

CLIMATE CHANGE IMPACTS ON WATER RESOURCES: A STUDY OF OGUN RIVER CATCHMENT, ABEOKUTA METROPOLIS, SOUTHWESTERN NIGERIA

Alimi Jamiu Alao^{1*}, Ibrahim Abdulrazaq Adesoji² and Olukayode Oluwakemi Omolara³

¹ Department of Survey and Geoinformatics, National Water Resources Institute, Kaduna, Nigeria

² Department of Civil Engineering, National Water Resources Institute, Kaduna, Nigeria

³ Department of Earth Sciences, Olabisi Onabanjo University, Ago Iwoye, Nigeria

*Corresponding Author: Alimi J.A. (jamiualimi69@yahoo.com)

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ABSTRACT

The variations in the Earth's global or regional climate over time are referred to as climate change. It is believed that climate change since the twentieth century is caused by increased emission of greenhouse gas from burning of fossil fuel and forest conversion. Changes in water supply, its demand and availability are some impacts of climate change on water resources. These changes are expected to affect food availability which can lead to decreased food security and increased vulnerability of poor rural farmers. The aim of the study is to determine the impact of climate change on water resources in Abeokuta metropolis and to collect information on adaptation measures being employed in the area to mitigate the effect of climate change. Structured questionnaires, Google scholar, grey literature sources, official reports, and materials from government and non-governmental organizations were used to gather data for this study. The study reveals that the observed increase in annual mean temperatures and the marked variability in rainfall patterns are key indicators of climate change, affecting both water availability and crop yields in the area. The concern among residents regarding temperature rise, heat waves, erratic rainfall and the resulting impacts on livelihoods, such as poor crop yields, loss of native forests and declining fish catches, points to the urgent need for adaptation and mitigation strategies.

Key words: Climate change, water availability, rainfall, temperature, adaptation, mitigation

1.0 INTRODUCTION

Climate change refers to the variations in the Earth's global climate or in regional climate over time. The Intergovernmental Panel on Climate Change (IPCC 2007) concludes that increased global temperature since the twentieth century is very likely due to increased anthropogenic Greenhouse Gas (GHG) emissions from burning of fossil fuel and forest conversion. According to IPCC special report (1997), changes in climate could lead to periodic and chronic shortfalls of water particularly in arid and semi-arid areas of the world. Climate-induced water stress directly affects agricultural productivity, malnutrition, human health and sanitation while too much water impacts human settlements, infrastructure and agricultural land (MoEnv, 2010). Changes in water supply, changes in its demand and changes in resources availability are some impacts of climate change on water resources (Nicol and Kaur, 2009). According to projections from the Food and Agriculture Organizations (FAO), the irrigation water demand will increase by between 5-20% by 2080. So also, it has been established that there will be a projected increase in household water and industrial water demand due to climate change (Bates *et al.*, 2008). Climate change may also lead to increasing frequency and intensity of

floods and deteriorating water quality (Brody *et al.*, 2008). Changes in water quantity and quality due to climate change are expected to affect food availability which can lead to decreased food security and increased vulnerability of poor rural farmers.

Nigeria has been experiencing climate change, as evidenced in temperature increase, variable rainfall, rise in sea level and flooding, drought and desertification, land degradation, frequent extreme weather events, and loss of biodiversity. Climate change is recognized as a factor affecting water resources globally. In Nigeria, greater percentage of the populace does not have access to clean water and unfortunately climate change will make this worse. It is even more pronounced in areas vulnerable to environmental changes such as Abeokuta South Local Government Area (LGA) in Ogun State. Abeokuta and its environs are experiencing effects of climate change as evidenced by drying water sources and unpredictable rain patterns leading to decline in food crop production by farmers practicing rain fed agriculture; and incidence of flooding which are widely reported as affecting the means of livelihood of fishermen and fadama farmers. Improved understanding and awareness of

the climate change as it affects water supply and demand as well as the impacts on all sector water users in the area will help policy makers in carrying out better water resources management in the area. Also, the impact of climate change on water resources of the area has not been well researched. Hence there is a gap on how policy makers can improve future responses to climate change in the area. The overall aim of the study is to determine the impact of climate change on water resources in Abeokuta metropolis.

2.0 MATERIALS AND METHODS

2.1. Description of Abeokuta South LGA, southwestern Nigeria

Abeokuta is located on the eastern bank of River Ogun, and is the capital city of Ogun State in the southwestern part of Nigeria. The town which lies between latitudes 7°10' N and 7° 19' N and longitudes 3° 30' E and 3° 40' E and occupies a comparatively vast land mass of about 879 Km² at an elevation ranging from 100 m to 400 m above sea level (Eseigbe *et al.*, 2018). It is a historically important agrarian city and is bordered by Ibadan and Iseyin to the north, Lagos to the south, Ayetoro, Yewa North to the west and Sagamu to the east (Figure 1). Notable landmarks in Abeokuta include Olumo Rock, a prominent granite outcrop that serves as a historical and tourist site, and the Alake’s Palace, which is the residence of the traditional ruler of the town.

Abeokuta’s population was estimated at 607,580 in 2025 (World Population Prospects, 2024). The area is characterized by bimodal rainfall pattern. The wet season is from February to October and dry season from November to January (Aiboni, 2001). The mean annual rainfall between 2009 and 2012 ranged between 97.0 and 133.26 mm; and in 2016 was 54.7 mm. The mean relative humidity ranged between 78.2 and 82.6% in 2009-2012 and 61.0% in 2016. The mean maximum temperature ranged 31.7 °C and 32.3°C while mean minimum temperature was between 22.3 and 23.2°C in 2009-2012; and 32.7 °C and 23.3°C for maximum and minimum temperatures in 2016. The city is drained by two major rivers, Ogun and Oyan and many streams, with river Ogun serving as the drainage basin of all the smaller streams (Figure 2). Some of these streams take their source from local rocky hills while some are small distributaries to the two major rivers (Adekunle *et al.*, 2023).

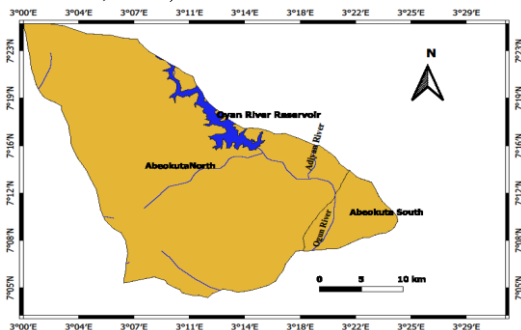


Figure 1: Location map of Abeokuta

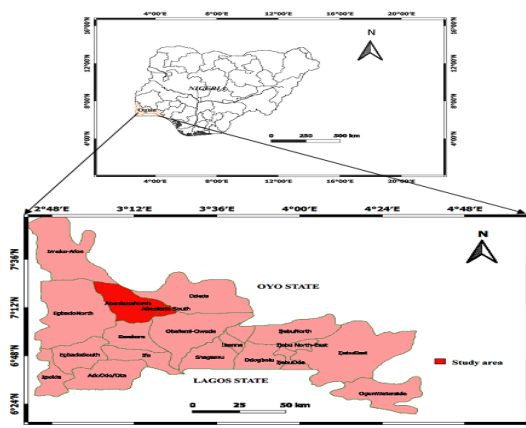


Figure 2: Drainage map of Abeokuta

2.2 Socio-Economic Context

Abeokuta has become increasing cosmopolitan since its elevation to the status of a state capital in 1976. The city has been expanding over the past few years from the central part spreading in all directions into the once rural areas which have now developed into big towns. This increase in population has placed a serious strain on the efficiency of municipal water supply in areas covered by public water supply, such that the search for potable water has become a common challenge for the people of the town. Ogun State is an economically viable state, ranking 4th in 2023, in terms of internally generated revenue among the 36 states of the country (BudgIT, 2023).

2.3 Methods

Interviewer-administered structured questionnaires were used in this research work. The questionnaires were used to elicit information on the demographic and socio-economic characteristics of the respondents, their perception on climate change, water sources and quality, their adaptation strategies, suggested options to mitigate against climate change and adaptation measures being taken by water related agencies to mitigate against climate change. Target respondents included farmers (crop, fishing and hunting), traders, artisans, civil servants and government and non-governmental organizations such as Ministry of Environment, Ministry of Agriculture, State Water Corporation, State Rural Water Supply and Sanitation Agency (RUWASSA), local government department of Water Supply, Sanitation and Hygiene (WASH) and state branch of the Association of Water Well Drilling Rig Owners and Practitioners (AWDROP). Other sources of information for this research included Google scholar, grey literature sources, official reports, and materials from government and non-governmental organizations. MS Excel software was used for data analysis and graphical presentation.

3.0 RESULTS

3.1 Demographic and Socio-economic Characteristics of Respondents

The demographic and socio-economic characteristics, as well as the awareness and perception on climate and of the sampled respondents are presented in figure 3(a-h).

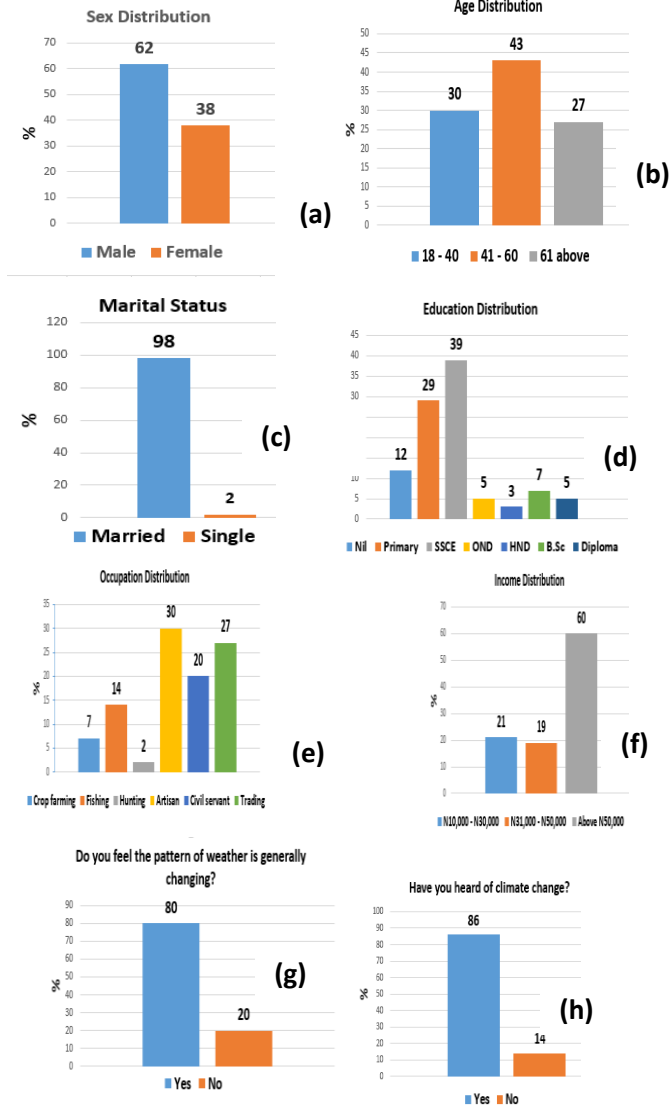


Fig. 3 (a) Sex Distribution, (b) Age Distribution, (c) Marital Status, (d) Education Distribution, (e) Occupation Distribution, (f) Income Distribution, (g & h) perception on Changing Weather

Table 1 presents the responses of the respondents to the various indicators reflecting the perceived and observed changes in environmental conditions. These indicators help to understand the extent and nature of these impacts as experienced by the community. Figure 4 shows the responses on water supply sources in the community and the perception of the respondents on water quality. The perceptions of the respondents on the impacts of climate change on livelihoods in the study area are presented in Table 2. Table 3 shows the responses to the various adaptation strategies adopted in the

study area. Responses of the various water related agencies in the state on suggested climate change mitigations options are listed in Table 4: The responses of the various water related agencies in the state on implementation of various adaptation measures are presented in Table 5.

Table 1: Perception of Environmental Impacts of Climate Change

Assessing impacts of climate change (Have you experienced any of the following in the last five years?)	Yes	No	Mean	Decision
Increasing flood %	31 (69)	14 (31)	1.69	High perspective
Sea level rise %	0 (0)	45 (100)	1.02	Low perspective
Erratic rainfall %	32 (76)	10 (24)	1.64	High perspective
Ocean surge %	0 (0)	45 (100)	0.71	Low perspective
Increasing destructive wind leading to uprooting of trees %	34 (89)	4 (11)	1.60	High perspective
Drought incidence %	31 (79)	8 (21)	1.56	High perspective
Increase in temperature %	40 (93)	3 (7)	1.84	High perspective
Loss of biodiversity %	29 (76)	9 (24)	1.49	High perspective
Heat waves %	37 (93)	3 (7)	1.71	High perspective
Incidence of acid rain %	7 (24)	22 (76)	0.80	Low perspective
Have you personally observed changes in water availability or quality in recent years?	34 (83)	7 (17)	1.67	High perspective
Do you believe the climate change is affecting water resources in your community?	36 (90)	4 (10)	1.69	High perspective

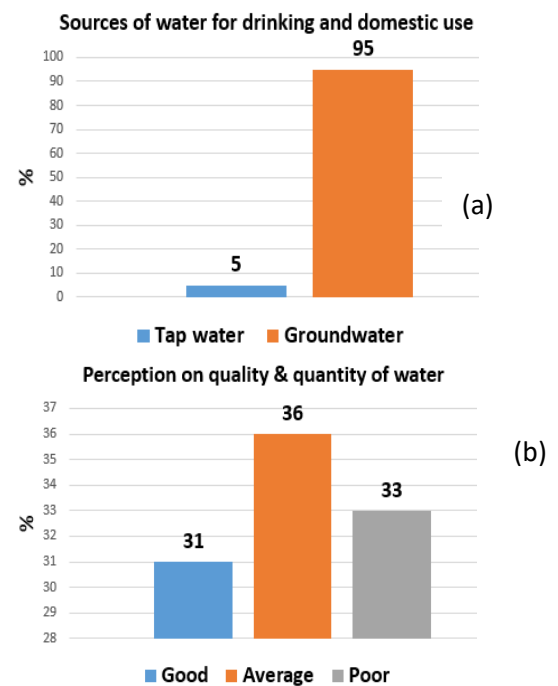


Figure 4: Water Sources and Quality

Table 2: Perceptions of Impacts of Climate Change on Economic Activities

	Have you experienced impacts of climate change on any of these economic activities?		
	Yes	No	Mean
Poor crop yield (%)	39 (100)	0 (0)	1.73
Flooding of fish pond (%)	24 (92)	2 (8)	1.11
Fish catch draught %	20 (91)	2 (9)	0.93
Loss of arable land %	23 (88)	3 (12)	1.09
Flooding of farm land %	22 (96)	1 (4)	1.00
Water logging %	24 (100)	0 (0)	1.07
Depletion of forest resources %	30 (91)	3 (9)	1.40
An increasing number of mosquitoes %	41 (100)	0 (0)	1.82
Disappearing of native forests %	26 (100)	0 (0)	1.16
Increasing flooding and erosion %	31 (94)	2 (6)	1.42
crop failure %	28 (97)	1 (3)	1.27

Table 3: Adaptation strategies adopted in the community

Which of these do you employ as effective adaptation strategies in your area?				
Strategies	Yes	No	Mean	Decision
Water saving practices %	35 (95)	2 (5)	1.6	High perspective
Rain water harvesting %	31 (97)	1 (3)	1.4	High perspective
Protecting and restoring natural ecosystem such as wetlands, forest and watershed %	4 (18)	18 (82)	0.9	Low perspective
Creation of awareness among community members on how to reduce water usage %	24 (73)	9 (27)	1.3	High perspective
Encouraging the recycling of grey water from sinks and showers for irrigation purposes %	21 (75)	7 (25)	1.1	Low perspective
Promote the use of permeable pavement to allow rainwater to infiltrate into the ground %	25 (86)	4 (14)	1.2	High perspective
Encouraging residence to minimize the use of fertilizer and pesticides to prevent ground contamination %	24 (86)	4 (14)	1.2	High perspective
Establishing community-led groundwater monitoring programs to track groundwater levels and quality and to protect local water resources %	23 (92)	2 (8)	1.1	Low perspective
Supporting local policies that promote sustainable water management practices %	22 (92)	2 (8)	1.0	Low perspective

Table 4: Mitigation measures by water related agencies

Mitigation measures	Yes	No	Mean	Decision
Water Conservation practices to reduce demand on groundwater resources	83.33	16.67	5.5	High suggestion

Rain water harvesting systems to reduce reliance on groundwater	50	50	4.5	Low suggestion
Encouraging the recycling and re-use of wastewater for irrigation and industrial uses to reduce energy and carbon emissions associated with treating fresh water	66.67	33.33	5	Low suggestion
Promoting the use of efficient irrigation methods such as drip irrigation	83.33	16.67	5.5	High suggestion
Preserving and restoring natural watersheds areas such as forests and wetland	83.33	16.67	5.5	High suggestion
Implementing measures to reduce pollution from agricultural runoff, industrial activities which can degrade groundwater quality	100	0	6	High suggestion
Transitioning water supply and treatment facilities to renewable energy sources such as solar or wind power	83.33	16.67	5.5	High suggestion
Encouraging green infrastructure such as gardens, permeable pavement to reduce flooding	100	0	6	High suggestion
Educating communities about the importance of groundwater conservation and sustainable water management practices	100	0	6	High suggestion

Table 5: Percentage Response on Adaptation Measures for Climate Change Mitigation

	Implemented	Planned	Not Considered	Mean	Decision
Technical flood protection e.g. raise dykes, increase volume of reservoirs, upgrade drainage system %	3	0	2	3.67	High implementation
Restriction of settlement/building development in risk areas %	60	0	40	3.67	High implementation
Natural retention of flood water e.g. flood plain restoration, increase groundwater recharge %	2	2	1	2.67	Low implementation
Regulation of flood management %	40	40	20	4.33	High implementation
Drought/low flow protection %	1	1	3	0.33	Low implementation
Increase efficiency of water use by all sectors, e.g. leakage reduction, use of grey water, decrease in water losses in irrigation systems, water resources saving technologies, water metering %	20	20	6	3.00	Low implementation
Economic instruments (e.g. water pricing for both industries and the public) %	3	2	0	4.67	High implementation
Improving drought forecasting, monitoring, information and early warning system %	80	20	0	3.33	Low implementation
Combined use of surface water, groundwater %	40	20	40	3.67	High implementation

Awareness raising and involvement of the public %	6	0	0	6.00	High implementation
	100	0	0		

4.0 DISCUSSION

4.1 Demographics and Socio-economic Characteristics of Respondents

From figure 3 (a-f), the majority of respondents are male (62%) and age distribution shows a significant portion of respondents (43%) are between 41-60 years old suggesting that the views and experiences related to water resources may be influenced by the perspectives of a mature and potentially more experienced population. Ninety-eight percent (98%) of the respondents are married; this implied that the study may benefit from understanding of how family structures and responsibilities influence perceptions and concerns about climate change and water resource management. The educational profile shows that a significant portion of respondents have only primary or secondary school education (68% combined), which may impact awareness and understanding of climate change and its effects on water resources. The occupational distribution of the respondents shows a diverse occupation, with a strong representation of artisans (30%), as well as reasonable percentage of the respondents involved in fishing (14%) and crop farming (7%). This indicates that the study will reflect how different occupations might be differently affected by changes in water availability and quality. Artisans and traders might experience lower impacts compared to those directly involved in agriculture and fishing. The majority of respondents (60%) earn above ₦50,000 per month, indicating a relatively higher income level within the sample. This could influence their ability to adapt to changes in water resources, as higher incomes might afford better access to adaptive measures than those with lower incomes.

4.2 Awareness and Perception of Climate Change

Figure 3 (g-h) shows the responses of the people on their perception of weather changes. The fact that 80% of respondents believe that weather patterns are changing, indicates a significant awareness of environmental changes. This suggests that climate change is impacting daily life and majority within the community noticed it. With 86% of respondents aware of climate change implies there is a high level of awareness about the concept. This suggests that climate change is a known issue within the community which could be attributed to educational initiative, media exposure or experience from changing weather.

4.3 Environmental Impacts of Climate Change

The analysis of the data in Table 1 which shows the result of assessment of the environmental impacts of climate change indicates widespread in the study area with notable concerns including increased temperatures (93%), heat waves (93%) and erratic rainfall (76%). A significant portion of respondents also report increasing destructive winds (89%), drought incidence (79%) and changes in water availability or quality (83%). Other impacts include increasing floods (69%) and

loss of biodiversity (76%), while fewer respondents have noted acid rain (24%). These findings show extensive and varied effects of climate change in study area environment. It also shows the need for targeted adaptation strategies and interventions to mitigate these environmental impacts to enhance community resilience.

4.4 Water Sources and Quality

Figure 4 presents the result of the survey on primary source of drinking water and their perception on water quality and quantity in their community. Analysis of water source dependence in the study area reveals heavy reliance on groundwater as 95% of respondents rely on groundwater as their primary source of water. With such a high reliance on groundwater, climate induced changes such as altered precipitation patterns or increased evaporation could affect groundwater recharge and quality. One-third of the respondents were of the opinion that their water resources are sufficient and of good quality. Substantial percentage of respondents perceives their water as poor in terms of quantity and quality. This perception highlights a potential vulnerability that could be exacerbated by climate change.

4.5 Socio-Economic Impact of Climate Change

Analysis of the data on the socio-economic impacts of climate change (Table 2) reveals that all respondents report poor crop yields reflecting severe disruptions in agricultural productivity due to climate change. Poor crop yields can also be attributed to water logging which was reported by all respondents. The universal experience of the respondents in terms of increasing mosquitoes possibly due to impounding water and warmer temperature poses a significant health risk. All respondents observe a loss of native forests, pointing to severe environmental degradation and possible impacts on biodiversity and ecosystem services. Other significant impacts of climate change on the economic activities of the study area include widespread flooding of farmland and fish ponds, declining fish catches, loss of arable land, forest resource depletion. These impacts have serious implications for food security, public health and environmental sustainability. The widespread nature of these effects underscores the urgent need for targeted adaptation and mitigation strategies to address these environmental challenges.

4.6 Climate Change Adaptation Strategies

The climate change adaptation strategies used in the study area can be regarded as hybrid as can be seen in the Table 3. The study reveals a high level of engagement and proactive participation by residents in adopting climate change adaptation strategies to manage resources. Key findings include widespread adoption of water saving practices and rain water harvesting, with the majority of residents actively involved to reduce water usage and supplement water supply. There is a strong support for sustainable water management practices, as evidenced by the promotion of permeable pavements, recycling grey water, and minimizing fertilizer use to prevent groundwater contamination. Additionally, a significant number of residents are involved in community-

led groundwater monitoring and support local policies that advocate for sustainable water practices. However, while there is notable participation in water conservation and community awareness efforts, strategies like protecting and restoring natural ecosystems have seen relatively lower levels of engagement. Overall, the findings suggest a community that is largely committed to sustainable water management but also indicate areas where further education and participation could enhance adaptation efforts.

4.7 Climate Change Mitigation

Climate change mitigation is an anthropogenic intervention to reduce the sources or enhance the reduction of greenhouse gases (IPCC, 2014). Suggested climate change mitigations options by the various water related agencies in the state are listed in Table 4. It was observed from the survey results that certain mitigation measures, such as reducing pollution, promoting green infrastructure received unanimous support across all agencies. Other measures like rainwater harvesting (50%) and recycling and reuse of wastewater (66.67%) show mixed responses, suggesting that these strategies may require further discussion or incentivization to encourage wider adoption among agencies.

The high level of support for measures like “Water Conservation” (83.33%) and “Efficient Irrigation Methods” (83.33%) indicates a strong commitment to improving water use efficiency. Agencies seem to prioritize measures that provide tangible, immediate benefits to water management and resource sustainability.

4.8 Adaptation Measures for Climate Change Mitigation

Apart from the individual efforts, government is also engaged in some form of climate change adaptation measures. Analysis of the data in Table 5 on adaptation strategies employed by relevant water resources agencies in the state revealed the following adaptation strategies employed by the government – construction of embankments/dykes, restriction of settlement/building development in risk areas, combined use of surface and groundwater, awareness raising and involvement of the public. The data indicates that while many water agencies have made significant strides in implementing climate change adaptation measures, there are still gaps in the adoption of some key strategies. A large majority of agencies have successfully implemented awareness raising initiatives, with 100% of agencies engaging in public involvement activities. Similarly, measures like technical flood protection, regulation of flood management and economic instruments (such as water pricing) have been widely adapted, with high implementation rates (60% or above). These reflect a proactive approach towards mitigating flood risks and managing water resources through economic tools. However, there is less attention given to measures related to drought protection, natural retention of floodwater, and improving water use efficiency. Drought protection measures are notably absent, with 100% of agencies not planning to implement them. Natural retention of floodwater is also underdeveloped, with 60% of agencies not planning to adopt it. Moreover, while some progress is made in water efficiency measures

(e.g. leak detection and gray water use), 40% of agencies have yet to plan these actions. In general, while there is strong progress in areas like flood protection and public engagement, more focus is needed on addressing drought risks, improving water use efficiency and integrating natural solutions for flood management,

5.0 CONCLUSION

The study reveals high awareness of climate change and its impacts among the respondents. Among the impacts of climate change as reported by the respondents are in increase flooding, erratic rainfall, increase in temperature and heat waves and loss of biodiversity. These have impacted livelihoods in many ways such as poor crop yields, loss of native forests and declining fish catches. The adaptation measures employed by the residents include water saving practices such as recycling grey water, rain water harvesting and promoting the use of permeable pavement to allow rainwater to infiltrate into the ground. Many government agencies have successfully implemented awareness raising initiatives, technical flood protection, regulation of flood management and economic instruments (such as water pricing). These reflect a proactive approach towards mitigating flood risks and managing water resources through economic tools. However, attention still needs to be paid to measures such as drought protection, natural retention of floodwater, and improving water use efficiency.

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