 3 indicates the ANOVA statistics conducted. It demonstrates a statistical significance between the flood measures. The Multiple Comparisons shows the different measure from each other. Tukey post hoc test is generally the preferred test for conducting the post hoc tests on a one-way ANOVA. Since the p-value (Sig = .001) calculated was less than the target level 0.05 in all the independent variables, the null hypothesis was therefore rejected and alternative hypothesis was in favour which stated that there exist significance measures put in place to control flooding in Yaoundé VII.

For further confirmation and to either accept or reject the hypothesis the t test was used. As shown on the Table 3, the t test has different values but all fall within the same range between t =32,633 for tree gardening to t = 44,511 for street tree planting. P-value (Sig. = .001) for all the t test was not up to the target significance level (.05), all of these having the same degree of freedom (df = 399), the null hypothesis was therefore rejected.

4.3 Talk on the Major Findings

Based on the sample respondent's perception, flooding in Yaoundé VII Municipality is triggered most especially by violation of planning regulations, heavy rainfall, flood from rivers, poor condition of tarred and earth road surfaces and inadequate drainage among others. Despite the challenges faced, local measures have been put in place by the Municipality to coup with the situation such as urban tree planting, creation of forest parks, growing vegetation parks among

others. The findings are in agreement with some findings the study outlined that flood events in the area under study is caused by heavy rainfall, flood from rivers, poor condition of tarred roads, inadequate drainage channels, failure of flood defence, buildings along water channels, violation of planning regulation and farming along flood plains. This is in overall agreement with Adetunji and Oyeleye [16], who outline similar causes in a vulnerability flood area in Ibadan Oyo State, Nigeria. The same view have been shared by Agbonkhese; Jeb and Aggarwal [17,18], who both suggested that rainfall linked with unscrupulous man's activities on the environment, the absence of basic urban systems such as drainage facilities, well-planned road network in cities have left hundreds of people distressed and homeless as a result of flooding. Likewise, the illegal dumping of solid waste on drainage channels, poor drainage conditions have been observed to lead to floods.

The findings have also greatly corroborated with Aderoju, et al. [19], on adaptation strategies to control flooding and victims of floods level of preparedness. According to these authors, they believed in the necessity of modern facilities which when installed can help agencies and the municipal government to identify flood vulnerable areas which can lead to better planning to combat floods events in the future. Some of these agencies such as the National Assessment of Flood Risk, The Environment Agency in England, (2009), listed a good number of important roles urban trees, forest parks and woodlands play in reducing the risk of flooding that was recognized in the Natural Environment

paper. The National Agency stipulated that Surface water from runoff was the major cause of flooding in urban areas while the presence of trees was considered to be very significant as they reduces the rate of surface run-off into main watercourses and drainage systems.

5. CONCLUSION

Flooding is an inevitable phenomenon as it continues to ravage most parts of urban cities around the world. Urgent action in order to control, cope and adapt with flooding in terms of its causes and effects are more than necessary at this point in time. Though the urban populace of Yaoundé VII have indicated efforts in handling the situation at hand, there is still urgent need for the Cameroon government to provide funding to conduct studies on hazards management and prevention. Government and municipalities should help put mechanism in place that can detect flooding phenomenon so as to minimize impacts when flooding eventually occurs.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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