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# Mitigation and Adaptation Measures of Peri-Urban Farmers as a Response to Climate Change in Temeke District, Dar es Salaam Region.

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**Abstract**

This paper assessed mitigation and adaptation measures used by peri-urban farmers of Temeke District against climate change. A cross sectional design was applied of which 240 households were randomly selected for the household surveys and focus group discussions. Qualitative data were analysed through descriptive and inferential statistics while content analysis was used for qualitative data analysis. The findings revealed a high level of adoption of both mitigation and adaptation measures. Kruskal Wallis Test results suggest statistically significant difference in the level of adoption of mitigation measures across three age groups at $p<0.05$. Nonetheless, there was no significant difference in the adoption of adaptation measures across three age groups at $p>0.05$. The implemented mitigation measures include cultivating cover crops, alternative energy sources, mixed farming and agroforestry. Adaptation measures comprised of drought resistant crops, economic diversification, irrigation, mixed farming, cover crops sequential cropping and intercropping. Conclusively, a high level of adoption of mitigation and adaptation measures indicates that they are inevitable. Some of adaptation measures were also used as mitigation measures indicating that they are complementary to each other. The study recommends on enhancement of existing mitigation and adaptation measures. More studies on determinants of mitigation and adaptation measures are also recommended.

**Keywords:** Mitigation, adaptation, peri urban farmers, Temeke.

## 1. Introduction

Peri-urban farming (PUF) refers to production units close to town, which operate semi intensive or fully commercial farms of vegetables, crops and livestock (Komirenko and Hoermann, 2008). PUF is influenced by changes taking place in peri-urban areas such as expansion/influence of the city, high rate of land use, land cover changes and loss of agricultural land. PUF is also associated with opportunities for commercial or market-oriented cultivation of high-value crops (Choy *et al.,* 2007; Simon, 2008). Besides that, PUF is constricted by increase in land prices in peri-urban areas which poses insecurity for farmers (Mlozi *et al*., 2014). These features indicate that PUF is always in transition with implication on environmental changes particularly climate change.

In Tanzania, the impacts of climate change are obvious. They include the water level drop of Lake Tanganyika, Lake Victoria and Lake Jipe, melting of nearly eighty percent of glacier of Mount Kilimanjaro. and the inundation of Maziwe Island in Pangani District (Boko *et al*., 2007). Other impacts include the prolonged droughts and unpredictable rain cycles experienced in different parts of the country including Dar es Salaam Region (Kassenga and Mbuligwe, 2013; Mlozi *et al*., 2014). These impacts necessitated assessment of mitigation and adaptation measures among peri-urban farmers of Temeke District. Mitigation measures include initiatives to reduce emission and/or enhance the sinks of greenhouse gases such as carbon dioxide, methane, nitrous oxides and chlorofluocarbons (IPCC,

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2007). These measures include sustainable forest management and Land Fill Gas Methane Recovery (IPCC, 2007).

On the other hand, adaptation refers to human adjustment in response to climate change in order to moderate harm or exploit their beneficial opportunities. Adaptation measures include: food security issues, introducing drought and saline resistant crops, developing local food banks, improving farming systems and non-farming options such as economic diversification (IPCC, 2007; FAO, 2008). Adaptation therefore, helps farmers to adjust their livelihood in the changing climate situation.

Different stakeholders have scaled up efforts to address mitigation and adaptation measures. Globally, United Nations Framework on Climate Change (UNFCCC) and the Kyoto Protocol have placed much emphasis on mitigation and adaptation on climate change (IPCC, 2007). In Tanzania, the initiatives are evidenced by the adoption of National Adaptation Plan of Action (NAPA) of 2007 and development of the National Climate Change Strategy (NCCS) in 2012 (URT, 2007; URT, 2012**)**. Others are: the National REDD+ Strategy and its Action Plan. This Strategy provides incentive to reduce emission from deforestation and forest degradation at the national level (URT, 2013).

Besides those initiatives, the Government of Tanzania for a long time has given much attention on forest conservation and has reserved 16 million ha of forests; with 2 million ha of forests in national parks. This went hand in hand with identification of the drivers of deforestation and forest degradation alongside adoption of legal frameworks and participatory forest management (URT, 2012). In Dar es Salaam, the Government is implementing a climate change mitigation project at the closed solid waste dump site at Mtoni where methane is captured for the sake of generating 2.5 to 5 MW of electricity. Along the same line, the city has constructed a sea wall near the Ocean Road hospital to protect the road from being eroded by sea waves (Kiunsi, 2013).

Various studies on climate change mitigation and adaptation in agriculture have been conducted in different settings such as semi-arid and rural areas (Yanda *et al.,* 2006; Lema and Majule, 2009; Mongi *et al*., 2010; Lyimo and Kangarawe, 2010). Few researches have partly addressed mitigation and adaptation measures in peri-urban setting (Kassenga and Mbuligwe, 2013). Despite the fact that, peri-urban settings are likely to accelerate consequences of climate change due to a growing demand of the land resources that does not match with the available land size, yet the threat of climate change on peri-urban settings has not been given much attention in developing countries including Tanzania. While it is crucial to understand dynamics of supply and demand of the land resource and the consequences of climate change in the settings of peri-urban, unfortunately, the mitigation and adaptation initiatives undertaken by peri-urban farmers are not well known (Mlozi *et al.,* 2013; Kashaigili *et al*., 2014).

Other researchers (Sumberg, 1996; Tesha, 1996; Komirenko and Hoermann, 2008) have emphasised the important roles of PUF; but, have not addressed climate change mitigation and adaptation strategies among these farming communities. The unique features of peri-urban areas imply that mitigation and adaptation measures will equally be unique as opposed to the other settings. This is also underpinned by different studies: For example, IPCC (2007) and FAO (2008) emphasized on the importance of location specific measures due to the fact that the impacts of climate change vary from place to place. The Tanzania National Climate Change Strategy (URT, 2012) also does not specify measures that suit different geographical locations including peri-urban areas. Similarly, NAPA stresses on communities taking adaptation measures but does not specify location specific adaptation measures.

Other evidence shows that local people are the ones who know what works better on their specific environment (Dungumaro and Hyden, 2010). According to Jan and Anja (2007) local communities are very successful in managing their environment, but they are rarely considered in policies and other interventions. Most studies on climate change in African agriculture are regional or national, yet, mitigation and adaptation are place based which consequently necessitates having location specific measures (Fischer *et al*., 2002; Kurukusariya & Mendersohn, 2008 and Deressa *et al.,* 2011).

Furthermore, it is important to assess the local communities' responses to climate change because they are rarely documented, but handed down through local expertise and oral history (Lema and Majule, 2009). Therefore, this paper reports on mitigation and adaptation measures undertaken by peri-urban farmers in mediating the effects of climate change. The problem has been addressed through answering the following research questions: i) what is the level of adoption of mitigation and adaptation measures among peri-urban farmers? ii) which mitigation measures are applied by peri-urban farmers to mediate the impact of climate change? iii) which adaptation measures are implemented by peri-urban farmers against climate change?

## 2. Theoretical framework and literature review

### 2.1. Theoretical Framework

This study draws from the Disaster Crunch Model which offers a systematic approach for understanding the occurrence of a disaster and individuals' response to it (Blaikie *et al.*, 1994). Disasters like droughts, food shortages and recurrent floods affect various population groups differently on the basis of their gender, age or economic class (Blaikie, 2002). According to the model, vulnerability to a disaster is rooted in the socio-economic processes like economic hardships which trigger communities to take a pressure release or disaster risk reduction.

In case of this study, severity of climate change is a function of the resilience or economic capability of vulnerable communities in responding to the disaster and in sustaining the livelihoods (IPCC, 1997). The study postulates that climate change in forms of droughts and unreliable rainfall has affected farming practices in the study area. The prevalence of droughts and the decrease in rain cycles in the study area was also revealed in the other study (Lunyelele *et al.*, 2016). In this view, this study intends to examine how peri-urban farmers have been prompted to adjust their livelihood by devising appropriate mitigation and adaptation measures so as to sustain their farming practices in the face of climate change.

### 2.2. Literature review

#### 2.2.1. Peri-urban farming and climate change

Peri-urban farming is part and parcel of the phenomenon of climate change. Limited land due to urban expansion trigger farming through intensive application of chemical fertilizers and other inputs (Choy *et al.,* 2007). When land scarcity is combined with climate change, the application of intensive agriculture become more paramount. However, intensive application of chemical fertilizers increases emission of methane (one of greenhouse gases). Despite that, PUF is affected by the incidences of the rising temperature, decreasing the amount of rainfall and the prevalence of droughts (Shretha and Sada, 2013). Urban farming particularly livestock sector is also vulnerable from the decrease in rain cycles especially in Dar es Salaam Region (Mlozi *et al.*, 2013). Agricultural production in urban and peri-urban areas depends on cheap water and cheap energy for nitrogen based fertilizers and agricultural processes all of which contribute to climate change (Havaligi, 2009).

In Dar es Salaam Region, incidences of rising temperatures coupled with decreasing in rainfall amounts (START, 2011; Mlozi *et al.,* 2014) pose a direct impact on peri-urban farming. This situation is likely to exacerbate further vulnerability of climate change among peri-urban farmers if there would be mitigation and adaptation deficits. Nonetheless, PUF is also viewed as a source of improving urban micro climate through reducing methane emission from the land fills. This indicates that improving PUF practices improves environmental condition while poor farming practices have an imminent impact on increasing emission of greenhouse gases.

#### 2.2.2. Mitigation and Adaptation Measures

Mitigation and adaptation measures have raised concern in different settings. In the context of peri-urban settings, debates on mitigation and adaptation measures are more focused on other issues rather than farming versus climate change (Mdemu *et al.*, 2012; Kashaigili *et al.*, 2014). For example, Kashaigili *et al.* (2014) attempted to examine the best adaptation practices due to land cover changes. They observed that land cover changes trigger a shift in land use into the production of high value horticultural products and the use of forest products.

Another attempt indicated that livestock keepers of urban and peri-urban areas in the Region were vulnerable to climate change consequences and they were planning to implement adaptation strategies (Mlozi *et al.,* 2013)**.** Debate which has partially focused on peri-urban farmers addressed climate change adaptation on coastal Dar es Salaam (Kassenga and Mbuligwe, 2013). Although issues related to environmental changes in Africa and least developed countries are broadly studied, it is important to note that response to climate change in peri-urban areas have received little attention despite the fact that these places constitute risk parts of Africa (Ricci, 2012).

Despite little attention given on mitigation and adaptation measures for climate change, PUF has been reported to be of greater importance for the livelihood of the local communities of Dar es Salaam, Tanzania and other parts of the world (Sumberg, 1996; Tesha, 1996; Gündel, 2006). Meanwhile, it is emphasised in different literatures that climate change affect different communities differently. This situation triggers the local communities to device localized climate change responses based on individual traditional knowledge and skills.

Nonetheless, most of debates have mainly explored climate change combating strategies and measures in rural and semi arid areas of Tanzania and outside the country (Ishaya and Abaje, 2008; Lema and Majule, 2009; Ringo *et al.,* 2018a; Sani *et al*., 2016). Those debates are supported by the findings discussed by Smith *et al.* (2007) who asserted that the best approaches to reduce emissions depend on local conditions of a particular setting. In connection to the aforementioned evidences, peri-urban areas have unique local conditions as opposed to other areas including rural, urban and semi arid areas. Besides that, peri-urban farmers are vulnerable from climate change (Mlozi *et al*., 2013; Lunyelele *et al*., 2016) despite the fact that empirical information on appropriate responses remains scanty. Therefore, the paucity of information on how peri-urban farmers react on climate change have triggered the need to explore mitigation and adaptation measures used in the study area.

## 3. Methodology

### 3.1. The study area

The study was done in Temeke District in Dar es Salaam Region. The district is located between latitudes 6 º55' to 6º90º South and longitudes 39º25' and 39º.33' East (UNAIDS, 2010). According to 2012 Population and Housing Census, the population of the district is about 1,368,881 with 669,056 males and 699,825 females (URT, 2013). The average annual intercensal growth rate is 5.6% (URT, 2016). Based on this trend the current population is estimated to be 1.7 million people. The District is characterized by a modified type of equatorial climate which is generally hot and humid throughout the year with the average annual temperature of 29ºC (URT, 2004). Rainfall is segmented into long rains and short rains. The long rains start from mid of March to the end of May while short rains start from mid October to late December (Mlozi *et al*., 2013). Nonetheless, there are empirical evidences revealing the decline in rainfall in both seasons in the whole of Dar es Salaam Region where the study area is found (START, 2011). This has a strong negative implication in the performance of crop sub sector in Temeke District.

Natural vegetation includes coastal shrubs, miombo woodland, coastal swamps and mangrove trees although they have been significantly degraded by human activities (Mlozi *et al*., 2013). Economic activities carried out in Temeke District include farming, businesses as well as wages employment. The main sources of income among the local communities include; sales of food crops, forest products, livestock and associated products and fishing.

### 3.2. Research design

The study used a cross sectional research design to examine existing mitigation and adaptation measures across four selected peri-urban wards of Temeke District. This design was opted due to the fact that it allows data to be collected at a single point in time (Babbie, 1990).

### 3.3. Sampling design and sample size

The study used multiple sampling procedures. Purposive sampling was applied to select Temeke district based on two grounds: The district has the large land under cultivation (33,000ha) as compared to Kinondoni (13,600ha) and Ilala (11,678ha). Also, agriculture in the district provides the Region with more tons of food in comparison with the counterpart districts of Kinondoni and Ilala (URT, 2014). The choice of the four wards namely: Kisarawe II, Somangila, Pemba Mnazi and Kimbiji involved purposive sampling in order to include wards which are dominant in farming activities. Furthermore, four streets were chosen randomly from each ward; making a total of 16 streets. Finally, a total of 15 farming households were randomly selected from each street, making a total of 240 households.

### 3.4. Data collection

Primary data were collected through household surveys which used semi structured questionnaire to 240 households in the four sampled wards. In addition, in each ward there were three focus group discussions: one for males, one for females and one for young farmers of both sexes. Secondary data were collected through a review of published and unpublished literature from various places including the ward offices, libraries and online resources. This review solicited information on various aspects including mitigation and adaptation measures, population trends, climatic records and land use patterns.

### 3.5. Data analysis

Quantitative data were analyzed through Statistical Package for Social Sciences (SPSS) programme while qualitative data from Focus Group Discussions were analyzed through content analysis. Socio-economic and demographic characteristics as well as mitigation and adaptation measures were analysed through descriptive statistics.

The level of adoption of mitigation and adaptation was measured by calculating scores obtained by the individual household. The scores was based on Likert Scale (LS) statements weighed 1 – 5 in which 1= Strongly Disagree to 5= Strongly Agree. In terms of mitigation measures, a respondent who scored 5 in all cases would have a total score of 20 while the respondent who scored 1 would yield a total of 4 scores. As of adaptation measures, a respondent who scored a total of 5 in all items would have a total of 35 points while one who scored 1 in all cases would have 7 points.

The final score for every respondent in category (mitigation and adaptation measures) was divided by the total score resulting into an interval scale ranging from 1 to 5 as described as follows: i) Low level of adoption (1 - 2): in this category a respondent would score a maximum of 8 (2*4 items) in the adoption of mitigation measures or 14 (2*7 items) in adopting to adaptation measures. ii) Medium level of adoption (2.01 – 3.99): iii) High level of adoption (4 - 5): Descriptive statistics were applied to calculate frequencies and percent of the scores obtained from each individual level so as to establish the level of adoption of both; mitigation and adaptation measures. In addition, inferential statistics entailed the application of a Kruskal Wallis Test to explore significant differences in the level of adoption of mitigation and adaptation measures across the age groups.

## 4. Results and discussions

### 4.1. Selected socio-economic and demographic characteristics of the respondents

Socio-economic and demographic characteristics were assessed to reveal the baseline information of the characteristics of interest of the study population. These characteristics are presented in Table 1. The findings show that 59.2% of the respondents were males while 40.8% were females. In terms of the age groups 21 – 34 years comprised of 25.42%, 35 – 59 years 61.66% while 12.92% were respondents with 60 years and above. The mean age was 43.33 indicating that majority of the farmers were more energetic and that they are likely to devote to more time on farming besides other economic activities.

Of all the respondents, 68.8% indicated that they had completed primary education, 5.4% had secondary education while less than 1% had ordinary certificates attained upon completion of form four. In terms of occupation, 49.2% were farming, while 48.3 were also doing commercial activities in addition to farming. Based on the findings, PUF is more practiced by middle age people and with low education level. About 88% of the respondents owned land and about 13% either rented or were permitted by land owners to use for farming.

**Table 1. Socio economic and demographic characteristics of the respondents (n=240)**

| Education | Percent |
|---|---|
| No formal education | 12.9 |
| Primary | 68.8 |
| Secondary | 5.4 |
| Ordinary certificates | 0.4 |
| Adult education | 12.5 |
| **Total** | **100** |
| **Occupation** | |
| Farming only | 49.2 |
| Farming with petty business | 48.3 |
| Formal employment with farming | 2.5 |
| **Total** | **100** |

### 4.2. The Level of adoption of mitigation and adaptation measures

The study assessed the level of adoption of mitigation and adaptation in order to ascertain an overview of the farmers' initiatives to address climate change at the contextual level. In terms of mitigation measures, the findings reveal that 60.8% of the respondents had the highest level of adoption, 32.5% had medium level and 6.7% had the lowest level. This indicates that the level of mitigation measures pursued by the households in mediating climate change is reasonably high. This is because most of farmers use more than one mitigation measure to mediate climate change effects. Equally, this implies that local level initiatives are not helpless in the bid to reduce global greenhouse gas emissions.

The level of adoption of mitigation measures was correlated with the age groups. Results from a Kruskal Wallis Test suggest statistically significant difference in the level of adoption of mitigation measures across three groups at $p< 0.05$ (Table 2). As observed in the table, mean ranks for the groups suggest that the older group (60 years and above) had the highest level of adoption with the younger group reporting the lowest level of adoption. The possible reason for the findings is that the older farmers are more likely to engage in activities which translate to mitigation than the younger farmers.

**Table 2. Comparison of the level of adoption of mitigation measures across age groups (n=240)**

| Mitigation measures | Age Groups | Mean Rank | Chi-Square | df | Sig |
|---|---|---|---|---|---|
| Level of Adoption | 20 – 34 | 103.07 | 13.777 | 2 | 0.001 |
| | 35 – 59 | 119.54 | | | |
| | 60+ | 159.35 | | | |

As of adaptation measures, the findings revealed that 72.5% of the respondents had highest level of adoption, about 27% had medium level while 0.41% had the lowest level. This reveals that the level of adoption of adaptation measures is very high. High level of adoption is likely to be associated with the high level of climate change awareness and the resultant effects in Temeke District (Lunyelele *et al.*, 2016). High level of adaptation was also raised by other researchers in the other settings (Kihupi *et al.*, 2015; Abaje *et al.*, 2014; Lema and Majule, 2010). In the present study farming also appears to be an important economic activity which necessitates farmers to adopt mitigation and adaptation measures as key options to sustain PUF.

The findings from Kruskal Wallis Test revealed that there were no statistically significant differences in the adoption of adaptation measures across three age groups at $p> 0.05$ (Table 3). This indicates that different age groups take more or less equal initiatives in implementing adaptation measures.

**Table 3. Comparison of the level of adoption of adaptation measures across the age groups (n=240)**

| Adaptation measures | Age Groups | Mean Rank | Chi-Square | df | Sig |
|---|---|---|---|---|---|
| Level of Adoption | 20 – 34 | 106.44 | 4.430 | 2 | 0.109 |
| | 35 – 59 | 112.87 | | | |
| | 60+ | 136.84 | | | |

### 4.3. Mitigation measures

Peri-urban farmers implement several mitigation measures including the use of cover crops, adoption of alternative sources of energy, mixed farming and agroforestry. Table 4 provides a list of mitigation measures.

#### 4.3.1. Cover crops

Cover crops appear to have a unique importance in soil fertility improvement. The study sought to establish the extent to which cover crops are applied in climate change mitigation. The findings revealed that 81.6% of the respondents indicated that they use cover crops to mitigate climate change effects. Farmers cultivate leguminous cover crops mainly for food purposes while the same crops provide environmental benefits. Although farmers were not able to describe scientifically on how cover crops act as mitigation measure they linked frequent cover cropping with an increase in soil fertility which consequently increases yields per unit area.

**Table 4. Mitigation Measures used by Peri-urban Farmers against Climate Change (n= 240)**

| Mitigation measure | Agree % | Undecided % | Disagree % |
|---|---|---|---|
| Cover crops | 81.6 | 10 | 8.4 |
| Alternative energy sources ** | 72.1 | 23.7 | 3.8 |
| Mixed farming * | 82.4 | 5.4 | 12.4 |
| Agroforestry | 60.9 | 30 | 9.2 |

Note: * crop production and animal husbandry
** gas instead of fuel wood and charcoal

According to Barthes *et al.* (2004) cover crops add and retain carbon to the soil. This subsequently reduces atmospheric emission of carbon dioxide. Paustian *et al.* (2004) also showed that cover crops such as legumes mitigate climate change through reducing reliance on fertilizers, pesticides and other inputs. This implies that besides increasing soil fertility, cover crops contribute to the decrease in greenhouse gases (methane) emission per unit area. Scientifically, cover crops like other vegetation contribute to climate change mitigation through photosynthesis in which green plants absorb carbon dioxide (greenhouse gas) and use it to make food. Similar concern was raised in the other studies (Adger *et al.* 2003; Parry *et al.,* 2007). Enhancing cover cropping has a potential implication in reducing atmospheric carbon emissions despite the fact that they are of greater importance in improving soil fertility.

#### 4.3.2. Alternative energy sources

The study intended to ascertain the extent of adoption of alternative energy sources by farmers in the study area in relation to mitigation purpose. The findings show that 72.1% of respondents reported that alternative sources of energy is amongst the mitigation measures found in the study area. This indicates that farmers in the study area are taking initiatives of shifting from forest based resources to the modern sources mainly efficient gas stoves. This consequently reduces forest degradation, hence; reduces emissions meanwhile increases carbon sinks. The importance of alternative sources of energy in reducing tree clearance and mitigating climate change was also emphasised by other researchers (Moomaw *et al.*, 2011; Kiunsi, 2013).

Apart from mitigation, the increasing use of alternative sources of energy for cooking is also because the surrounding communities have destroyed the natural vegetation and they don't have adequate fuel woods. Focus group discussions revealed that the pace of clearance of tree was very high to the extent of affecting efforts geared towards environmental management. The same observations were reported by Mlozi *et al.* (2013) who argued that the local communities of Dar es Salaam Region have significantly destroyed the natural vegetation in search for fuel wood and charcoal. Promotion of alternative sources of energy is therefore important for domestic purposes with an imminent value in mitigating climate.

#### 4.3.3. Mixed farming

The findings show that 82.4% of respondents reported that they practice mixed farming to mitigate climate change effects. This might be due to the fact that a good combination of crop cultivation and animal rearing reduces emissions while improving environmental condition through animal fertilizers. Although ruminant animals such as cattle and sheep produce methane, farmers in the study area keep ruminant animals mainly dairy cattle in small scale. Meanwhile, they invest more on indigenous chicken which have less environmental impacts. This practice decreases the emission of methane which could be produced by ruminant animals such as cattle and sheep if they would be kept in a large scale. For example Opio *et al.* (2005) showed that in the year 2005 about 4255.9 million tonnes of carbon dioxide were emitted by the global cattle sector. This implies that increasing in cattle rearing increases carbon emission. In contrast, low cattle stocking done in the study area indicates total reduction of greenhouse gases per unit of area.

#### 4.3.4. Agro forestry

Agroforestry involves planned initiatives of growing of woody perennials on the same unit of land as agricultural crops and/or animals, either in some form of spatial mixture or sequence (Nair, 1993). In the context of this study, assessment of agroforestry focused on the system in which growing of woods or wood fruits and crops are grown in the same field. Results show that 60.9% of respondents reported that agroforestry is amongst mitigation measures used in the study area. In view of the findings agroforestry appears to be a least mitigation measure, which indicates that it is not more practiced as compared to the other mitigation measures. This is possibly due to the dramatic land use changes taking place in the study area, which continue to squeeze farmlands and reduce areas under cultivation. During the focus group discussions it was reported that the increased human settlement trigger higher demand for land which trigger tree clearance. Incidences of tree clearance at a higher pace in search for fuel wood, charcoal and expansion of farms and human settlement were also reported in the other study (Lunyelele *et al.*, 2016; Ringo *et al.,* 2018b). Those land use practices have impaired sustainability of agroforestry in the study area.

Despite these findings, the importance of forests in reducing emission and enhancing carbon sinks is well acknowledged (Kandji *et al.,* 2006; Oke and Odebiyi (2007); Smith and Olesen, 2010; Dubelling, 2011; Mbwambo, 2012; URT, 2012; Mbow *et al.*, 2014). Agroforestry is also emphasised as an important component in climate-smart agriculture due to its multiple roles of mitigation and adaptation on climate change (Thorlakson and Neufeld, 2012).

This indicates that in order to gain the multiple benefits initiatives on agroforestry are more paramount.

### 4.4. Adaptation to climate change

Peri-urban farmers implemented different adaptation measures including the use of drought resistant crops, economic diversification and irrigation (Table 5).

#### 4.4.1. Drought resistant crops

Drought resistant crops are crucial to increase resilience of the farmers against the incidences of drought. In view of the findings from the present study, 94.5% of the respondents reported that they use drought resistant crops as an adaptation measure. Drought resistant crops used in adapting to climate change in the study area are mainly cassava and sweet potatoes. Results from FGDs indicated that drought resistant crops are of greater importance due to their resistance against climatic stressors than the other crops. Kassenga and Mbuligwe (2013) also showed agronomic shift of peri-urban farmers of Dar es Salaam Region from maize to cassava cropping. The use of drought resistant crops was also observed in the other studies done in the other settings (Lyimo and Kangarawe, 2010; Idrisa *et al*., 2012; Niang *et al.,* 2014; Komba and Muchapondwa, 2015).

Nonetheless, this finding contradicts from a study done by Oruonye (2014) which showed adaptation measures related with drought resistant crop selection was the least important measure. As observed from different studies, it appears that the use of drought resistant crops is a common adaptation measures. However, drought resistant crops reported in other studies were not very similar with those found in this study possibly due to variations in farming experience across different settings. Crops such as sorghum, millet and sunflower were reported in the other studies done in other settings (e.g. Lema and Majule, 2009; Lyimo and Kangarawe, 2010; Kihupi *et al.,* 2015). This indicates that other factors such as local consumers' taste preferences influence cultivation of particular drought tolerant crops (Lobell and Marshal, 2010; Kalungu *et al*., 2013). This reinforces the notion that adaptation on climate change is location specific initiative grounded on the prevailing local circumstances as it is practiced in the study area.

#### 4.4.2. Economic diversification

The findings show that 90.8% of the respondents identified economic diversification as one of the climate change adaptation measures used in the study area. In view of the findings this appears to be the second most important adaptation measure next to drought resistant crops. Focus group discussions revealed that that climate change has clearly caused decreased crop yields and the overall ability of farming to sustain farmers' livelihood. Due to the situation and proximity of the study area to the city centre, economic diversification into commercial related activities becomes a more paramount adaptation measure. The types of petty businesses they mentioned included food vending, selling fish, selling charcoal and mini groceries among others. The results are complimentary to another different study which indicated livelihood diversification towards lower dependency on natural resources and increased reliance on urban opportunities as adaptation used by peri-urban dwellers (Ricci, 2012).

In contrast to this study, Mongi *et al.* (2010) showed that farmers in semi-arid areas adapt to climate change effects by expanding areas under cultivation. This is obviously not possible in settings with limited land sizes such as Temeke District. However, frequent land use changes coupled with rapid population increase in peri-urban areas create enabling environment for alternative income generating opportunities. Other opportunity due to the interaction is the market for products produced in peri-urban areas. Similar results were reported in the other different study (Kassenga and Mbuligwe, 2013). The results are also supported by the other studies done in Western Europe and in Kathmandu Valley, Nepal. These studies indicated the advantage of proximity to urban proper for the diversification of income generating activities and markets in peri-urban areas (Antrop, 2000; Shretha and Sada, 2013). Thus, economic diversification seems to be more pronounced in peri-urban settings as opposed to other settings such as rural areas, which also face climate change episodes.

**Table 5. Adaptation Measures used by Peri-urban Farmers against Climate Change (n= 240)**

| Adaptation measure | Agree % | Undecided % | Disagree % |
|---|---|---|---|
| Drought resistant varieties | 94.5 | 2.1 | 3.3 |
| Economic diversification * | 90.8 | 2.9 | 6.2 |
| Irrigation farming | 85 | 3.3 | 11.3 |
| Mixed farming ** | 79.5 | 13.4 | 7.1 |
| Sequential cropping | 73.7 | 20.9 | 5.5 |
| Intercropping strategy | 74.5 | 16.7 | 8.8 |
| Cover crops | 72.1 | 20.8 | 7.1 |

Note: * petty trade, food vending, selling fish, groceries etc. ** farming and animal husbandry

### 4.4.3. Irrigation farming

Irrigation is an important farming practice especially in areas characterized by inadequate amount of rainfall such as desert and semi desert areas. In this study, the findings revealed that 85% of the respondents mentioned irrigation farming as an adaptation measure against climate change. Farmers reported that they used to cultivate paddy rice in ponds, which reserve water for a period of time. FGDs added that, green leafy vegetables including tomatoes, chinese cabbage, ladies finger, green potatoes' leaves, amaranths and pepper were mainly cultivated through irrigation. The results are in line with the other study, which showed that most peri-urban households in Dar es Salaam Region were depending on water accumulated in boreholes to irrigate their farms (Ricci, 2012).

Similar results were reported in the previous studies done in semi-arid areas of Ethiopia and Iringa District (Deressa *et al*., 2009; Kihupi *et al*., 2015; Sani *et al*., 2016), which indicated irrigation as an important adaptation measure. However, the mode of irrigation presented in those studies differs from this study. Kihupi *et al*. (2015) reported that farmers in Pawaga ward were irrigating their farms through rivers. The importance of irrigation farming was also revealed in the other study on climate change adaptation on peri-urban farming (Shretha and Sada, 2013). The mode of irrigation reported in that study was involving the use of electric water pumps for lifting water from the river to farmlands and irrigation charges to farmers.

In the present study, the rapid population increases in Dar es Salaam Region increases the demand for perishable foods, mainly green leaves produced in peri-urban areas. This situation increases the potential of irrigation in order to ensure a prolonged supply of commodities from peri-urban areas. Green leaves are also not able to resist transport related complications from the countryside. Thus, the short distance from peri-urban areas to consumers (urban centre) assures the farmers with the reliable market for their products. Equally, as opposed to other settings like rural areas, which are more flexible, in peri-urban areas land use changes and competitions limit a number of adaptation including fallowing and migration to resource rich areas. Therefore, this makes irrigation more paramount in peri-urban farming.

### 4.4.4. Mixed farming

The findings showed that 79.5% of the respondents mentioned mixed farming as an adaptation measure. This involved crop cultivation and keeping domestic mainly dairy cattle, goats, layers and indigenous chicken. Farmers reported that mixed farming increases farmers' assurance against climate change. That is, when climate change affects crop cultivation animals kept substitute the risk due to crop failure. During focus group discussions it was reported that, animal manure is of greater importance for crops to flourish well and increase yields per unit of land.

On the other hand, plant residues act as fodder for animal feeds. Thus, a synergy between crops and livestock increases ecological cum economic benefits and assurance against climatic stressors. Nonetheless, this practice was also reported as a mitigation measure. This indicates that, adaptation measures also contribute to mitigation. Interrelations between mitigation and adaptation were also reported in the other studies (FAO, 2009; Smith *et al*., 2008). This implies that improving farmers' adaptive capacity has a positive implication in mitigation of climate change.

### 4.4.5. Intercropping

Intercropping is also implemented in the study area. This includes early maturing maize seeds, and vegetables such as okra, peppers, tomatoes and water melon. Such crops take short time to mature, thus; they are suitable in adjusting farming practices against short rain cycles experienced in the study area.

The practice is also important because it reduces risks associated with a failure of a particular crop in a given season or a year. Intercropping was also emphasised by Adger and Vicent (2005); Orindi and Eriksen (2005), and Kurukulasuriya and Mendelsohn (2006b). Niang *et al.* (2014) also reported shorter maturing crops as adaptation on increasing incidences of rainfall variability.

Nonetheless, those studies were carried out in other parts of Africa with different geographical characteristics from Temeke District. Equally, not very similar intercropping techniques reported in the study area were also reported in those studies. They showed of a combination of sorghum, maize and millet as well as millet and groundnuts, which are not applied in Temeke District.

This is more likely associated with farming experiences inherited from previous generations, which differ across different geographical settings. It is clear from this study and others that intercropping can differ from one location to another.

#### 4.4.6. Cover crops

The findings indicate that cover crops, mainly leguminous were also reported by peri-urban farmers as adaptation measure. Although, this was also reported as a mitigation measures it is not surprising to be mentioned as adaptation measure. Scientifically, among the benefits of cover crops include prevention of soil erosion and surface run off which consequently increases soil fertility as well as soil moisture content. These are either obvious or unobvious adaptation values as they contribute to the wellbeing of other crops cultivated in the same field with cover crops.

Therefore, cover crops were mentioned as adaptation measures probably due to their scientific potential of improving soil fertility through nutrient retention, which is obvious among the farmers. The importance of cover crops in adapting to climatic stressors was also observed in the U.S Corn Belt (Roesch-Mcnally, 2016). On the other hand, cover crops have a scientifically mitigation potential of retaining soil carbon resulting into reducing atmospheric carbon emissions. Although, this is not very obvious among the farmers, scientific value of cover crops in terms of adaptation and mitigation is scientifically evident. This finding is concomitant with the findings by Somorin *et al.* (2016), which revealed the importance of a synergy between mitigation and adaptation measures. Therefore, enhancing cover cropping implies taping both climate change mitigation and adaptation benefits.

## 5. Conclusions and Recommendations

The level of adoption of mitigation and adaptation measures in the study area is generally high. This indicates that in the bid to address climate change and sustaining peri-urban farming mitigation and adaptation measures are not optional. Further, some mitigation and adaptation measures are similar which implies that there is synergic role between mitigation and adaptation measures in the course of addressing climate change. This also implies that mitigation and adaptation measures are complementary to each other. Thus, enhancing farmers' adaptive capacity has a potential and long-term implication on mitigating climate change. Therefore, in order to address climate change mitigation and adaptation measures should be pursued simultaneously.

Farmers in the study area should enhance the use of existing adaptation measures with the Government providing the required assistance including extension services. Moreover, the study recommends more studies on mitigation and adaptation measures in order to find the appropriate ways of helping them to address successfully climate change stressors. Further to that, more studies on determining factors for mitigation and adaptation are also recommended in order to enable interventions, which will improve adaptive capacity among the local communities including peri-urban farmers.

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