

**CLIMATE CHANGE EFFECTS ON FOOD SECURITY AND COPING
STRATEGIES BY WOMEN GROUPS IN GIKINDU DIVISION,
KIHARU SUB COUNTY, MURANG'A COUNTY, KENYA**

KAMAU JOSEPH GAKUU (BEd. SCi)

N50/CE/21200/2012

**A RESEARCH PROJECT REPORT SUBMITTED IN PARTIAL
FULFILMENT FOR THE REQUIREMENT FOR THE AWARD OF THE
DEGREE OF MASTER OF ENVIRONMENTAL STUDIES (CLIMATE
CHANGE AND SUSTAINABILITY) IN THE SCHOOL OF
ENVIRONMENTAL STUDIES OF KENYATTA UNIVERSITY**

NOVEMBER, 2018

DECLARATION

This research project is my original work and has not been presented for a degree in this or any other university

Signature.....

Date.....

Kamau Joseph Gakuu

N50/CE/21200/2012

SUPERVISORS

We confirm that the work in this project was done by the candidate under our supervision.

Signature.....

Date.....

Dr. Kamau Mburu

Department of Environmental Education

Signature.....

Date.....

Dr. Evelyn Wemali

Department of Environmental Education

DEDICATION

This project work is dedicated to my wife Lydiah Nyokabi, my children Joyce Nyambura, Stephen Kamau and Samuel Nderitu. You were my pillar of support and inspiration in the course of carrying out my studies.

ACKNOWLEDGEMENT

I acknowledge support from my supervisors Dr. Kamau Mburu and Dr. Evelyn Wemali. Your constructive criticisms and corrections enabled me to complete the project. The participation by the respondents in the way of filling in the questionnaires and attending the focus group discussions are equally highly acknowledged. Support from the meteorological department by way of availing secondary data is also highly acknowledged. Insights from Murang'a East Sub County Agricultural Officer are also appreciated.

ABSTRACT

The study sought to find out the climate change effects on food security, and the community coping strategies in Gikindu Division in Murang'a County. The study was in response to the profound climate change effects over the years leading to depressed rainfall and increased temperatures exposing the farmers to the risk of diminished returns from the production activities. Gikindu area sits on a low agro-ecological zone five and six which is prone to persistent crop failure attributed to the vagaries of climate change. It was established that climate change effects have been felt in the area, and the same had caused a negative effects on food security, coping strategies employed to mitigate it. A descriptive research design was employed to achieve the desired data in the area. The members of the women groups actively engaged in agricultural activities served as the target respondents. The women groups engaged in agricultural activities were eleven in number and had a total of one hundred and eighty members. Data was collected by use of questionnaires which were administered to group members, focus group discussions which were used to reach the group officials, an interview schedule for the Divisional Agricultural Officer, an observation checklist and a document analysis guide. Data was analyzed by use of quantitative analysis which entailed descriptive and inferential statistics and qualitative data was analyzed by use of content analysis. The analyzed data was presented in frequency tables, pie charts and bar graphs. The study found out that: most of the respondents perceived the difference in rainfall and temperature levels to be profound thus confirmation that over a period of time, there had been noticeable variation in terms of the rainfall amounts and the temperature levels. It was observed that majority (55%) of the respondents considered there to have been improvement of their agricultural production activities by virtue of participation in the group activities thus confirmation that membership in the women groups had impacted positively on the households' economic mainstays. The climate change phenomenon had occasioned suffering to the farmers. Likewise, majority of the families in the area were entirely dependent on the rains for their agricultural production activities exposing them to risk at the advent of crop failure. The study concluded that the challenges faced by farmers in the area are to a great extent as a result of the climate change that has taken place over time. The study also concluded that a considerable number of the families in the area had since lost hope in agricultural production and instead relied upon governmental relief supplies as a way of life. Farmers in the area had adopted creative coping strategies to help them overcome the effect of climate change. The coping strategies were found to be effective as they helped improve on the situation of food security in their families. The study recommends that; legal provisions should be put in place to ensure that farmers have access to information on climate change as a measure of forestalling the event of losses accruing from the agricultural production activities in unmitigated situations, the county government should put in place an integrated approach as pertains to invoking the participation of women in the agricultural production activities with a view of engendering food production to assure security. The national government through the ministry of Agriculture should ensure that farmers have both the information and the drought tolerant crops which can withstand the harsh weather conditions, ensure that water as a resource is harvested and harnessed in the requisite manner alongside encouraging members of the area to participate in organized farming groups activities.

TABLE OF CONTENTS

DECLARATION	ii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
TABLE OF CONTENTS	vi
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF PLATES	xi
LIST OF ABBREVIATIONS AND ACRONYMS	xii
DEFINITION OF OPERATIONAL TERMS	xiii
CHAPTER ONE: INTRODUCTION	1
1.1 Background of the Study	1
1.2 Statement of the Problem.....	2
1.3 Research Questions	3
1.4 Research Objectives	3
1.5 Research Hypothesis	4
1.6 Justification of the Study	4
1.7 Conceptual Framework.....	5
CHAPTER TWO: LITERATURE REVIEW	7
2.1 Introduction.....	7
2.2 Empirical Literature	7
2.3 Variability of Temperature and Rainfall.....	12
2.4 Effects of Rainfall and Temperature Variability on Food Security.....	14
2.5 Coping Strategies against Rainfall and Temperature Variability	15
2.6 Role of Women Groups in Assuring Community Food Security	17
2.7 Knowledge Gaps.....	20
CHAPTER THREE: RESEARCH METHODOLOGY	21
3.1 Study Area	21
3.2 Research Design.....	22
3.3 Target Population.....	22
3.4 Sampling Procedures	22
3.5 Sample Size.....	22
3.6 Research Instruments	22
3.7 Data Collection Procedure	23
3.8 Data Analysis	23

CHAPTER FOUR: RESULTS AND DISCUSSION	24
4.1 Introduction.....	24
4.2 Socio-Demographic Information of the Respondents.....	24
4.2.1 Respondents Age	24
4.2.2 Respondents Education Levels.....	25
4.2.3 Marital status	26
4.2.4 Length of Membership in Women Groups.....	27
4.2.5 Length of Leadership in Women Groups	28
4.2.6 Awareness of Climate Change by Women Group Members	29
4.2.7 Initiatives to Sensitize the Women Group Members about Climate Change	30
4.2.8 Usefulness of Climate Change Information among Women Group Members	31
4.3 Rainfall and Temperature Variability Trends in Gikindu Division.....	32
4.3.1 Respondents View on Rainfall and Temperature Variability in Gikindu Division	32
4.3.2 Effects of Rainfall and Temperature Variation on Agricultural Production Capacity	34
4.3.3 Perceptions of rainfall and temperature variability on household food security.....	35
4.4 Effects of Climate Change on Food Security in Gikindu Division	41
4.4.1 Dependence on Rainfall to Grow Food Produce	41
4.4.2 Instances of Total Crop Failure.....	42
4.4.3 Perceptions on Effects of Rainfall and Temperature on Variability of Food Security	44
4.4.4 Exposure of Women Group Members to the Acute Need for Relief Food	48
4.4.5 Consideration of Households Food Security	49
4.4.6 Assistance from Organizations in Ensuring Food Security	50
4.5 Coping Strategies by Women Groups to Mitigate Food Insecurity in Gikindu Division	51
4.5.1 Effects of Group Participation in Agricultural Production.....	51
4.5.2 Perceptions on the Role of Women Groups on Household Food Security.	57
4.5.3 Ways of Mitigating the Challenge of Food Insecurity Attributed to Climate Change	63
CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS.....	64
5.1 Summary	64
5.2 Conclusions.....	65

5.3 Recommendations.....	66
5.4 Suggestion for further study.....	67
REFERENCES.....	69
APPENDIX I: Questionnaire for Women Group Members	76
APPENDIX II: Focus Groups Discussion Questions for Group Leaders.....	83
APPENDIXIII: Interview Schedule for Divisional Agricultural Officer	84
APPENDIX IV: Observation Checklist.....	85
APPENDIX V: Murang’a Temperature Data From 1995 To 2014.....	86
APPENDIX VI: Murang’a Precipitation Trends From 1983 To 2014	87

LIST OF TABLES

Table 4.1: Respondents Age Brackets	24
Table 4.2: Respondents Education Levels	25
Table 4.3 Chi-Square Test between Climate Change and Usefulness of Climate Change Information	31
Table 4.4 Chi-square test variation in rainfall and temperature and their effects on agricultural production capacity	34
Table 4.5 Perceptions on Effects of Rainfall and Temperature Variability on Food Security	43
Table 4.6 Cross Tabulation between Dependence on Rainfall to Grow Produce and Instances of Total Crop Failure.....	47
Table 4.7 Perceptions on the Role of Women Groups on Household Food Security	57

LIST OF FIGURES

Figure 1.1	Conceptual Framework showing the effects of climate change and the coping strategies to mitigate food security	5
Figure 3.1	Study Area Map: Source: Survey Department of Kenya (2017)	21
Figure 4.1	Respondent’s Marital Status	26
Figure 4.2	Length of Membership in the Women Groups	27
Figure 4.3	Length of Leadership in Women Groups.....	28
Figure 4.4	Awareness of Climate Change by Women Group Members.....	29
Figure 4.5	Initiatives to Sensitize the Women Group Members about Climate Change	30
Figure 4.6	Usefulness of Climate Change Information among Women Group Members	31
Figure 4.7:	Respondents Views on Variability in the Rainfall and Temperature Levels.....	32
Figure 4.8	Respondents Views on Effects of Rainfall and Temperature Variation on Agricultural Production	34
Figure 4.9	Temperature trends from 1995 to 2014 (Thika Meteorological Station)..	39
Figure 4.10	Precipitation Trends from 1983 to 2014 (Thika Meteorological Station).....	40
Figure 4.11	Dependence on Rainfall to Grow Produce.....	41
Figure 4.12	Instances of Total Crop Failure as Reported by Women Group in Gikindu	42
Figure 4.14	Consideration of Household as Food by Women Groups in Gikindu	49
Figure 4.15:	Assistance from Organizations in Ensuring Food Security to Women Groups in Gikindu.....	50
Figure 4.16	Effects of Group Participation in Agricultural Production on Households’ Economic Mainstay	51

LIST OF PLATES

Plate 4.1: Dried up Water Pan as Evidence of Harsh Weather Conditions in Mirira	47
Plate 4.3 Water Pan Constructed by Women Group to Facilitate Farming During Dry Spells in Gikuo within the Study Area	53
Plate 4.5 Tissue Culture with Optimal Mulching to Safeguard against Water Loss in the Dry Weather Conditions.....	54
Plate 4.6 Adoption of Cassava Growing as a Food Insecurity Mitigation Measure Owing to its Drought Tolerance Capacity in Gikuo within the Study Area	54
Plate 4.7 Adoption of Technology to Mitigate Inadequate Rainfall as Evidenced by the Drip Irrigation Farming Systems in Mirira within the Study Area.....	55
Plate 4.8 Horticulture Farming Activities Undertaken by a Women Group in the Study area for Commercial Purposes in Kambirwa within the Study Area	55
Plate 4.9 Adoption of Drought Tolerant Cultivar (Carica Papaya) for Commercial Purposes to Mitigate Climate Change Effects in Gitungano within the Study Area	56
Plate 4.10 Tree Nursery for Women Group Members to Undertake Agro Forestry Activities for Income Generation.....	61
Plate 4.11 Tissue Culture Banana Nursery for Women Group Members to Encourage Adoption of the Technology	62
Plate 4.12 Women Group Greenhouse with a Background of Sweet Potato Vines in Kambirwa Area.....	62

LIST OF ABBREVIATIONS AND ACRONYMS

CBS	Central Bureau of Statistics
CGIAR	Consultative Group on Agricultural Research
CIRAD	Centre for Agricultural Research for Development
CSAE	Centre for the Study of Africa Economies in Oxford
CSCW	Computer Supported Competitive Work
DFID	Department of Foreign Investment and Development
FAO	Food and Agriculture Organization
FEWSHET	Famine Early Warning System Network
GDP	Gross Domestic Product
GHGE	Green House Gas Emissions
GoK	Government of Kenya
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
KIPPRA	Kenya Institute of Public Policy and Research
MoA	Ministry of Agriculture
NGO's	Non-Governmental Organizations
UN	United Nations
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
WCRF	World Cancer Research Fund
WHO	World Health Organization

DEFINITION OF OPERATIONAL TERMS

Afforestation	Continuous planting of trees to check the depletion of forest cover
Climate Change	Continuous and successive change in weather variation over a definite period of years
Food Security	Capacity to produce food in an environmentally sustainable manner and assure populations of its availability in an affordable manner
Women Groups	An association of women pooling together with a common Purpose and goal which they intend to achieve

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Climate change is an emerging phenomenon which has had far reaching ramifications on livelihoods globally. It has affected the human population greatly, negatively impacting the food security, emerging production and allied economic activities, (CGIAR, 2013). This has given rise to the formation of the research programme on climate change, agriculture and food security with support from the global donor platform for rural development to help ameliorate the impacts of climate change, (CGIAR, 2013). The Consultative Group on Agricultural Research has formed a commission which has an emphasis on the areas of agriculture, food and nutrition, economics and natural resources. It has a special focus on involvement of the member countries on the assessment of reports and articulation of scientific findings on the potential impacts of climate change on agriculture and food security globally and regionally to employ the most appropriate actions to achieve food security in the context of climate change (FAO, 2013).

Climate variability has positive correlation with increasing food insecurity and ways need to be devised on how to deal with the extremes and ensure that people adapt in the near future (Craine *et al.*, 2012). More research needs to be done on the bio- physical and socio- economic to bring greater understanding to the impacts of climate change on the vulnerability of the populace in relation to food security. Efforts are required to increase farmers' capacity in the areas where climate change is causing effects for them to adapt accordingly (Craine *et al.*, 2012).

Distribution and prevalence of weeds, pests, crops and livestock diseases may also be influenced by climate variability (Lloyd *et al.*, 2011). Evidence of occurrence of livestock diseases like Rift Valley fever and blue-tongue in East Africa, African horse sickness in South Africa after periods of dry spells followed by heavy rainfall give credence to the phenomena (Baylis & Githeko, 2006). Increased cases of extreme weather frequencies may predispose the spread of Rift Valley fever cases to Europe and other non-traditional areas (Martinet *et al.*, 2008). This may ultimately affect the food security situations.

The food security situation in Kenya has been heavily compromised by the climate change phenomena (Mugalavai, 2013). The increased incidences of drought can be directly linked to the situation of changing climatic patterns and there is need to come up with adaptation measures to check the climate change effects. The Central Kenya Region bears the brunt of climate change effects as a result of reducing forest cover arising from increase in population (CSCCW, 2012). A county stakeholder's consultative forum held in Nyeri developed the response strategies that can be employed to check the emerging risks and ameliorate the food security situation (CSCCW, 2012). The forum proposed that education of the populace about the reality of the phenomena was the only way out of the prevailing situation. The forum which entailed a common plan for Nyandarua, Nyeri, Murang'a, Kiambu and Kirinyaga Counties appreciated the need to develop policy to take charge of the situation.

Murang'a East Sub-county has realized the imminent risks posed by the threat of climate change in the food security situation. According to the sub-county, development strategy plan for the year 2012-2013 (GoK, 2012) investment in women agricultural producer groups has been identified as a key plank in mitigating the food security situation. This is by way of capacity building in sustainable agricultural activities, value addition and energy conservation to reduce greenhouse gas emissions. Various players including the Ministry of Agriculture, non-governmental organizations, faith based entities and private business having taken cue and joined hands in the programmes. The study sought to find out the effects of climate change on food security in Gikindu Division Muranga East Sub-County and the coping strategies put in place by women groups in the area to ameliorate the situation.

1.2 Statement of the Problem

Murang'a East Sub-county has the benefit of having a wide agro-ecological zone range. The presence of forest highlands and lowlands pre-disposes the county to a great variation in terms of agricultural production. To a layman the sub-county is a rich agricultural producer associated with the highland ecological zone disposition. However, the lowlands have suffered years of successive crop failure and food insecurity associated with the dry and arid conditions, as espoused in the Murang'a East Sub-county Development Strategy, 2012-2013, (GoK 2012). The development strategy which was anchored in the poverty reduction and wealth creation policy paper of the year 2003 calls for engendering of food production activities as a measure of

reversing the pain inflicted by climate change effects. The incidences of food insecurity have been evident from the frequent intervention programmes in the name of relief food provision which are carried out at least in every two years owing to erratic rainfall.

On the other hand, though, agricultural production activities carried out by women groups have been minimal. The women groups have proved veritable vehicles of communal engagement but have not been exploited to the optimum in terms of having them effectively serve as entities of food security assurance. Gikindu Division sits on a low agro-ecological zone (VI and VII) which has pre-disposed it to the risk of intermittent rain failure (NEMA, 2012). Little efforts have been made from a policy situation as regards investment in irrigation and empowering the women agricultural producer groups. The study thus sought to find out the effects of climate change on food security and the coping mechanisms employed in Gikindu Division of Murang'a East sub-county.

1.3 Research Questions

- i) How are the trends of rainfall and temperature variability in Gikindu Division in Murang'a East Sub-county in the period of 1983-2013?
- ii) What are the effects of climate change on food security in Gikindu Division in Murang'a East sub-county between 1983- 2013?
- iii) Which coping strategies have been employed against the climate change effects by women groups in Gikindu Division in Murang'a East Sub County?
- iv) How effective have the coping strategies been to assure the community of Gikindu Division of food security?

1.4 Research Objectives

- i) To analyze the rainfall and temperature trends in Gikindu Division of Murang'a East sub-county in the period of 1983-2013
- ii) To evaluate the effects of climate change on food security in Gikindu Division in Murang'a East sub-county in the period of 1983- 2013
- iii) To identify and examine the coping strategies that have been employed by women groups in Gikindu Division to check the climate change effects on food security
- iv) To determine the effectiveness of the coping strategies employed by women groups in Gikindu Division in assuring the community of food security

1.5 Research Hypothesis

- i) There has been significant rainfall and temperature variability in the period of 1983-2013 in Gikindu Division, Murang'a East Sub-county
- ii) The rainfall and temperature variability has had positive and negative effects on the household's food security situation in Gikindu Division in Murang'a East Subcounty

1.6 Justification of the Study

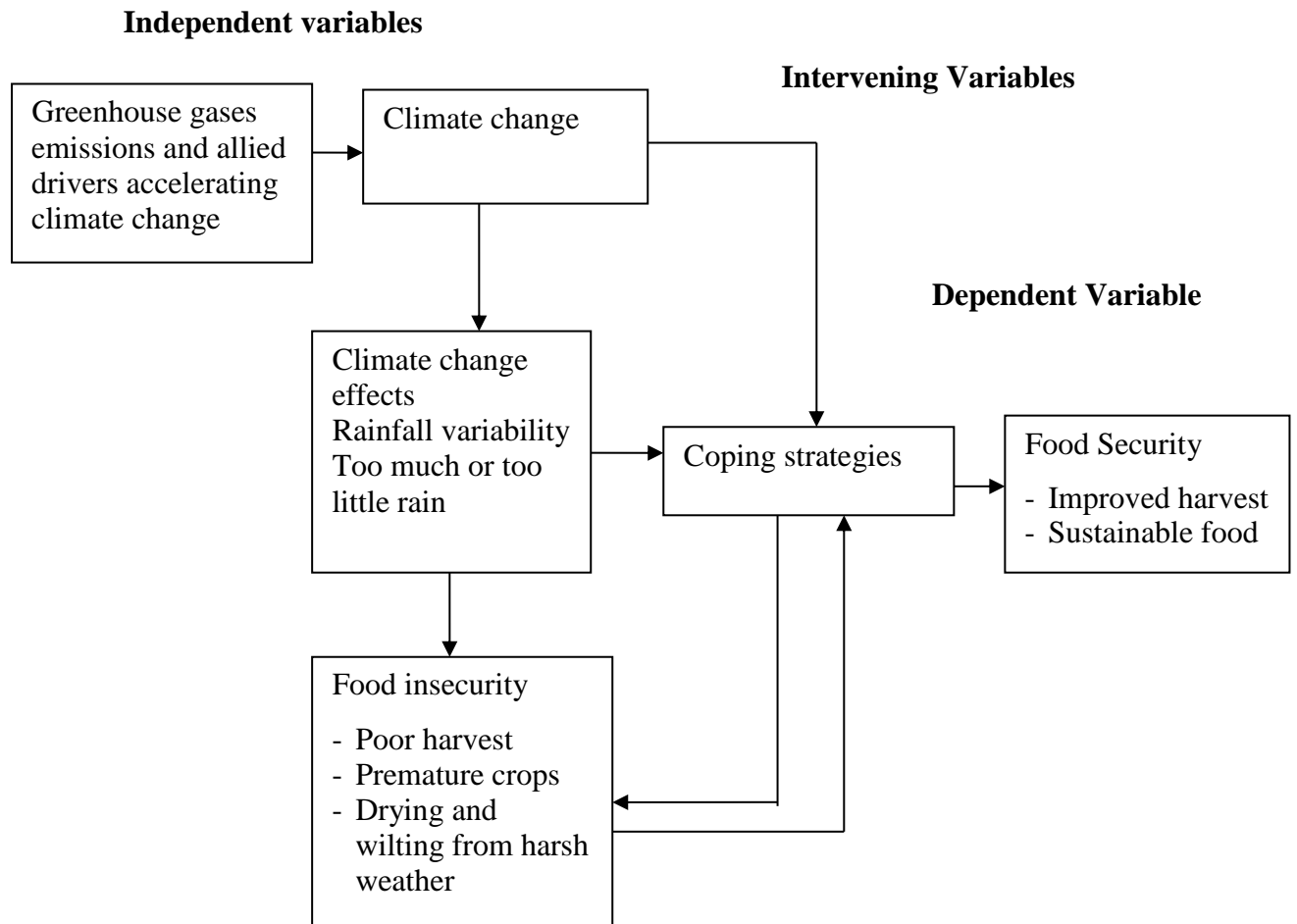
Agriculture is the backbone of the economy of the Republic of Kenya. It contributes heavily to the country's Gross Domestic Product and it's the leading foreign exchange earner for the country (MoA, 2013). It assures many households of their livelihoods and access to the basic provisions in terms of food security. On the other hand, most of the players in our country's agricultural sector are dependent on rain fed agriculture (MoA, 2013). The variability of rainfall has a direct correlation to the production levels in the agriculture sector thus impacting immensely on the food security situation.

Climate change phenomenon has had far reaching ramifications on the world's economy (IPCC, 2007). There has been a paradigm shift in policy formulation whereby all jurisdictions are taking cognizance of the great challenge that it portends (IPCC, 2007). There is thus the need to evaluate with an aim of authenticating the extent to which local communities have employed coping strategies to the phenomena.

A lot of intervention strategies have been employed in the arid and semi-arid areas by the government and non-governmental institutions. They have been geared towards addressing the food security situation especially in the rain dependent agricultural production areas. There is thus need to find out the extent to which the activities have impacted on the food security situation and their effectiveness.

Engendering the food security campaign has been practiced in many food deficient areas (Yiamma *et al.*, 2011). This is attributed to the fact that food production activities have been abandoned by many men in the rural areas. They have relegated the activity to the women and moved to urban areas in search of employment. There is need to find out how the engendering initiatives have worked out. This is with particular focus to the capacity of women groups to work hard and assure their communities of food security.

1.7 Conceptual Framework



Source: Adapted from Maureen Agnew and Clare Goodness (2009)

Figure 1.1 Conceptual Framework showing the effects of climate change and the coping strategies to mitigate food security

The rapid industrialization and allied economic activities leads to increased greenhouse gas emissions leading to greenhouse effect occasioning adverse climate change effects. The activities leading to the prevailing situation are carried out to facilitate human economic growth thus difficult to do away with. The production of higher levels of carbon dioxide is thus inevitable leading to accelerated climate change effects.

The climate change is manifested by either reduced rainfall over prolonged time spans and gradual temperature increase or too much rain that may cause flooding on low lying farms, erosion on the sloppy farms or affect soil drainage levels for certain crops. This exposes the populace to the risk of competition for natural resources owing to deprivation. The incidences of conflicts are manifested, reduced earnings and life

expectancy levels. Food insecurity is profound owing to reduced production levels attributed to unfavorable weather conditions. The situation of food insecurity is attributed to crop failure instances, premature maturation thus low harvests and drying up and wilting of crops from harsh weather.

Some of the coping strategies that can be employed to check the prevailing conditions include the engendering of food production whereby the female population members are given greater focus with regard to participating in agricultural production activities. Planting drought tolerant cultivars which withstand the vagaries of weather equally may positively affect the food security situation. Practicing irrigation and avoiding over-reliance on rain fed agriculture may equally be a good practice which may stem the tide of food insecurity. Engaging in best practices with regard to technology adoption in the realms of food production may also positively impact on the food security situation.

The employment of effective coping strategies may greatly impact positively on the food security situation. This is by way of having assured and reliable food supply systems which confer the requisite security to the populace owing to the availability of the food in a nutritionally acceptable manner. This is with regard to having it provide adequate nutrients to the persons consuming it. The food production systems should also not endanger the environment and accelerate the effects of climate change.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The following section has the empirical review encompassing trends as regards the rainfall and temperature variability on food security and it draws from the study objectives. It draws on the strengths and weaknesses of the reviewed literature.

2.2 Empirical Literature

Climate change affects biological and human systems in varied ways. Spatial heterogeneity of climate change impacts has been widely studied and global average temperature increases denote considerable variation in temperature rise. Precipitation rises are very likely in high latitudes, while decreases are evident in most of the tropics and subtropical land regions (IPCC, 2007). Projections show that as the planet warms evidence of climate and weather variability will be noted. Alternations in the frequencies and severity of extreme climate dynamics and variability of weather trends will have significant ramifications for human and natural processes. Increased health and nutritional demand variability's accrued from heat stress, drought and flooding may be immense in the ensuing future and may have adverse effects on many socio- economic activities (IPCC, 2012).

Possible effects of changes in climate variability may have profound implications on biological and food systems, impacting on the tropical and sub-tropical areas with deleterious effects of anthropogenic climate variations expected to be profound (Challinor *et al.*, 2009). The areas are not very developed and face enormous household food security challenges. Increased human populations evidenced in the regions equally have negative implications (UNDESA, 2013). Costs of climate change and extreme events have realized global importance. This is associated to the economic costs accrued from the events.

Economic costs of climate change extremes are varied with global annual damage from variability events increasing eightfold in the period of the 1960s and the 1990s, 1980 and 2004 and the costs of extreme weather amounting to US 1.4 trillion (Mills, 2005). Since 1980, annual costs have ranged from a few US billion to above US \$200 billion for 2005, the year of Hurricane Katrina (IPCC, 2012). Considerable variation is evident regionally and the economic costs of climate variation in proportion to the GDP

are greater in developing countries in comparison to the developed countries and in some instances go up to 8% in extreme cases. Increased upward trends in terms of the economic losses attributed to climate variation have been on an upward spiral since 1980 (Munich, 2011; Bouwer, 2011). Extreme climate variability's has profound effects on facets closely linked with climate like water, agriculture and food security. Peripheral areas like health, forestry and tourism are also affected by the impacts of climate variability on the sectors (IPCC, 2012).

Warmer climates accelerate growth and development of plants but instances of cool or extremely hot weather equally affects productivity in the agricultural sector. Early flowering and maturity of crops has been documented in relation to climate change attributed to higher temperatures than the optimal (Craufurd *et al.*, 2009). Increased temperatures can also lead to impaired yields and crop failure. Studies carried out by (Lobell *et al.*, 2011) showed that in the propagation of maize every degree above 30 °C leads to yields reduction by 1.7% in the event of drought conditions. Reduced temperatures equally affect crop production with evidence of rice yields reduced by 90% in instances of night temperatures at 27°C compared with 32°C (Mohammed *et al.*, 2009). The effects of temperatures and photo periods of optimum and sub optimum temperatures thus directly influence the growth rates of the crops all induced by the climate change variations (Craufurd *et al.*, 2009).

Studies in the U.S.A have shown that an increase in the temperatures by 3°C has had far reaching consequences on the populace health (Batisti, 2009). This has always been occasioned by the unhealthy food which greatly increases the existing health inequalities (Batisti, 2009). The unprecedented seasonal heat has been a precursor to future food insecurity owing to the imbalance in the production capacities. The changes may occasion new emerging patterns for crops and livestock. The altered use of pesticides and veterinary medicines has affected the main transfer mechanisms upon which they can move from the environment to the food. This thus not only portends the risk of food availability but also the potential for unsafe food in the wake of climate change (Batisti, 2009).

Climate variability is equally an important aspect for yield quality. Protein content in wheat grains was confirmed to have responded to changes in the means and variability of temperature and rainfall (Porter & Semenov, 2005); in the event of high temperature extremes in grain filling the protein content of the wheat grains is affected (Hurkman

et al., 2009). Rainfall variability causes inter-annual yields variability. Studies by (Hlavinka *et al.*, 2009) established statistically significant correlation the monthly drought index and area specific yields in the Czech Republic for winter and spring crops depicting differences in the sensitivity to drought driven by temperature and rainfall variability parameters. The intra and inter-seasonal variability's in temperature and rainfall have been confirmed to have influenced cereal yields in Tanzania (Rowhani *et al.*, 2011). Increases in rainfall variability may have future impacts on productivity and ecosystem services associated with agro forestry systems. This may have great effects on the food security situation in the affected areas.

Variations in rainfall and temperature trends and amounts have brought about changes in the onset and length of growing periods. Projections on the changes in lengths of the growing periods for Africa to the year 2090 were made by (Thornton *et al.*, 2011). Negative effects as regards decreases in the cropping and range land areas of subSaharan Africa are estimated to affect the growing seasons in terms of lengths and this may occasion losses of up to 20 percent of the crop yields. Probabilities of crop failures are estimated to be profound in sub-Saharan Africa, except in Central Africa and Southern Africa where there are favorable latitudes (Thornton *et al.*, 2013). This may compound the challenge of food security in the households occasioning disadvantage to the affected families.

Instances of enhanced climate variability may occasion more fundamental changes if high thresholds in temperature and rainfall are realized (Challinor *et al.*, 2009). This may induce changes in the timing of growing season for crops by smallholders geared towards shorter duration and heat tolerant cultivars. Domesticated livestock breeds with comfort zones of between 10 and 30 °C; may also be affected. Increased temperatures may cause the animals to reduce their feed consumption with 3–5% in the event of additional degrees of temperature (NRC, 1981). Livestock systems may have changes affecting feed quantity directly negatively impacting on the households dependent on livestock for food security. Droughts and enhanced rainfall changes may occasion animal feeds scarcity in arid land areas impacting negatively on livestock populations (Rao *et al.*, 2011). Grazing lands of pastoral communities in East Africa have experienced trends of droughts recurring in about one year after every five years (Speranza *et al.*, 2010). Increases in the intensity of drought and frequencies from one year in five to higher occurrences would lead to declines in the herd sizes (Thornton *et*

al., 2009). Losses of 1.8 million cattle are estimated to occur due to drought by 2030 attributed to increased drought frequencies and equally negative implications on the households' food security situations may suffice in the pastoralists' communities (Lloyd *et al.*, 2011).

Studies carried out by (Craine *et al.*, 2012) showed that in temperate grasslands, effects of profound droughts and high temperatures declines over the seasons led to levels of diminished effects of future plant propagation seasons. Ecosystems that were seasonally receptive to climate variability and increased understanding of plant productivity will thus need to recognize that the timing of climate change effects may just be as essential as their implications (Craine *et al.*, 2012). In grasslands plant species variation and composition affects livestock productivity levels. Variations in the rainfall patterns, temperature and CO₂ levels changes impact on the composition of mixed grasslands species. Climatic variations may influence dynamics and balance of grasslands species resulting in changes in livestock productivity levels (IPCC, 2007). Effects of variations in rainfall and temperature impacts on the variability of species composition and grassland quality thus affecting the livestock productivity levels (IPCC, 2007).

Fire occurrences may be predisposed by droughts in grasslands (IPCC, 2012). Evidence of increased grassland fires in the recent past has occasioned disasters in areas of China and Asia (Herrero *et al.*, 2010). Wildfires are estimated to increase by 60 per cent more in terms of frequency owing to the trends of drought. Mixed crop livestock farming systems are the mainstay of the developing world (Herrero *et al.*, 2010) and they could be greatly affected by the emerging trends attributed to climate change negatively affecting the households' food security situation (Raleigh *et al.*, 2010). The emerging trends may affect the relationship between crops and livestock thus impairing the capacity to assure the mixed farmers' household's food security (Hurkman *et al.*, 2009).

Increased use of water for irrigation as a climate change coping strategy in Africa and Asia has had the benefit of food security risk mitigation, (WHO, 2010). On the other hand through the risk of depleting ground water sources, river abstraction and deprivation of communities downstream of the commodity is real. The use of contaminated water for irrigation and allowing pesticides to flow downstream may also result in numerous health complications for the affected communities (WHO,

2010). There is thus the need to ensure that food security mitigation occasioned by climate change does not compound the prevailing situation, (WHO, 2010).

Distribution and prevalence of weeds, pests, crops and livestock diseases may also be influenced by climate variability (Lloyd *et al.*, 2011). Evidence of occurrence of livestock diseases like Rift Valley fever and blue-tongue in East Africa, African horse sickness in South Africa after periods of dry spells followed by heavy rainfall give credence to the phenomena (Baylis *et al.*, 2006). Increased cases of extreme weather frequencies may predispose the spread of Rift Valley fever cases to Europe and other non-traditional areas (Martinet *et al.*, 2008). This may ultimately affect the food security situations.

Increased use of water for irrigation as a climate change coping strategy in Africa and Asia has had the benefit of food security risk mitigation, (WHO, 2010). On the other hand through the risk of depleting ground water sources, river abstraction and deprivation of communities downstream of the commodity is real. The use of contaminated water for irrigation and allowing pesticides to flow downstream may also result in numerous health complications for the affected communities (WHO, 2010). There is thus the need to ensure that food security mitigation occasioned by climate change does not compound the prevailing situation, (WHO, 2010).

Food security is the availability of food in an environmentally sustainable and socially just manner at all times (FAO, 2011). The food is available in adequate nutrition's and culturally appropriate modes. The communities benefit from the adequate provisions and are assured of availability all year round. The populations are able to earn a decent living, have adequate access to food occasioned by the agricultural activities; food security in the households is thus based on the access to a sustainable and healthy system of food population (FAO, 2011)

Food security has been heavily compromised by the risk of climate change (Lipper *et al.*, 2010; Larborte *et al.*, 2011; Cline *et al.*, 2007). All the studies indicate that the assurance of food production in the global economy is greatly influenced and hinged on the prevailing weather situations. Variations on the rainfall amount and temperature range greatly, impacts negatively on the capacity of the agricultural production practices. This is in tandem with studies carried out by Mbogori *et al.*, (2013) who attested to the high risk that food security and nutrition status was occasioned by the

climate change. It had capacity to impoverish livelihoods and affect the economic mainstay of the country negatively if effective mitigation measures were not employed.

2.3 Variability of Temperature and Rainfall

Daily maximum and minimum temperatures, seasonal precipitation and the potential evapo-transpiration are used as variables for climate change (Black *et al.*, 2008). Studies show that with increased temperature coupled with high evapo-transpiration and the variability of season-to-season rainfall spread has a profound effect on seed germination, plant growing season's lengths, grain filling and household food security in the republic of Kenya (Hansen & Indeje, 2014). The ASAL areas appear to be bearing the highest climatic variations thus the biggest risk of food insecurity in the households (Hansen *et al.*, 2014).

Onsets of the rainfall seasons, cessation of the rainfall season, distribution of the rains and the amounts available have profound effects on household food security especially for areas dependent on the growth of cereals staples (Tubiello *et al.*, 2007). The distribution of rainfall and the amounts falling is of great importance to the support of rain-fed agriculture practiced in most parts of the country (Kanyenji, 2012). The effect of rainfall variability is very great on crop yields in rain fed agriculture practiced by most of the subsistence farmers (Kanyenji, 2012). Studies confirm that in the event of less the changes in the rainfall patterns the enhanced maize and related staple yields. Studies indicate that higher changes in the rainfall patterns above the average means occasions fluctuations yields and gives rise to food insecurity. The situation of food insecurity is graver in areas which are very dependent on rain-fed agriculture in the event of depressed rains and extreme temperatures affecting crop yields (Wheeler *et al.*, 2010). Evidence of reduced maize yields in Africa has been found in lower altitudes attributed to climate change. In Kenya studies have confirmed increased cases of warming and enhanced evapo- transpiration worsening the situation of plant stress (GoK, 2007). This has forced households to adopt heat and drought tolerant crops as a measure of cushioning themselves.

Research by Dinar *et al.*, (2008) carried out on climate change dynamics in Africa from 1900–2100 showed that climate change variations were bound to increase over the years. The increases in the mean differences could be 2 and 6°C warmer in the one hundred year period. The prevailing situation shows that the high temperatures in the

ASAL areas in Kenya are likely to accelerate evaporation and heat stress worsening food insecurity situations for the households negatively impacting on poverty reduction initiatives (Rarieya *et al.*, 2009). This has negative implications on the crop growth and production activities in rain fall dependent areas for agricultural activities by small holder farmers who undertake subsistence farming (Godfray *et al.*, 2010). Dependence on rains for agricultural production activities thus has immense potential for loss of yields by farmers carrying out activities (Funk *et al.*, 2008).

Surveys by the United States Agency for International Development Famine Early Warning System Network carried out in Kenya over the last forty years (1960-2009) have showed the heavy pronounced trends in rainfall and temperature variation (FEWNET, 2009). The same was confirmed in works by Fuschs *et al.*, (2009) and Brown *et al.*, (2008). The analysis conducted via rigorous geo-statistical technique showed that there was a reduction of rainfall by over 100mm from 1960-2009 in the long season in over seventy weather stations spread throughout the country. Substantial rainfall decline has equally been matched with increased food production and security situation (FEWNET, 2009).

The findings from FEWNET are in tandem with the results presented to the intergovernmental panel on climate change assessment (Christinen *et al.*, 2009). The IPCC report acknowledges the reduction of rainfall and the risks of increased temperatures. The findings equally narrow down to the potential impacts that the variation in rainfall and temperature would have on food production in central Kenya. It projects continued deficits in food sufficiency thus impacting negatively in the national food prices. The envisaged reduction of product to below 1, 100kg per hectare translates to 0.03 hectare per person with the growing population increasing and this may not auger well for the national food security situation (Christinen, *et al.*, 2009). The current rainfall and temperature trends portend a serious deficiency in the country's grain production. Maize yields have had a consistent reduction attributed to decreased precipitation. Analysis shows that if the prevailing trends hold per capita, harvested area may drop by 7% and the harvests decrease in yields may be greater if there is enhanced environmental degradation. There is need to stem the tide of environmental degradation to reduce greenhouse gas emissions and equally assure the population of food security (IPCC 2007).

2.4 Effects of Rainfall and Temperature Variability on Food Security

Food security is defined by the Food and Agriculture Organization of the United Nations (FAO) as the ability of people to adequately access, on their own, the requisite capacities of nourishment to lead healthy and active lives (FAO, 2008). Food security is integral to the realization of the sustainable development goals (SDG's). Goal number 1 is eradication of poverty and the relationship between poverty and food insecurity is immense. This thus brings to the fore the essence of food security as a measure of poverty reduction. Goal number 2 is the reduction of hunger in the communities thus a reflection of the need to ensure food security as a requisite for achievement of the goal (UN, 2016). Increased global population rise requires commensurate efforts towards food production (Godfray *et al.*, 2010).

Food security is influenced by a myriad of factors entailing changes in the social demographics in the communities, technology changes, the macro-economic disposition, transport and communication systems, trade programs and emerging trends as regards the cultural practices carried out at the farm levels (FAO, 2008). Changes in climate however greatly influence the dispositions towards the dynamics of food security associated with climate change effects (Schmidhuber *et al.*, 2007; Ringerler *et al.*, 2010; Battisti *et al.*, 2009). The effects are greatly felt at the point of plant growth and development. Climate change has the potential to have great ramifications on the future production of food crops by the farmers doing agricultural production in unregulated environments (Brown & Funk, 2008, Lobell *et al.*, 2008). Rising populations globally are thus a critical factor in the realms of food security owing to the demands placed by the changes in climate and its effects on the production levels.

The IPCC Fourth Report (IPCC, 2007), showed that, the farms may increase production at the advent of moderate increases in the temperature. Reports cited in the IPCC 4th Report showed that in the temperate regions, increases in the ranges of 1-3°C which are relatively small may induce improved production in the event of utilization of organic fertilizers in optimal manners. This however applies to the cool temperate areas only.

Variability in the rainfall and temperature levels has been profound globally (IPCC, 2007). The variations can be attributed to the emission of greenhouse gases in economic activities locally to the depletion of the ozone layer. An evaluation by the

inter-governmental panel on climate change member countries shows a consistent decline in the agricultural production levels since 1980 to date occasioned by climate change (IPCC, 2007).

Garnett (2008) argued that in a situation that is synonymous to cooking up a storm, the failure to effectively check greenhouse gas emissions has contributed to changing the climatic conditions. Studies carried out in the United Kingdom showed that increased greenhouse gas emissions had negative ramifications on the temperature levels (Garnett, 2008). The situation of the increased temperatures negatively affected agricultural production activities occasioned by the faster evaporation of rainwater. This led to reduced production negatively impacting on the agriculture yields. This is in line with Challabi *et al.*, (2007) and Mugweru *et al.*, (2010) who were of the position that immature maturation of farm produce occasioned the farmers great loss at the advent of high temperatures during agro-production periods.

Surveys by (CSAE, 2013) have linked the rise in temperature to deprived economic positions of African countries. The survey carried out under the auspices of the centre for the study of African Economies in Oxford found out that for every increase in 1°C, there was a reduction of 15% of the GDP (CSAE, 2013). This exposed the communities dependent on agriculture to the risk of potential ruin. Pastoralists engaged in fights for watering points, pasture and the risk of civil strife in competition for resources gets real and aggravated by the climate change situation.

The national economic outlook of the Republic of Kenya as postulated by the Central Bureau of Statistics (CBS, 2013) gives a detailed picture of the ravages of climate change on the country's economic performance. The situations of high temperatures and decreased rainfall have many at times occasioned communities to pain and anguish. Recession is always evident at the advent of crop failure. This is because resources are expended to import food and provide subsidy to the vulnerable populations. The findings tally with the positions taken by Huho *et al.*, (2013) in Kenya and Prapti *et al.*, (2013) in India.

2.5 Coping Strategies against Rainfall and Temperature Variability

The European Union members' status and the United States of America have placed stringent measures geared towards reduction of greenhouse gases emissions (WHO, 2012). This has been by way of enforcing the regulation of transport between the

countries of origin of agricultural produce and the buying states. This is with an aim of aiding reducing carbon foot prints in the name of greenhouse gas emissions. The encouragement of the citizenry to consume locally food that it is in season limits the costs of importation and greatly impacts positively on greenhouse gases emission reduction (Foster *et al.*, 2007). This is occasioned by the fact that lost energy is expended in the transportation and growth of irrigated crops out of season.

Investment in systems that ensure the harnessing of all rainwater and good use of the same is a sure way of mitigating the reduced rainfall and temperature increase (Guitausson *et al.*, 2011). This may portend good tidings in the name of assuring communities of abundant supply of food irrigated by use of the harvested water. Use of innovations to guard against losses from post-harvest handling is equally a requisite in the wake of seeking to confer community's food security (Guitausson *et al.*, 2011). Capacity to provide insurance programmes for the poor smallholder farmers and subsidizing at the advent of crop failure has also been confirmed as a fallback position for rainfall and temperature variability in the developing economies (Hess *et al.*, 2009; Mandago *et al.*, 2011).

Investment in irrigation programmes has been a policy initiative which has cushioned the poor from the ravages of climatic change in China (FAO, 2012). Government programmes have assured the communities of capacity to access irrigation facilities at commercial points. This has facilitated the local communities in terms of assuring them of food security. Similar initiatives have been replicated in Mexico and Bangladesh where the local communities benefit from water pans and irrigation canals built by government agencies (Aslam, 2011; Fuschs *et al.*, 2011).

Foley *et al.*, (2011) opined that individuals, communities and multi-sectoral agencies should be encouraged to come up with strategies geared towards assuring of the populace food security in a sustainable manner. The need for private sector participation cannot be underscored. This is in tandem with the situation in Gikindu division in Murang'a County. Private sector players have been encouraged to team up with the ministry in providing solutions to the food security situation occasioned by climate change (MoA, 2013). Anecdotes from the Ministry of Agriculture show that the partnership with the UZURI foods which trains the local population on water harvesting, value addition, sustainable energy solutions and growth of drought tolerant cultivars has been a welcome gesture to the local community (MoA, 2013).

Muteru *et al.*, (2012), opined that the growth of drought tolerant cultivars and sustained afforestation programmes were a sure way of checking the climate change effects. This is in tandem with the national poverty reduction and wealth creation strategy (GoK, 2003) .It called for increased afforestation and community capacity building to reduce the vagaries of climate change. The Murang'a East Sub-county Development Strategy (2012-2013) equally vouches for intensified afforestation, enhanced capacity building in the populace and the growth of orphan crops like sorghum and millet in the wake of seeking to assure communities of food security (GoK, 2012).

2.6 Role of Women Groups in Assuring Community Food Security

Food production in the face of climate changes has had great implications on the populace in South America (Coulibaly, 2011). The strengthening of women groups has been done with an aim of strengthening the position of women in the food production process (Coulibaly, 2011). The women have their potential in seeking for alternatives, in sharing of ideas, seeking markets and innovations of how to counter the threats of enhanced climate change in the groups that they work in. The same applies to women groups in India which have been formed with a specific aim and purpose of conferring empowerment to women in the face of reduced production associated with climate change. This has greatly impacted on the capacity of the women to adapt and exploit the acquired skills in climate change mitigation in the farming activities impacting positively on their households' food provision (Coulibaly, 2011).

Gender dimensions in activities carried out by the International Fund for Agricultural Development (IFAD, 2011) Food and Agriculture Organization (FAO, 2012) and the World Food Programmes (WFP) have borne results in Ghana and Mozambique (Yiamma *et al.*, 2011 and Bench *et al.*, 2011). The women have been sensitized on the need to actively engage in environment friendly production activities in their agricultural pursuits. They have been trained on water harvesting and exploitation of renewable energy in their households in the wake of seeking to combat the ravages of climate change.

Women groups in Australia faced the challenge of access to communal land for actualization of their projects. They were forced to engage in production in the individual members plots which posed a risk to them owing to lack of communal assets (Fredrick, 2011). This identified with Reema (2010) who posited that women groups

in India were mainly forced to lease land for productive engagements. This disenfranchised them owing to failure to have the leases renewed regularly and impaired their capacities to ensure food security in the households. Similar situations sufficed in Ghana whereby Yiama, 2011 opined that land tenures which favoured men negatively impacted on the ability of women groups to carry out activities and reap maximum benefits from their production discouraging them from participation in crop and animal husbandry without husbands consents. This negated the essence of the groups empowering the members.

The patriarchal nature of Indian banking sector was a drawback to the women groups causing them the pain of not having the members get the requisite benefits. The married members of the women groups were required to have husbands' consents before accessing credit facilities. This occasioned them risk when their husbands failed to identify with the ideas and agricultural activities at hand (Sewa, 2010). This impaired the capacity of the women in terms of ability for inclusion in financial services provision and slowed down the activities aimed at ensuring enhanced households food security. Despite access to extension services the women were forced to bend low to get the husbands consent before accessing credit facilities from the financial services providers (Sewa, 2010).

Financial literacy impeded growth of women groups in Uganda as elucidated by Lolwa, (2011). Women group members insisted on sharing proceeds of harvest after every season causing them to stagnate owing to failure to have an increase in the member's populations. This exposed them to the risks of going through the myriad cyclic patterns of deprivation after failing to plan for their bounty harvests. Exploitation of best practices was a challenge to the women groups in Tarime area in the Republic of Tanzania. Studies by FAO, (2011) in Tanzania showed that the members of the groups spent a lot of time in the manual fetching of water to irrigate their crops. Exposure and capacity building to access better alternatives like drip irrigation would ultimately curb wastage of water and save the women precious time to engage in more activities (FAO, 2011).

Building of networks between entities of varied activities has seen growth of the women groups in India, (Reena, 2010). The groups were collated and their potential exploited by the benefits of economies of scale. Demystifying of the leadership approaches in the women groups inculcated a sense of ownership of programmes in

Ghana (DFID, 2011). The grassroots group members became trainers and rapidly spread the knowledge and they had acquired to the others. This facilitated growth of the activities, skills transfer and appreciation of every other person's capacity to engage in agricultural activities (DFID, 2011).

The promulgation of the constitution of Kenya in the year 2010 opened a new window in the disposition of equality and human rights. The equality between men and women has been enshrined in the constitution. This has proved to be an emerging paradigm as regards the empowerment of the rural women (Were, 2011). Programmes conducted by the United Nations International Children's Emergency Fund have aimed at inculcating skills and building the capacity of women groups engaged in agricultural production in the wake of climate change. This has greatly impacted on the capacity of their individual households to access quality nutrition and get an assurance on food security.

The Millennium Development Goals aim at reducing and eradicating extreme poverty and hunger by the year 2015 (MDG's, 2010). The reduction of hunger can only materialize at the advent of assuring households of food security. This is equally in line with the poverty eradication and wealth creation strategy paper for the Republic of Kenya (GoK, 2003). The paper identified empowerment of women groups as a strategy which can effectively enlist their participation in agricultural activities and assure households of food security.

Women group members in Machakos area experienced heavy losses once their horticultural produce was rejected by the export companies. A study commissioned by the Horticultural Crops Development Authority (GoK, 2013) found out that lack of training in pest control and related farm practices caused the producers losses. The study called for capacity building and skills transfer to have the women groups operate profitably as measure of having them realize their essence of meeting member obligations (GoK, 2013). Exploitation by middlemen was a handicap that women groups engaged in tissue culture banana growing in Murang'a South sub-county faced. Studies by Kamande, (2012) showed that tissue culture banana growing was slowed down by the over-exploitation the women faced. The Murang'a County Integrated Development Plan identified the engendering of the value addition training as a critical factor in assuring the fruit industry of growth and flourishing on the engagement of

women in active production (GoK, 2013). This is a premise of ensuring food security and enhancing members' livelihoods.

Facilitation of skills transfer and appreciation of current best practices was a key resolve in the success of the women groups in Turkana, Kenya (Kauchak, 2012). Programmes facilitated by the Red Cross society and the World Vision saw the members trained on current best practices in horticulture production. Occurrence of losses at various occasions owing to the glut in the peak fruit harvesting periods and overproduction of horticultural products forced the women groups in Gikindu Division to embrace current best practices (GoK, 2013). Initiatives by the county government, Uzuri foods and HACCP were motivated by the frustrations experienced by women groups. They were forced to appreciate solar drying and value addition in fruits and vegetables to help curb the losses and turn them back into profitability (GoK, 2013).

2.7 Knowledge Gaps

Studies carried out by Huho *et al.*, (2013) in Nakuru showed that there was need to invest in capacity building of the rural members of the population in the quest of having them adapt to the challenges of climate change. This was with a focus of equipping them in terms of skills and technology as a mitigation measure which would empower them to apply the current best practices in their agricultural production activities and safeguard them from the risk of food insecurity. The study sought to compare the impacts of climate change two years after a similar study carried out in Gikindu Division in Murang'a East sub-county. It also sought to identify and examine other coping strategies employed in the wake of climate change to mitigate the food security situation.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study Area

This study was conducted in Gikindu Division in Murang'a County located on the eastern part of the county. Most parts of the study area have semi-arid conditions and fall in the agro ecological zone 4, 5 and 6 (low potential). The areas also receive erratic rainfall in comparison to other regions in the county (NEMA, 2012). The area has 2 administrative locations namely Kambirwa and Gikuo. The area has black cotton soils and scrubby vegetation in most parts. It is predominantly arid and most of the farmlands are virgin and uncultivated. The population of the area stands at 23,349 as per the central bureau of statistics records (CBS, 2016). The temperatures in the area average 32-35°C (NEMA, 2012). The area has a total population of 163,000 persons, (GoK, 2010).

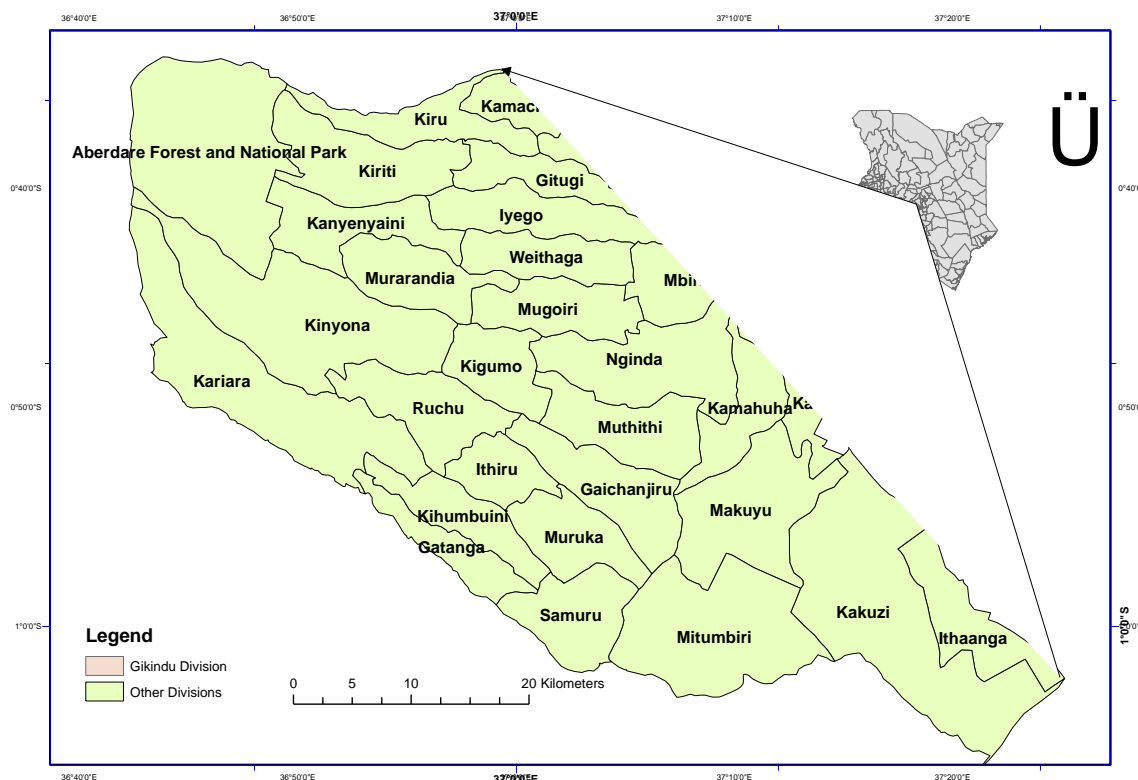


Figure 3.1 Study Area Map: Source: Survey Department of Kenya (2017)

3.2 Research Design

The research design used in the study was descriptive survey. This was considered as a relatively better approach that could be used to get the results of the study without manipulating the findings (Orodho, 2009). The descriptive design can be used when research problem is specific and the emphasis is determination of how the problem is influenced by the different variables being looked at in the study (Orodho, 2009). The design was considered appropriate since data was collected, analyzed, interrogated and reported as it existed on the ground without any undue influence over the variables guiding the study.

3.3 Target Population

All the women groups engaged in agricultural production activities in Gikindu division, Murang'a East sub-county acted as the target population. They were eleven in number with a total enrolment of one hundred and ninety eight members.

3.4 Sampling Procedures

The census sampling method was used. Three officials from each women group were considered for focus group discussions. All the other members were subjected to questionnaires to gather primary data. The officials were the chairperson, secretary and treasurer. The Division Agricultural Officer as a key informant was equally reached by way of the administration of a scheduled interview.

3.5 Sample Size

The sample size was all the one hundred and sixty five members of the women groups who were subjected to questionnaires. The thirty three leaders were engaged in focus group discussions and the Sub County Agricultural Officer was subjected to a scheduled interview as a key informant.

3.6 Research Instruments

Structured and semi structured questionnaires were administered to the respondents. The study further used likert scale to obtain some specific data from the respondents. Questionnaires had the benefits of ease of analysis and are easy to administer as compared to others like interview schedules in terms of time as one may cover a wide area (Kombo & Tromp, 2009). The focus group discussions augmented the responses from the questionnaires while the essence of conducting the scheduled interview was

having a one on one interaction with the sub county Agricultural Officer who was considered a key informant with valuable information. Use of an observation checklist helped verify the provided information and the interrogation of secondary data valuably complemented all the collected primary data.

3.7 Data Collection Procedure

The study engaged the women group members and administered the questionnaires. The group officials were subjected to focus group discussions after making prior arrangements with them. Physical visits to the members' homes and farms were undertaken for observation purposes. Seeking out the secondary data in terms of the official records from the meteorological Department and the Ministry of Agriculture was equally done to provide the basis for authentication of the collected data.

3.8 Data Analysis

The data was analyzed using qualitative and quantitative techniques. The quantitative data from the closed ended questions in the questionnaires was analyzed by way of using computer spreadsheets and the Statistical Package for Social Sciences (SPSS). The analysis entailed descriptive and inferential statistics. The descriptive statistics entailed mean, mode, median and measures of standard deviation. The inferential statistics entailed Chi-Square tests. Qualitative data was analyzed by way of content analysis. The study aligned it to previous studies carried out in the realms of food security as influenced by climate change.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and discussions of the study. The study sought to find out the climate change effects on food security, and the community coping strategies in Gikindu Division in Murang'a East sub-county.

4.2 Socio-Demographic Information of the Respondents

The study had a response rate of 100% thus reflective of willing participation from the respondents. The respondents had a diverse array of socio-demographic characteristics as captured in the following section.

4.2.1 Respondents Age

Table 4.1: Respondents Age Brackets

Age bracket	Frequency	Percentage
20-25 years	14	10
26-35 years	24	16
36-45 years	28	19
46-55 years	36	24
56-65 years	45	31
Total	147	100.0

Membership of the women groups was varied with significant populations coming from the community members who were advanced in age. The responses show that 55 % of the respondents were aged 46 years and above. This is perhaps informed by the fact that agri-business and agri-production is viewed as less viable option to the young people therefore, seeking alternative means of survival. The responses depicted a situation whereby most of the members of the women groups who carried out agricultural production activities were advanced in age. This was an indication that most members of the community who were advanced in age valued the groups as significant vehicles of carrying out agricultural activities. Similar variations were evident in the focus group discussions thus confirmation of the ability of the study to

have the benefits of reaching persons from all dispositions in terms of the age groups. Similar observations were noted in Kibaara *et al.*, (2011) study.

4.2.2 Respondents Education Levels

Table 4.2: Respondents Education Levels

Education Level	Frequency	Percentage
Primary	58	40
Secondary	34	23
Tertiary	24	16
Graduate	10	7
Any Other/Adult Literacy	21	14
Total	147	100.0

The respondents had varied education levels with 40% of them having the primary school level as the highest point of their academic certification. The responses depicted hampered progression into the post primary school levels of schooling by members of the local community. Evidence of respondents having gone past the primary school levels and being in the women groups was reflective of the capacity of the groups to attract diverse following from the local community. Membership with tertiary and graduate qualifications equally enhanced the profiles and stature of the groups with regards to their capacity to attract following even from learned persons. It was interpreted to mean that the women groups had gained relevance from a diverse membership of the community as mediums of enhancing food security in the study community. Evidence of higher academic proficiency in the leadership was confirmed by the ability to have enhanced academic qualifications in the leaders with most of them confirming to have attained tertiary and secondary school education.

4.2.3 Marital status

Majority (75%) of the respondents who participated in the study were married (Figure 4.1.)

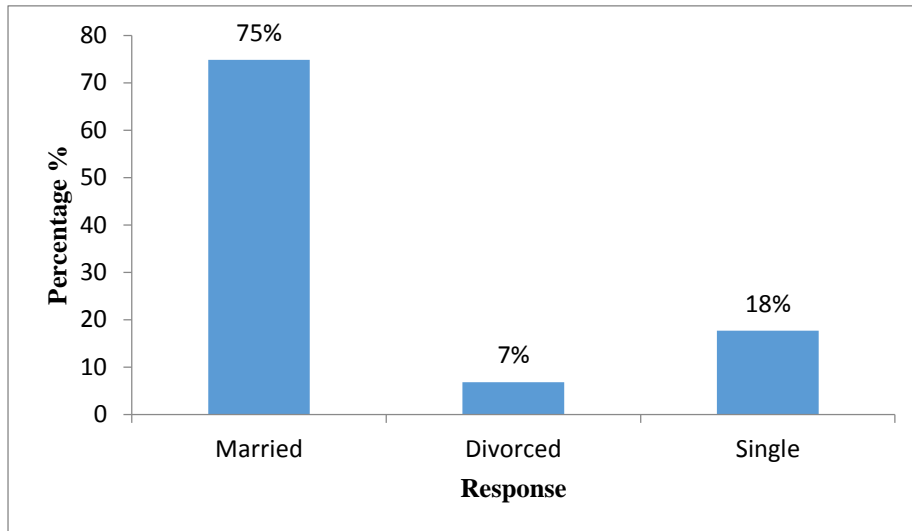


Figure 4.1 Respondent's Marital Status

A significant percentage (18%) of the respondents was single reflecting the presence of young persons who were not married being members of the women groups. Divorced persons were equally represented in the membership. It was interpreted to mean that most of the women groups had an open policy as regards the marital status of the members and it was not a factor restricting membership in them. The results were reflective of a situation whereby the stability of the households with regard to the sanctity of marriage in most of the women group members was assured. It brought to the fore the capacity of the women group members in terms of their ability to have responsibility in their households as partners in marriage and assuring their children sustenance as regards food provision. This identified with the essence of the women groups as pertains to the need to empower the membership on the food security situation. Many of the leaders in the groups equally confirmed that they were married in the focus group discussions.

4.2.4 Length of Membership in Women Groups

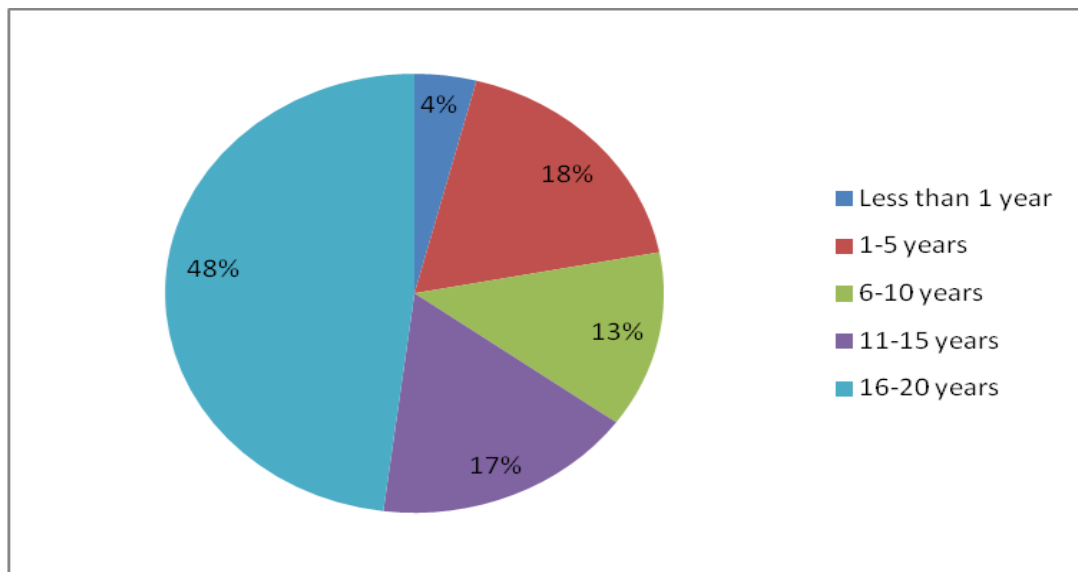


Figure 4.2 Length of Membership in the Women Groups

Most (48%) of the respondents had been members of the women groups for periods of 16-20 years (figure 4.2). The responses reflected stability with regard to the capacity of the groups to hold and have the same persons as members of the groups for long. This was an indication that the groups had realized the much required unity and the members had no major issues which may have caused them to drop out from the groups. This depicted maturity and contentment in the activities carried out by the groups. It was interpreted to mean that most of the groups had held together for long owing to the length of membership of the respondents. This was confirmation of the capacity of the members to appreciate the activities carried out and benefits accruing from the membership. The leaders equally confirmed the ability of the groups to hold together in unity for long thus capacity in terms of longevity. The study findings identified with previous works carried out by Coulibaly, (2011) who found out that the leadership in the women groups in South America facilitated the groups to survive for long and the character and disposition of the leaders directly affected the activities of the groups. Similar experiences sufficed in India as evidenced by Reena, (2010) and further authenticated by Lolwa, (2011) in Uganda.

4.2.5 Length of Leadership in Women Groups

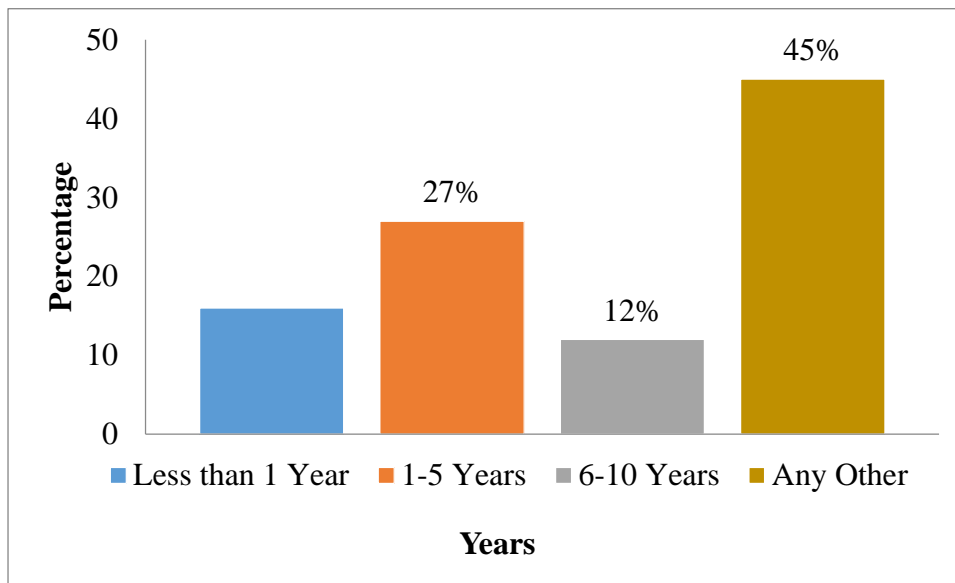


Figure 4.3 Length of Leadership in Women Groups

Most (45%) of the respondents confirmed that they had been leaders in their groups for long periods of time which exceeded ten years (Figure 4.3). The responses were an indication that the groups had identified with the leadership abilities of the respondents and had bestowed them with the responsibilities for long. This was a vindication of their abilities in terms of the leadership prowess and capacity. It was interpreted to mean that the leadership function in most of the groups was exercised by some few individuals who had handled it for many years. Similar sentiments were confirmed in the focus group discussions when the members attested to their ability to steer the groups effectively thus confirmation that this was a factor that had enhanced their capacity to meet members' aspirations. It could thus be interpreted to mean that the leadership systems in place were of profound influence to the ability of the groups to hold together. This identified with the position of (Reena, 2010) view that building of networks between entities of varied activities has seen growth of the women groups in India and enabled them to hold together for long. The groups were collated and their potential exploited by the benefits of economies of scale.

4.2.6 Awareness of Climate Change by Women Group Members

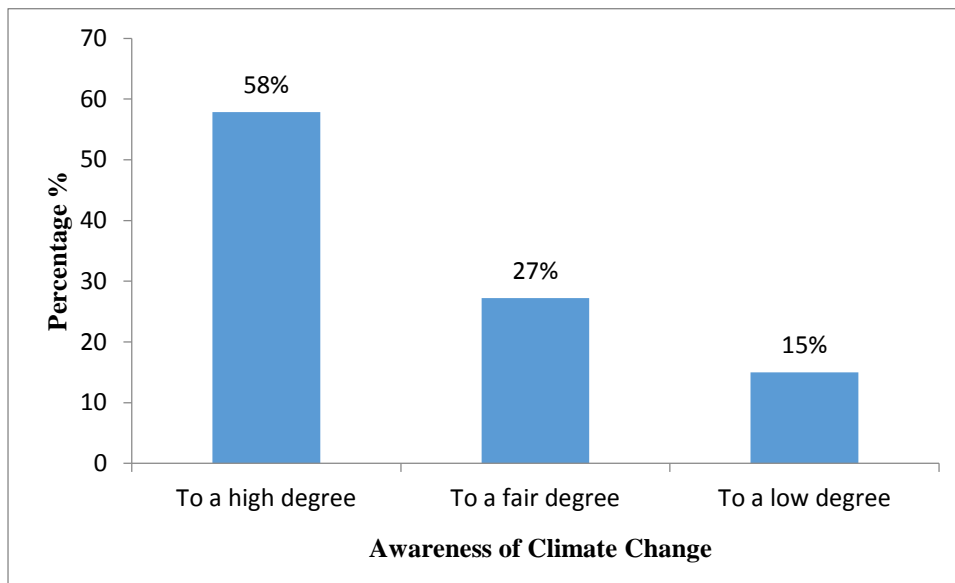


Figure 4.4 Awareness of Climate Change by Women Group Members

The study found out that (58%) of the respondents was aware of climate change (Figure 4.4.) The responses showed that climate change was a phenomenon which had been highly appreciated and was real in the local community. This denoted the fact that the reality of climate change had dawned even on the rural communities and it was an indication that massive sensitization activities had been carried out in the local populaces with a view of ensuring that they understood it. The responses equally brought to the fore the gravity of the unfolding reality as regards climate change mainly motivated by the fact that in the event of all the respondents being aware, this was a confirmation that they had been directly affected by the situation. It can thus be interpreted to mean that climate change awareness levels in the local community were profound and the populace had appreciated the prevailing situation. The leaders equally confirmed in the focus group discussions that the members were aware of the climate change phenomenon. This authenticated Kauchak (2012) who averred that facilitation of skills transfer and appreciation of current best practices by World Vision had enabled the success of women groups in Turkana, Kenya as regards climate change awareness.

4.2.7 Initiatives to Sensitize the Women Group Members about Climate Change

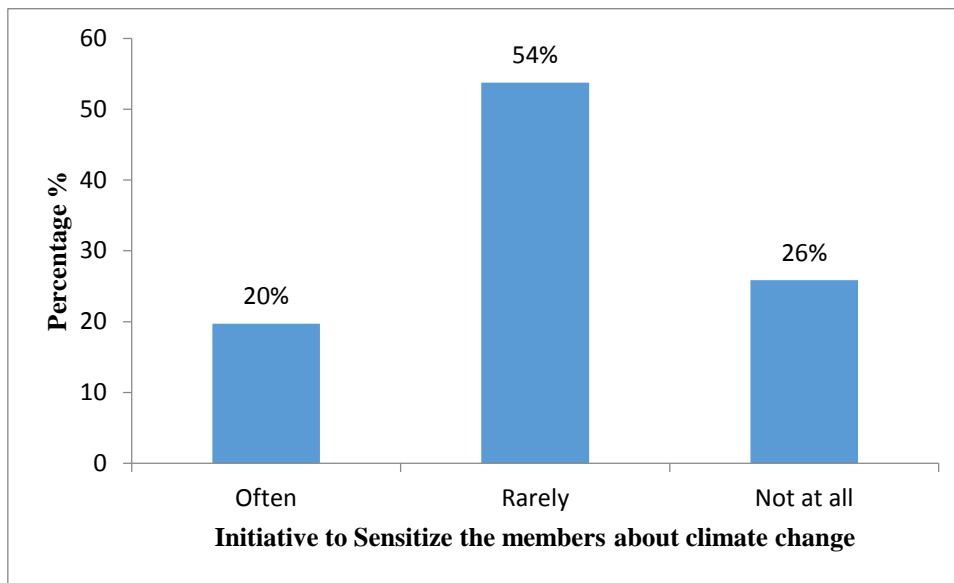


Figure 4.5 Initiatives to Sensitize the Women Group Members about Climate Change

The results showed that (54%) of the respondents deemed the initiatives in place geared towards sensitizing the women group members about climate change as rare (Figure 4.5). The responses were an indication that the information acquired by the members about the climate change phenomenon had been accessed from other sources like the media and public gatherings devoid of the participation in the women group activities. It was thus an indication that despite low sensitization initiatives via the women groups, the sources of climate change information in the local community were many thus the members were privileged to access the information from other points. It was therefore interpreted to mean that most of the women groups had no definite initiatives in place geared towards members' sensitization on prevailing climate change issues but the members' accessed information from other sources. This may have been as a result of lack appropriate procedures in approaching sensitizing programmes or as a result of laxity by the data/information providers. This therefore, was an indication of failure to have optimal climate change awareness information dissemination forums in the community. Similar sentiments were shared by the agricultural officer thus an indication of the dearth of climate change dissemination initiatives thus disenfranchising the local farmer community.

4.2.8 Usefulness of Climate Change Information among Women Group Members

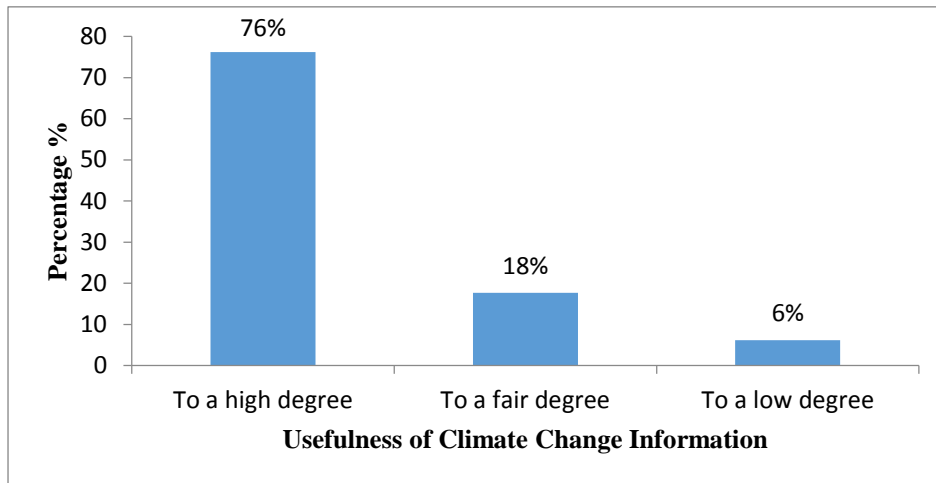


Figure 4.6 Usefulness of Climate Change Information among Women Group Members

The usefulness of climate change information was confirmed by most (76%) of the respondents to have been high. The response was an indication that the climate change information availed was highly appreciated and was of great significance to the women group members. This denoted the fact that the information was probably put into good use as regards the economic livelihoods transformation and the capacities to enable the members mitigate the climate change situation. It can thus be interpreted to mean that the knowledge acquired as regards the climate change information conveyed to the women groups was beneficial to the members. This was thus an indication of the essence of knowledge dissemination as a medium of local empowerment on climate change.

Table 4.3 Chi-Square Test between Climate Change and Usefulness of Climate Change Information

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	131.768 ^a	4	.000

Chi-square test was carried out between the initiatives to sensitize the members about climate change and usefulness of climate change information which yielded a value of test statistics as $\chi^2 = 131.768$ at a significance level of 0.05. The cross tabulation whose degrees of freedom (df) of 4 was calculated yielded a corresponding p value of 0.000.

Since the p-value is lesser than the significance level ($\alpha = 0.05$), the study upheld the null hypothesis and further concluded that there was enough evidence to suggest that there was a strong association between the initiatives to sensitize the members about climate change and usefulness of climate change information. However, in Brazil for instance, climate change outputs is highly underutilization directly because climate change models used to obtain climatic data exhibit systematic error (biases) due to the limited spatial resolution, thermodynamic processes, numerical schemes or incomplete knowledge of climate systems. Errors in climate change simulations relative to historical observations are large (Ramirez-Villegas *et al.*, 2013). Hence, it is important to bias-correct the raw climate model outputs in order to produce climate projections that are better fit for agricultural modeling. Based on the results, the study was convinced that there was sufficient evidence of an existing relationship between the two variables.

4.3 Rainfall and Temperature Variability Trends in Gikindu Division

4.3.1 Respondents View on Rainfall and Temperature Variability in Gikindu Division

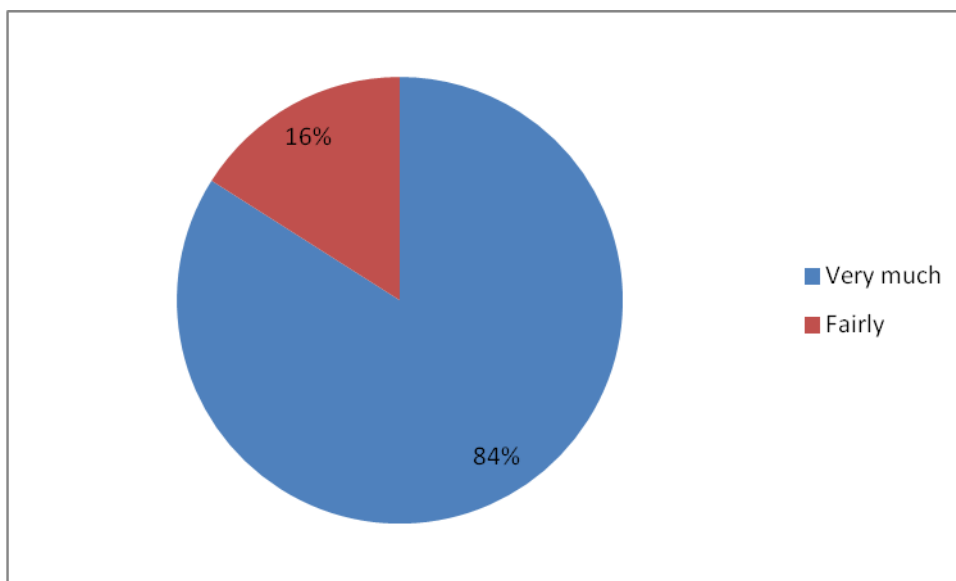


Figure 4.7: Respondents Views on Variability in the Rainfall and Temperature Levels

Most (84%) of the respondents were of the view that the difference in rainfall and temperature levels was profound. This was an indication that they appreciated that over a period of time, there had been significant and really noticeable variation in terms of

the rainfall amounts which used to fall before and the temperature levels which were prevailing previously. It can thus be interpreted to mean that the variation in rainfall and temperature was significant to the extent of being noticed by most of the women group members. The group leaders equally affirmed to having had noticed variations in the climate patterns thus confirmation that the community was assertive to the extent of identifying with the changing trends in climate. A similar position was expressed by the agricultural officer who affirmed that the climate situation as pertains to the variation in the rainfall and temperature patterns in the community was real and had been dully noticed by most of the community members owing to the changes that were manifest.

The study findings confirmed the position of Tubiello *et al.*, (2007) who were of the view that onsets of the rainfall seasons, cessation of the rainfall season, distribution of the rains and the amounts available have profound effects on household food security especially for areas dependent on the growth of cereals staples. The distribution of rainfall and the amounts falling is of great importance to the support of rain-fed agriculture practiced in most parts of the country (Kanyenji, 2012). The effect of rainfall variability is very great on crop yields in rain fed agriculture practiced by most of the subsistence farmers (Kanyenji, 2012). Studies indicate that higher changes in the rainfall patterns above the average means occasions fluctuations yields and gives rise to food insecurity. The situation of food insecurity is graver in areas which are very dependent on rain-fed agriculture in the event of depressed rains and extreme temperatures affecting crop yields (Wheeler *et al.*, 2010). Evidence of reduced maize yields in Africa has been found in lower altitudes attributed to climate change. In Kenya studies have confirmed increased cases of warming and enhanced evapo-transpiration worsening the situation of plant stress (GoK, 2007). This has forced households to adopt heat and drought tolerant crops as a measure of cushioning themselves.

4.3.2 Effects of Rainfall and Temperature Variation on Agricultural Production Capacity

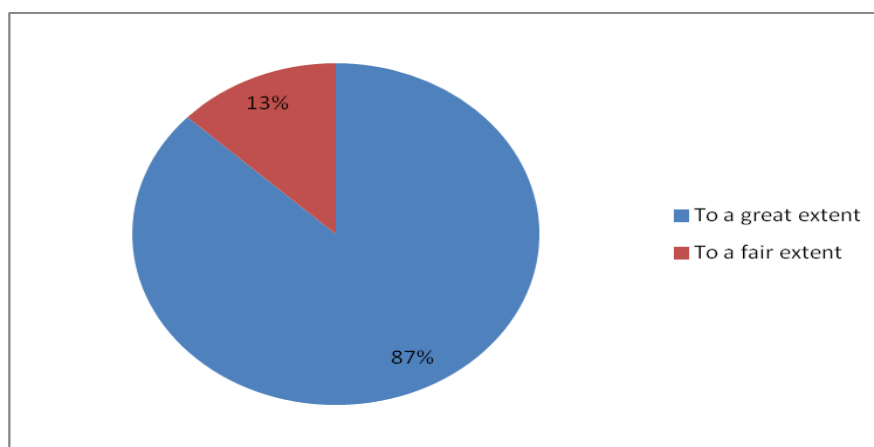


Figure 4.8 Respondents Views on Effects of Rainfall and Temperature Variation on Agricultural Production

Most (87%) of the respondents deemed the effects of rainfall and temperature variation on agricultural production capacity to have been great. This was an indication that the variation in temperature and rainfall levels had significantly affected the agricultural production capacities and the members had been directly affected by the decline motivated by the prevailing situation. It can thus be interpreted to mean that agricultural production levels had been negatively affected on by the variation in temperatures and rainfall levels and this had been greatly felt by the members of the women groups in the study area. The group leaders equally confirmed that the changes in climate had affected the levels of food crops production to the extent of having negative implications on the trends and levels of the outputs generated.

Table 4.4 Chi-square test variation in rainfall and temperature and their effects on agricultural production capacity

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	117.640 ^a	8	.000

Chi-square test between the variation in the rainfall and temperature levels and their effects on agricultural production capacity gave a $\chi^2 = 117.640$ at a p value of 0.05 and a df 7 of which was more than the tabled critical value of $p = 0.000$. There was thus a relationship between the difference in rainfall and temperature levels and the effects of rainfall and temperature variation on agricultural production capacity. It was

interpreted to mean that in the event of variation in rainfall and temperature, agricultural production was directly affected leading to significant effects on the livelihoods of persons who are dependent on the activities.

The research findings confirmed work by Dinar *et al.*, (2008) who carried out a study on climate change dynamics in Africa from 1900–2100 which showed that climate change variations were bound to increase over the years. The increases in the mean differences could be 2 and 6°C warmer in the one hundred year period. The prevailing situation shows that the high temperatures in the ASAL areas in Kenya are likely to accelerate evaporation and heat stress worsening food insecurity situations for the households negatively impacting on poverty reduction initiatives (Rarieya *et al.*, 2009). This has negative implications on the crop growth and production activities in rain fall dependent areas for agricultural activities by small holder farmers who undertake subsistence farming (Godfray *et al.*, 2010). Dependence on rains for agricultural production activities thus has immense potential for loss of yields by farmers carrying out activities (Funk *et al.*, 2008).

4.3.3 Perceptions of rainfall and temperature variability on household food security

Table 4.3 Perceptions on Effects of Temperature and Rainfall Variability on Household Food Security

Variation in rainfall amounts had led to increased rainfall levels leading to hailstones which negatively affected the existing forms agricultural production in the area as confirmed by 51% of the respondents. This was an indication that the climate change phenomenon had occasioned suffering to food stuff farmers especially maize, beans at the advent of occurrence of hailstorms leading to the destruction of crops while in the farmlands. It study noted that the area suffered incidences of increased rainfall in intermittent situations more than to the required levels which in turn occasioned destruction to the food crops and the environment. This was associated to sudden warming of the sea surfaces occasioning the hailstorms which are not beneficial to the farmers but destructive. Such an irregular distribution of rainfall cannot sustain a crop growing season e.g. maize or bean in the area. The responses were an indication that the reality of hailstorms had affected many members of the local community and it was a vindication of the advent of climate change and its vagaries in the local community. It was therefore interpreted to mean that majority of the members in the study

community had suffered losses occasioned to them by the destructive hailstorms that destroyed their crops.

A significant percentage (18%) of the respondents dissented to the occurrence of hailstorms in the study area. The response was an indication that they had not suffered losses associated with the phenomenon. It was thus a reflection of the situation of hailstorms not being very profound in the study area. It can thus be interpreted to mean that despite the reality of hailstorms being evident in the study community, not all members had been negatively affected. This is perhaps due to the type of crop they grew, or technology they employed to manage agricultural activities on their farms.

Depressed rainfall had always occasioned the members of most (88%) of the women groups' crop losses. This was an indication that there were profound incidences of reduced rainfall in the study area leading to immense crop losses attributed to the adverse weather. This was an indication that the incidences of drought had negative implications on the capacity of the women group members to realize optimal harvests from their agricultural production activities. This exposed them to the risk of diminished prospects as regards their households' food security situation. It was thus a confirmation that the adverse weather contributing to depressed harvests and instances of crop losses had heavily compromised the households' food security. Very few members of the women groups one percent were of the view that their households had not suffered undue exposure occasioned by cases of depressed rainfall in the study area. This was an indication that the affected respondents may have gotten the skills to exploit early maturing crops and drought resistant varieties. This may have helped them to mitigate the underlying situation as regards food security thus not getting exposed to the risk of crop failure.

The responses identified with surveys by the United States Agency for International Development Famine Early Warning System Network carried out in Kenya over the last forty years (1960-2009) which showed that the heavy pronounced trends in rainfall and temperature variation (FEWNET, 2009). The same was confirmed in works by Fuschs *et al.*, (2009) and Brown *et al.*, (2008). The analysis conducted via rigorous geo-statistical technique showed that there was a reduction of rainfall by over 100mm from 1960-2009 in the long season in over seventy weather stations spread throughout the country. Substantial rainfall decline has equally been matched with increased food production and security situation (FEWNET, 2009).

Most (63%) of the respondents perceived the increase in temperatures to cause early maturation of crops on their farms. Temperature stresses on annual and perennial crops have an impact on all phases of plant growth and development. Exposure of plants to extreme temperatures will limit the ability of those plants to produce fruits due to untimely disruption of the pollination process. The magnitude of this impact varies among species; however, there is a consistent negative impact on plants. One aspect of high temperature extremes often overlooked is the effect of extreme events on the atmospheric water vapor demand. This was an indication that the crops were in often cases affected by the adverse temperature heightening the growth and maturation before their due time. This exposed the farmers to immense losses occasioned by the situation of their crops maturing before time leading to depressed harvests and compromising the food security situation. The findings were a confirmation that the gravity of temperature variability which is an attribute of climate change were being felt in the local community and had negatively affected the capacity of the households to be food secure (Hutton & Landsberg, 2000).

Some insignificant percentage (2%) of the respondents held the view that they had not been affected by the adverse temperatures which occasioned depressed harvests. This was an indication that some of the farmers had realized the essence of exploit the drought tolerant crops which were not affected by temperatures thus having optimal harvests despite the unduly high temperatures. It was interpreted to mean that some farmers had acquired knowledge on how to mitigate the high temperatures situation by way of planting drought tolerant crops which were not affected.

Most (66%) of the respondents confirmed that high temperatures lead to wilting and drying of transplanted crops leading to great losses. This was an indication that the study area had been affected by the high temperatures leading to negative implications during the periods of transplanting crops. Adverse conditions attributed to the high temperatures affect the transplanting of crops thus impairing the farmers' ability to grow vegetables and other crops requiring transplanting into the main fields from the nurseries. This highly affected the capacity of the farmers to engage in commercial farming activities of high value crops in the vegetable and horticulture segments requiring transplanting endangering the food security situation and their prospects as regards undertaking commercial agricultural activities. It was interpreted to mean that

the farmers had borne the brunt of high temperatures exposing them to the failure of not undertaking activities which require crop transplanting optimally.

Most (85%) of the respondents confirmed that high temperatures lead to wilting of harvested fresh produce occasioned farmers losses in the area. The responses were an indication that the farmers had suffered losses after investing in fresh produce production attributed to high temperatures which negated their abilities to deliver the produce in the requisite manner. The responses were an indication that the adverse weather had eroded the farmers' gains even after they had exploited the high value crops in the name of fresh produce. This had discouraged them in terms of rendering their ability to produce optimally redundant and equally the loss of the investments made in the production exercises. The responses projected the image of farmers who had strived to acquire skills and exploit them in the hope of realizing good proceeds from the fresh produce market but unpredictable temperatures (at times high and other times low) had occasioned losses to them. It was interpreted to mean that the capacity of many farmers to make good returns from the agricultural production activities in the realms of fresh produce had been impeded by such unfavorable temperatures attributed to climate change. This had exposed the farmers to losses and compromised their ability to maximize from the commercial ventures by extension risked the households food security situation.

The study findings are in tandem with the results presented to the intergovernmental panel on climate change assessment (Christinen *et al.*, 2009). The IPCC report acknowledges the reduction of rainfall and the risks of increased temperatures. The findings equally narrow down to the potential impacts that the variation in rainfall and temperature would have on good production in central Kenya. It projects continued deficits in food sufficiency thus impacting negatively in the national food prices. The envisaged reduction of product to below 1,100kg per hectare translates to 0.03 hectare per person with the growing population increasing and this may not auger well for the national food security situation (Christinen *et al.*, 2009). The current rainfall and temperature towards many portend a serious deficiency in the country's grain production. Maize yields have had a consistent reduction attributed to decreased precipitation. Analysis shows that if the prevailing trends hold per capita, harvested area may drop by 7% and the harvests decrease in yields may be greater if there is enhanced environmental degradation (Christinen *et al.*, 2009). There is need to stem

the tide of environmental degradation to reduce greenhouse gas emissions and equally assure the population of food security (IPCC 2007).

Similar sentiments were shared by the group leaders who had noticed profound situations of the changes in the levels of temperature and precipitation to the extent of negatively impairing the crop production patterns in the local community. Instances of the crops not reaching full maturation and times of excessive rainfall were cited. This had negative ramifications on the outputs accrued from the farmers' production trends thus negatively impacting on the household food security situations. The agricultural officers shared the same position and confirmed that the changes in the rainfall and temperature levels heavily influenced the local food production situation and the women groups had realized the essence of coalescing together and maximizing on the factors of production as a measure of cushioning their households.

Employment of surface water harvesting and water pans to mitigate the effects of the reduced precipitation levels by the individuals undertaking agricultural production activities was evidence of the gravity of the prevailing situation as regards the dearth of water for agricultural production. This was confirmation of the extent to which the climate change effects had been felt and affected the farming activities in the study area.

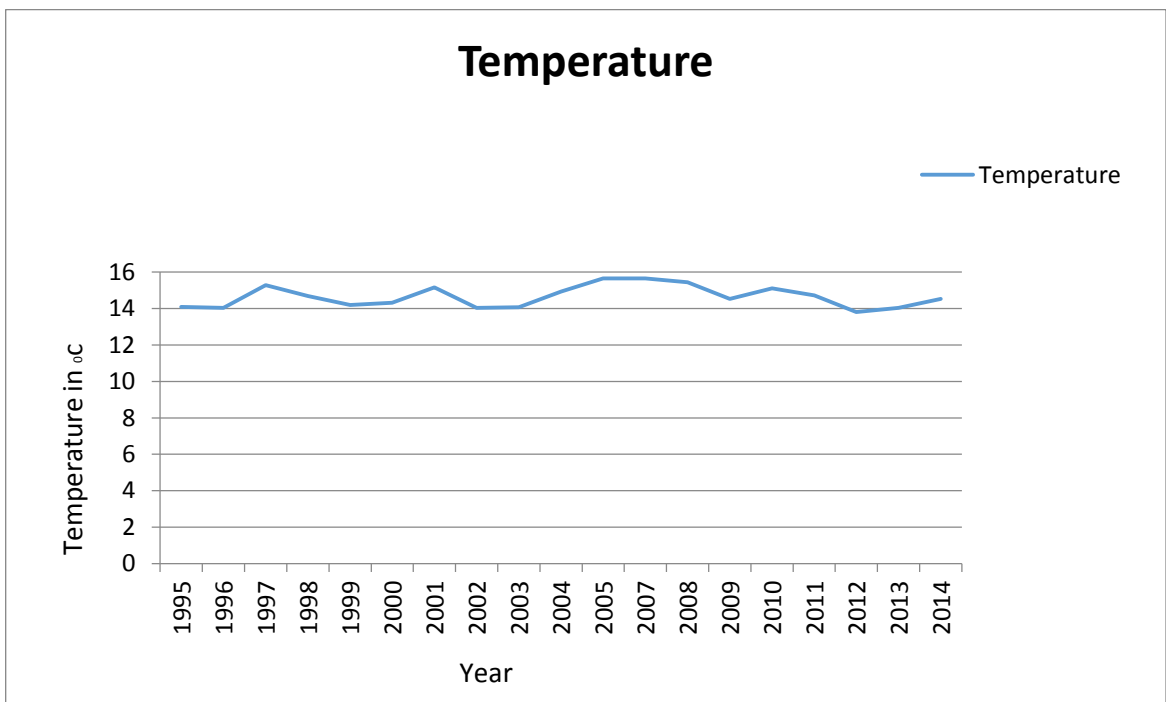


Figure 4.9 Temperature trends from 1995 to 2014 (Thika Meteorological Station)

Trends depicting the temperature patterns from Thika meteorological station and evidence of marginal increases in the temperature levels are clearly vivid from 1995 to the year 2014 in figure 4.9 as derived from Appendix VI. The mean temperature for the period under review was 14.62448.

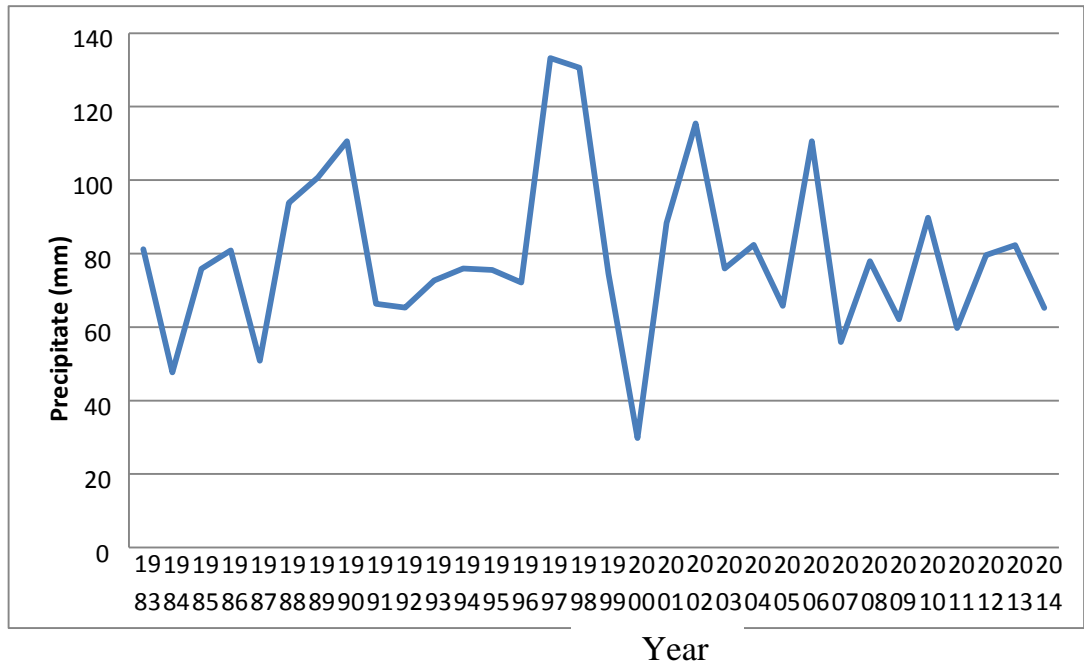


Figure 4.10 Precipitation Trends from 1983 to 2014 (Thika Meteorological Station)

Figure 4.10 shows the trends of precipitation patterns in the Thika meteorological station from 1983 to the year 2014. The trends depict patterns towards precipitation levels reduction with fluctuations towards increase in the period of 1997 to 1998. The trends are evidence of reduced precipitation levels and confirmation of the reality of climate change within the study area as correlated with reduced precipitation levels. The mean precipitation level for the period under consideration was 79.59. The available rainfall was thus inadequate to fully sustain agricultural production activities. The trends are further defined in appendix VII.

4.4 Effects of Climate Change on Food Security in Gikindu Division

4.4.1 Dependence on Rainfall to Grow Food Produce

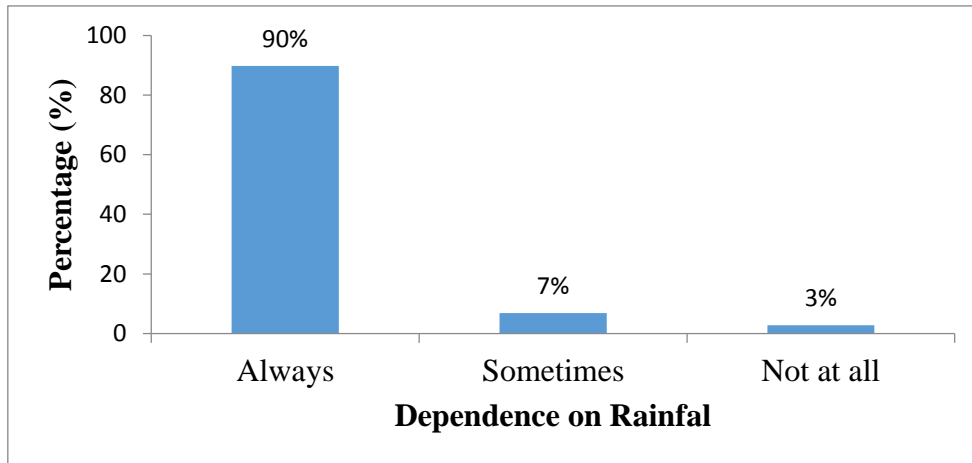


Figure 4.11 Dependence on Rainfall to Grow Produce

Most (90%) of the respondent's dependence on rainfall to grow produce was entirely dependent on rainfall for their agricultural production activities. The responses were an indication that the study community was dependent on rain fed agriculture for most of its production activities. This exposed the community to the risks of loss at the advent of rain failure thus having negative implications on the capacity to realize good harvests attributed to dependence on rainfall. The responses equally brought to the fore inhibited capacity on the part of the study community as regards the ability to mitigate against climate change and the adoption of new technologies in the spheres of irrigation and non-rain fed agricultural production activities.

An insignificant (7%) of the respondents were of the position that at times they did not depend on rainfall for their agricultural production activities. This was an indication that some farmers had adopted irrigation as a measure of ensuring that they produced all year round regardless of the weather and allied climatic motivating factors. It was a confirmation on the ability to adapt and conform to the dictates of climate change by way of engaging in irrigation for agricultural production. It can thus be interpreted to mean that despite most of the members of the study community depending on rainfall for the agricultural production activities, a part of the community had adopted irrigation as a measure of mitigating against climate change and enhancing the food security in the households.

The study findings confirmed the position taken by FAO, (2008) which was of the view that food security is influenced by a myriad of factors entailing changes in the social demographics in the communities, technology changes, the macro-economic disposition, transport and communication systems, trade programs and emerging trends as regards the cultural practices carried out at the farm levels Changes in climate however greatly influence the dispositions towards the dynamics of food security associated with climate change effects (Schmidhuber *et al.*, 2007; Ringler *et al.*, 2010; Battisti *et al.*, 2009). The effects are greatly felt at the point of plant growth and development. Climate change has the potential to have great ramifications on the future production of food crops by the farmers doing agricultural production in unregulated environments (Brown *et al.*, 2008 and Lobell *et al.*, 2008). Rising populations globally are thus a critical factor in the realms of food security owing to the demands placed by the changes in climate and its effects on the production levels.

4.4.2 Instances of Total Crop Failure

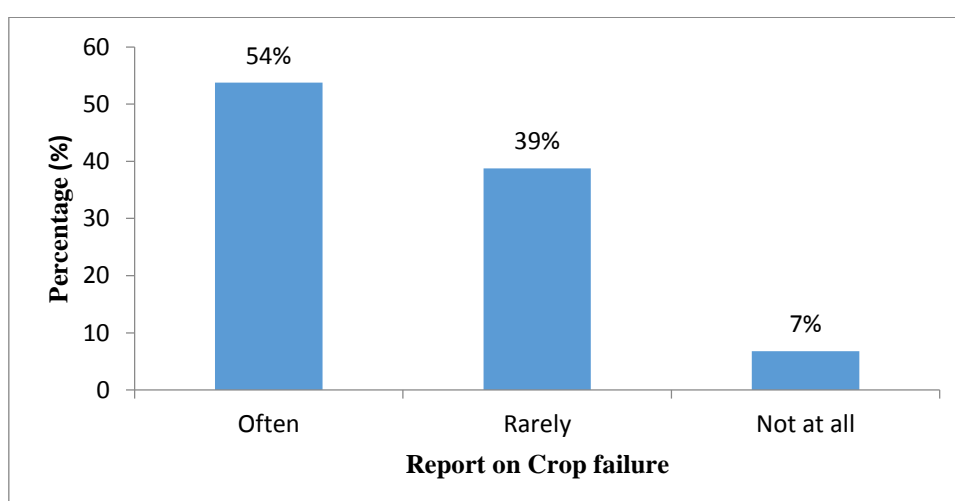


Figure 4.12 Instances of Total Crop Failure as Reported by Women Group in Gikindu

Most (54%) of the respondents confirmed that there had been often instances of crop failure among the members of the study community (Fig 4.12). The responses were reflective of a situation whereby the local community had experienced the pain of having instances of planted crops failing to totally survive to the point of getting harvested. This was an indication of the fact that the gravity of climate change had been felt in the study area leading to crop losses and the failure to harvest anything from the farms. This had caused the farmers to have their households run the risk of having

nothing to feed on after the planting season. The responses brought to light the gravity of the situation and the pain that the farmers went through even after working hard in their farms in gainful agricultural production all in the name of climate change. It was interpreted to mean that the farmers in the study area had experienced the pain of enduring losses in terms of crop failure occasioned by the vagaries of climate change. Similar sentiments were shared by the group leaders and the sub county agricultural officer.

Table 4.5 Perceptions on Effects of Rainfall and Temperature Variability on Food Security

Effects of rainfall and temperature levels variation on the food security situation		Frequency	Percentage (%)
The rainfall failure has had occasion of causing me total crop failure and exposing my failing to food insecurity	Undecided	6	4
	Agree	44	30
	Strongly Agree	97	66
Dependence on rain fed agriculture has caused members of our group to have low yields at the event of poor rains	Undecided	7	5
	Agree	44	30
	Strongly Agree	96	65
High temperatures have occasioned the risk of falling flowers and the aborting reducing the yields	Disagree	3	2
	Undecided	10	7
	Agree	41	28
	Strongly Agree	93	63
Heavy rains have led to leaching of soil nutrients leading to soil infertility and poor yields thus food insecurity	Disagree	51	35
	Undecided	24	16
	Agree	26	18
	Strongly Agree	60	41
The variation in rainfall and temperature has not affected my agricultural production in any way and food security is assured in my household	Strongly Disagree	49	33
	Disagree	56	38
	Undecided	15	10
	Agree	12	8
	Strongly Agree	16	11

4.4.3 Perceptions on Effects of Rainfall and Temperature on Variability of Food Security

Most (67%) of the respondents were of the view that rainfall failure had occasion of causing them total crop failure and exposing their families to food insecurity (Table 4.5). The responses depicted a situation whereby the families had been entirely dependent on the rains for their agricultural production activities and this had exposed them to risk at the advent of crop failure. This was an explicit pointer to the pain that the households suffered in the event of failure to have their crops doing well in the farms due to adverse weather conditions. It also denoted the precarious positions that the households were exposed to as regards the dependence on rain fed agriculture and the risks accruing to them as regards the food security situation. It was interpreted to mean that dependence on rain fed agriculture had exposed many households in the study area to the risks of food insecurity at the advent of total crop failure in instances of inadequate rains.

The findings confirmed the IPCC report 2007 which elucidated that variability in the rainfall and temperature levels has been profound globally. The variations can be attributed to the emission of greenhouse gases in economic activities locally to the depletion of the ozone layer. An evaluation by the inter-governmental panel on climate change member countries shows a consistent decline in the agricultural production levels since 1980 to date occasioned by climate change.

Most (95%) of the respondents were of the view that dependence on rain fed agriculture had caused members of their groups to have low yields at the event of poor rains. The responses were an indication that dependence on rain fed agriculture was profound in the study area and it compromised the ability of the local community in terms of realizing good yields. This was occasioned by the fact that the local community was heavily dependent on rainfall for agricultural production activities and at the advent of depressed amounts; the same had a ripple effect on the production capacity. This had negative implications on the yields realized and it exposed the farmers to the risk of diminished harvest and impaired potential to get optimal harvests. It was interpreted to mean that dependence on rainfall for agricultural production activities within the study area had the effect of compromising the food security of the households due to the unreliability of the rains.

The study findings confirmed the position of Garnett (2008) who argued that in a situation that is synonymous to cooking up a storm, the failure to effectively check greenhouse gas emissions has contributed to changing the climatic conditions. Studies carried out in the United Kingdom showed that increased greenhouse gas emissions had negative ramifications on the temperature levels. The situation of the increased temperatures negatively affected agricultural production activities occasioned by the faster evaporation of rainwater. This led to reduced production negatively impacting on the agriculture yields. This is in line with Challabi *et al.*, (2007) and Mugweru *et al.*, (2010) who were of the position that immature maturation of farm produce occasioned the farmers great loss at the advent of high temperatures during agro-production periods.

High temperatures have occasioned the risk of falling flowers and aborting reducing the yields as confirmed by most (63%) of the respondents. This was an indication that the high temperatures present within the study area had negative implications on the physiology of plants occasioning the risk of the abortion of flowers before their due time. This impaired the capacity of the plants as regards optimal production ability owing to the fact that the flowers produce the fruits. There was thus a correlation between the ability of the plants to have their flowers holding and withstanding to maturity and their production abilities. It can thus be interpreted to mean that the high temperatures had serious implications on the yields accruing from the agricultural production activities attributed to the abortion of flowers before their due time.

The study findings were also in consonance with research carried out by CSAE, (2013) which linked the rise in temperature to deprived economic positions of African countries. The survey carried out under the auspices of the centre for the study of African Economies in Oxford found out that for every increase in 1°C, there was a reduction of 15% of the GDP. This exposed the communities dependent on agriculture to the risk of potential ruin. Pastoralists engaged in fights for watering points, pasture and the risk of civil strife in competition for resources gets real and aggravated by the climate change situation.

A insignificant percentage (7%) of the respondents dissented to the situation of the high temperatures leading to abortion of flowers. This was an indication of the fact that in some instances the farmers had capacity to irrigate and condition the environment by use of structures like green houses to take care of the high temperature levels and

mitigate against the abortion of flowers. It was interpreted to mean that some of the farmers were assertive enough to take care of the prevailing changes as regards temperature levels with a view of ensuring that they realized good proceeds from their agricultural production activities.

The situation of heavy rains leading to leaching of soil nutrients occasioning infertility and poor yields was confirmed by most (51%) of the respondents. The responses were an indication that there had been instances of intermittent heavy rainfall within the study area leading to the leaching of soil nutrients. The heavy rainfall was an indication of instances of abnormally high than the expected amounts falling and coming along with destruction to the soil structure by virtue of leaching and draining the nutrients to the lower layers beyond the reach of the plants. This can be interpreted to mean that the study area had borne the brunt of abnormally high rainfall occasioning erosion and leaching of soils nutrients to the detriment of the farmers thus poor yields.

A significant percentage (35%) of the respondents dissented to the situation of abnormally high rains within the study area which occasioned leaching of soil nutrients. The responses were an indication of the fact that in some of the areas the respondents had not experienced unprecedentedly high rainfall which was beyond the averages experienced. It was reflective of the situation of drought, normal and below normal rainfall within the study area thus failure to have the risk of leaching of nutrients. It was interpreted to mean that the situation of excessive rainfall occasioning leaching of nutrients was not very profound in some parts of the study area.

The variation in rainfall and temperature was confirmed to have affected agricultural production in most (70%) of the households of the women group members and their food security was not assured. The responses were a confirmation that the vagaries of climate change had negative implications on the capacity of the households to be food secure. This is because their capacities in terms of the agricultural production had been greatly affected. It was interpreted to mean that the prevailing situation in terms of climate change in the study area had negatively affected the capacity of many households to engage in gainful agricultural production thus compromising their food security.

Insignificant percentages (13%) of the respondents were of the view that food security in their households was not compromised. This was an indication that some households

had taken charge of the situation as regards the gravity of climate change and had employed effective measures to mitigate against the same. It was reflective of enhanced capacity as pertains the ability to employ adequate safeguards which ensured optimal agricultural production despite the ravages of climate change.

The ravages of the food insecurity situation in the study area were in line with the national economic outlook of the Republic of Kenya as postulated by the Central Bureau of Statistics (CBS, 2013) which gave a detailed picture of climate change on the country's economic performance. The situations of high temperatures and decreased rainfall have in many at times occasioned communities to pain and anguish. Recession is always evident at the advent of crop failure. This is because resources are expended to import food and provide subsidy to the vulnerable populations. The findings tally with the positions taken by Huho *et al.*, (2013) in Kenya and Prapti *et al.*, (2013) in India where both studies argue that a warmer atmosphere holds more moisture thereby increasing precipitation by 7% for every degree centigrade of warming.



Plate 4.1: Dried up Water Pan as Evidence of Harsh Weather Conditions in Mirira

Table 4.6 Cross Tabulation between Dependence on Rainfall to Grow Produce and Instances of Total Crop Failure

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	111.498 ^a	14	.042

Cross tabulation between dependence on rainfall to grow produce and instances of total crop failure gave a Chi-square value of $\chi^2 = 111.498$ at a significance level of 0.05 and df of 13 which was more than the tabled critical value of $p = 0.042$. The response showed a situation whereby dependence on rainfall for agricultural production exposed the farmers to the risk of crop failure at. It was interpreted to mean that at the advent of entirely depending on rainfall for agricultural production activities, the farmers were exposed to the risk of crop failure.

The prevailing conditions identified with the Fourth IPCC Report of 2007 which showed that, the farms may increase production at the advent of moderate increases in the temperature. Reports cited in the IPCC Fourth Report showed that in the temperate regions, increases in the ranges of 1-3°C which are relatively small may induce improved production in the event of utilization of organic fertilizers in optimal manners. This however applies to the cool temperate areas only. In the arid areas evidence of reduced production and total crop failure were vivid.

4.4.4 Exposure of Women Group Members to the Acute Need for Relief Food

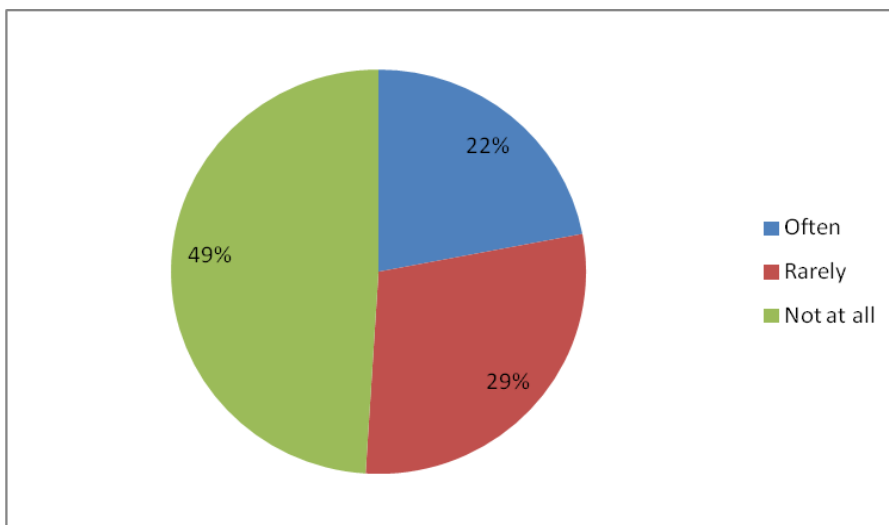


Figure 4.13 Exposure of the Group Membership to the Acute Need for Relief Food Provision by Government in Gikindu

Most (51%) of the respondents confirmed that they had incidences of receiving relief food. The responses were an indication that the members of the local community had diminished agricultural production capacities which occasioned them the failure to be food secure. It was reflective of a situation whereby the local community had been negatively affected by the challenge of failure to have security to the extent of having

government intervention in terms of relief food provision. Similar positions were taken by the sub county agricultural officer and the group leaders.

A significant percentage (51%) of the respondents had the experience of receiving relief food at any given point. The responses were an indication that some members of the community had strived to ensure that they were food secure and this had positively saved their face as regards failure to depend on relief food. It was interpreted to mean that some of the community members had worked hard to ensure that the food security situation in their households was assured and this has effectively mitigated against relief food provision.

4.4.5 Consideration of Households Food Security

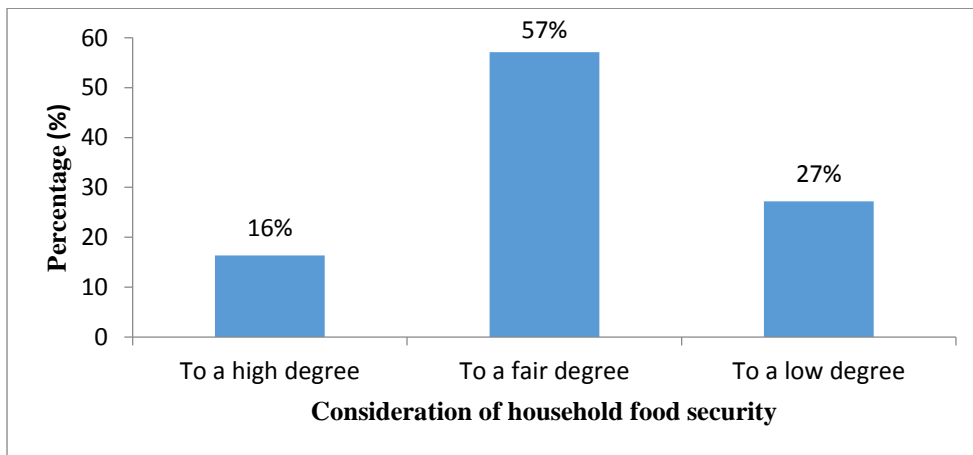


Figure 4.14 Consideration of Household as Food by Women Groups in Gikindu

The responses show that most (57%) of the respondents considered their households as fairly food secure. The responses denoted fair capacity as regards the food security situation in most of the households. This was an indication that the households had strived to be food reliant but the members were not wholly satisfied with the situation. Some of the respondents confirmed that their households were highly food secure. This was an indication that their households had not suffered from lack of food despite the prevailing situation as regards climate change and the risks that it portends in terms of food security. It was interpreted to mean that the food security situation had not been greatly affected in most of the households despite the gravity of climate change.

A very significant percentage of the respondents (whose response to household food security was either fair or otherwise too low) (84%) was taken to mean that they were

food insecure. The responses reflected a situation whereby despite membership in the women groups, little effects with regard to enhancing food security and agricultural production had been felt. This was an indication that the members had not derived the much needed benefits in terms of the capacity to ensure sustainable agricultural production activities to enhance their households' food security. The study interpreted it to mean that some of the households within the study area had suffered from food insecurity mainly accelerated by the ravages of climate change despite membership in women groups gearing towards ensuring sustainable agricultural production. Similar observations were made in Feenstra (2016) with assertions that even with the growing specialization of agro-production; farmers achieve quite little from the farms due to factors such as time, biological and ecological among others.

4.4.6 Assistance from Organizations in Ensuring Food Security

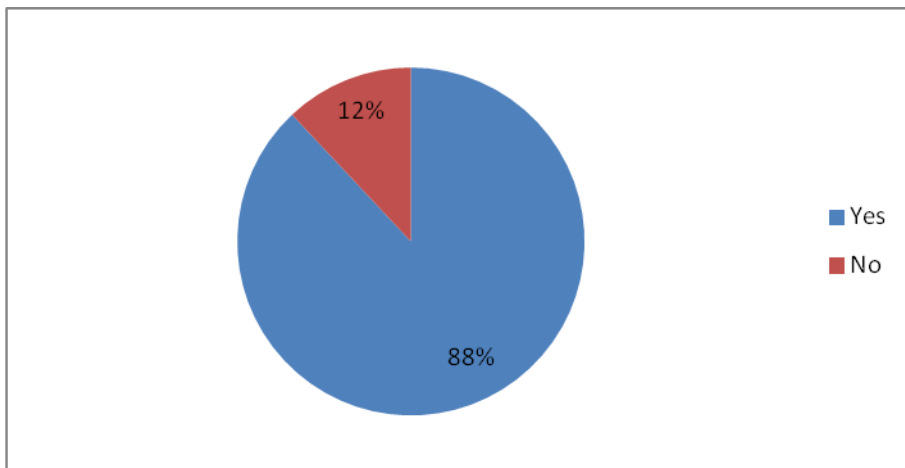


Figure 4.15: Assistance from Organizations in Ensuring Food Security to Women Groups in Gikindu

Most (88%) of the respondents confirmed that they had obtained assistance from organizations in ensuring that the food security realization strategies were effective. This was an indication that the organizations had forged partnerships with the women groups in the quest of enhancing their food security situations. It vindicated the women groups with regards to strategy formulation and capacity building all in the quest of achieving member satisfaction as pertains to their food security. It was interpreted to mean that the women groups had worked hard to ensure enhanced standards for food security in the local populace.

Cross tabulation between perceptions of households food security and incidences of food assistance gave a Chi-square value of $\chi^2 = 103.637$ at a p value of 0.05 and a df 2

which was more than the tabled critical value of $\chi^2 = 78.897$. The showing perceptions of household food security and incidences of food assistance were related. It was interpreted to mean that partnership with organizations geared towards food security enhancement ensured that the households positively benefitted.

4.5 Coping Strategies by Women Groups to Mitigate Food Insecurity in Gikindu Division

4.5.1 Effects of Group Participation in Agricultural Production

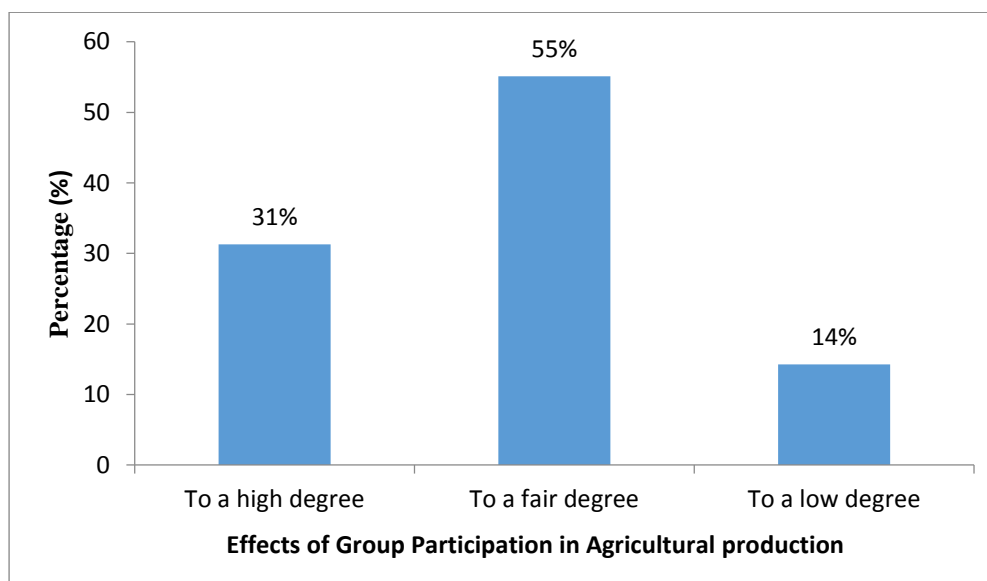


Figure 4.16 Effects of Group Participation in Agricultural Production on Households' Economic Mainstay

Most 55% of the respondents considered there to have been a fair degree in terms of improvement of their agricultural production activities by virtue of participation in group activities. The responses were an indication that membership in the women groups had greatly impacted positively on the households' economic mainstays by virtue of enhancing the individual members capacities to undertake agricultural production activities. It was reflective of a situation whereby most of the group members had an effect in terms of improved of economic mainstays associated with their participation in the group activities. The same position was taken by the sub county agricultural officer and the group leaders in the course of the data collection exercise.

A significant percentage (31%) of the respondents considered the effects of participation in group activities to have enhanced their capacities to a high degree in terms of food production. It was confirmation that the women groups had highly

affected the capacities of some of the members in terms of aiding improve the food security. It was interpreted to mean that the women groups had a profound effect on the ability of the members to positively change their economic mainstays and food security situation.

Some few respondents deemed the women groups as having a minimal effect on the members as regards enhancing their participation in agricultural production and ensuring household food security. This brought to the fore the reality of some of the groups not playing an effective role as regards ensuring the members food security.

The study findings confirmed the position taken by IFAD, (2011) which elucidated that gender dimensions in activities carried out by the International Fund for Agricultural Development Food and Agriculture Organization (FAO, 2012) and the World Food Programmes (WFP) have borne results in Ghana and Mozambique (Yiamma *et al.*, 2011 and Bench *et al.*, 2011). The women have been sensitized on the need to actively engage in environment friendly production activities in their agricultural pursuits. They have been trained on water harvesting and exploitation of renewable energy in their households in the wake of seeking to combat the ravages of climate change.



Plate 4.2 Surface Water Harvesting to Take Care of the Effects of Rainfall Reduction in Kambirwa within the Study Area



Plate 4.3 Water Pan Constructed by Women Group to Facilitate Farming During Dry Spells in Gikuo within the Study Area



Plate 4.4 Plastic Water Storage Tanks for Women Group to Mitigate Reduced Rainfall amounts in a Group Members Homestead in Mirira Area

The investment in the water storage facilities was confirmation of the gravity of the water scarcity situation mainly attributed to the prevailing precipitation levels reduction. This was an indication of the extent to which the local community had worked towards investing in the water storage capacities.



Plate 4.5 Tissue Culture with Optimal Mulching to Safeguard against Water Loss in the Dry Weather Conditions

The adoption of the tissue culture banana technology in the area was an indication of efforts made towards ensuring that the local community identifies with the emerging technologies of higher producing cultivars. Use of mulching for water loss mitigation was evidence of efforts put in place to train the local communities on the water loss mitigation in the planted crops as a measure of ensuring sustained production. It was also a confirmation of the ingenious measures in place to mitigate the climate change situation as pertains to the risks of water loss from the soil owing to increased evapotranspiration.



Plate 4.6 Adoption of Cassava Growing as a Food Insecurity Mitigation Measure Owing to its Drought Tolerance Capacity in Gikuo within the Study Area



Plate 4.7 Adoption of Technology to Mitigate Inadequate Rainfall as Evidenced by the Drip Irrigation Farming Systems in Mirira within the Study Area



Plate 4.8 Horticulture Farming Activities Undertaken by a Women Group in the Study area for Commercial Purposes in Kambirwa within the Study Area

Plates 4.6, 4.7 and 4.8 showed that the local communities especially so the women group members had been keen to adopt the emerging technologies. They still exploited the traditional drought tolerant cultivars as a measure of ensuring that they effectively mitigated the harsh weather conditions attributed to climate change. This insulated them from food insecurity.



Plate 4.9 Adoption of Drought Tolerant Cultivar (Carica Papaya) for Commercial Purposes to Mitigate Climate Change Effects in Gitungano within the Study Area

This was evidence of the ability of the households to effectively carry out activities geared towards enhancing their economic mainstays from the cultivation of commercial cultivars. Propagation of the commercial cultivars of the drought tolerant varieties has been a big boon to the area owing to the fast maturation of the crops and the enhanced production capacities in comparison to the local varieties. This was evidence of the capacity to have technology adoption in the propagation of crops as a premise for food insecurity mitigation by the residents of the study area.

The poultry production activities by the women group members were evidence of their approach to diversify their income generation activities. It was also an indication of the capacity of the group members to identify projects which met the needs of the local populace in the wake of undertaking the income generation activities. Each of the activity that members of the women group were found to have engaged into had some significance either by technology or need. For example cassava and sweet potatoes growing served as a perfect substitute for maize which had since failed; also due to fact that these crops were resistant to drought and required little rainfall.

4.5.2 Perceptions on the Role of Women Groups on Household Food Security

Table 4.7 Perceptions on the Role of Women Groups on Household Food Security

Effects of women groups		Frequency	Percentage
Membership into the women group has enabled technology transfer on agricultural best practices which has assured my household of food security	Strongly Disagree	18	12
	Disagree	36	25
	Undecided	9	6
	Agree	30	19
	Strongly Agree	54	37
Membership into the women group has positively impacted in my knowledge of climate change awareness and drought tolerant crop cultivars thus affecting the food security of my household positively	Strongly Disagree	19	13
	Disagree	43	29
	Undecided	10	7
	Agree	38	26
	Strongly Agree	37	25
Membership in the women group has facilitated the engagement in afforestation activities in our area combating desertification and checking climate change	Strongly Disagree	19	13
	Disagree	10	7
	Undecided	19	13
	Agree	50	34
	Strongly Agree	49	33
Membership in the women group has facilitated greater agricultural production activities by the members	Strongly Disagree	10	7
	Disagree	32	22
	Undecided	19	13
	Agree	35	24
	Strongly Agree	50	34
Membership in the women groups has facilitated increased assertiveness in the group members leading to greater participation in agribusiness activities	Strongly Disagree	15	10
	Disagree	29	20
	Undecided	16	11
	Agree	44	30
	Strongly Agree	43	29

An insignificant (37%) of the respondents considered the membership into the women group as having enabled technology transfer on agricultural best practices which had assured their households of food security. The responses vindicated the women groups in terms of the capacities to ensure that the members acquired the requisite skills and current technologies to enable them carry out agricultural production activities in an optimal manner. This was confirmation that knowledge dissemination on current best practices in the realms of agricultural production was done in the groups. It reflected the ability of the groups as regards the potential to act as vehicles for member empowerment and capacity building in agricultural production. It was interpreted to mean that the members of the women groups derived benefits from engagement in the activities and technology transfer was facilitated by the membership.

The research findings confirmed the position taken by Were, (2011) who was of the view that the promulgation of the constitution of Kenya in the year 2010 opened a new window in the disposition of equality and human rights. The equality between men and women has been enshrined in the constitution. This has proved to be an emerging paradigm as regards the empowerment of the rural women. Programmes conducted by the United Nations International Children's Emergency Fund have aimed at inculcating skills and building the capacity of women groups engaged in agricultural production in the wake of climate change. This has greatly impacted on the capacity of their individual households to access quality nutrition and get an assurance on food security (Doss, 2011).

Some of the groups however did not play any role as regards enhancing the capacities of the members and facilitating skills transfer to them in the realms of agriculture. The responses depicted a situation whereby the groups did not serve their essence to the expected standards and failed to meet member aspirations in terms of technology and skills transfer to improve the food security situation. It was interpreted to mean that some of the groups had no focus on enhancing members' skills as a premise of ensuring that the food security was enhanced.

Membership into the women group had positively impacted on the knowledge of climate change awareness and drought tolerant crop cultivars thus affecting the food security of the group members' household's positively as confirmed by (51%) of the members. The responses confirmed that membership in the women groups had facilitated knowledge acquisition on emerging trends as regards climate change and the

drought tolerant cultivars which can be adopted to enhance members food security. The responses reflected a situation whereby the groups served as points of interface and sharing between the members with an aim of facilitating knowledge dissemination. Capacity to get informed on climate change issues was brought to the fore by virtue of member participation in group activities. It was interpreted to mean that the participation in group activities had enhanced the capacity of the members to acquire knowledge on climate change and equally skills on drought tolerant cultivars which they can adopt to enhance their food security. This confirmed the ability of the groups to facilitate member food security by virtue of knowledge acquisition and adoption of drought tolerant cultivars.

A very insignificant (29%) of the respondents dissented to the capacity of the groups that they were members in to facilitate knowledge acquisition on climate change and incisive information on drought tolerant cultivars that can be adopted to enhance food security. This was reflective of a situation whereby the women groups served as avenues to carry out other activities other than enhancing member capacities in terms of food security and knowledge acquisition on climate change. The prevailing situation predisposed the members of the affected groups to the risk of failing to access knowledge on climate change. It also exposed them to the risk of failure to understand the drought tolerant cultivars that can be adopted as a measure of ensuring that the food security situation is enhanced in their households. It was interpreted to mean that some of the groups occasioned the members the disservice of failing to acquire information on climate change and understanding drought tolerant cultivars which they can adopt to enhance their households' food security.

Membership in the women groups had facilitated the engagement in afforestation activities combating desertification and checking climate change as confirmed by most (35%) of the respondents. The responses confirmed that the groups had acted as effective agents of change which had facilitated the members to plant trees and other agro forestry activities as a medium of climate change mitigation. This gave credence to the capacity of the groups in terms of member empowerment and facilitation in the realms of afforestation. It vindicated the capacity of the groups as pertains to their ability to influence positive change in the community and green the environment after planting trees to contain the gravity of climate change. It was interpreted to mean that

the women groups served as effective mediums to encourage afforestation in the community and combat climate change.

Failure by some of the groups to facilitate the membership in afforestation activities equally came out from the responses as reflected by (12%) of the respondents. This was evidenced by the inability to have them participate in afforestation which is a core activity in terms of climate change mitigation. It thus brought to the fore the situation of inactivity by some of the groups as regards to the engagement in afforestation activities in the requisite manner. This was an indication that despite the need to carry out concerted activities in the realms of afforestation and employ the women groups as vehicles for the activity, they had not fully realized their essence.

Membership in the women group had facilitated greater agricultural production activities by the members as confirmed by most (34%) of the respondents. This was an indication that the activities carried out collectively were of great benefits to the members of the groups who had come together for the purposes of attaining corporate gains. This was an indication that in most of the groups the ideals of membership had been met and the essence of achieving enhanced agricultural production had been attained. This was confirmation that the groups had effectively served the members and positioned them in improved situations as regards to the household food security owing to enhanced agricultural production activities. Situations whereby the women groups had not impacted on the agricultural production capacities of the local communities having membership in the groups were evident. This was an indication that some of the group members had received some very insignificant benefits from them as pertains to the ability to have increased agricultural production. This can be interpreted to mean that there was need to have the groups implored on to resonate with the ideals of cushioning the members from the risks of climate change and the situation of food insecurity attributed to it. This was the only measure of assuring the members capacity to derive benefits in terms of the household food security.

Membership in the women groups had facilitated increased assertiveness in the members leading to greater participation in agribusiness activities as it was confirmed by most (29%) of the respondents. This was an indication that the women groups had enabled the members to carry out business activities of diverse nature thus confirmation that the entities had served as good forums for membership capacity building as pertains to economic growth. It was also confirmation that the women groups had

provided the members with forums for interaction to the extent of networking and growing the individual mainstays for the households. The responses showed that the women groups had largely served their essence as pertains to shoring up the fortunes of the members in the realms of agribusiness activities. Some of the groups though did not serve the members effectively in the aspect of agribusiness activities. This was an indication that some of the groups acted as vehicles for social inclusion devoid of economic endowment for the members.

The findings were in line with the MDG's, (2010) which aimed at reducing and eradicating extreme poverty and hunger by the year 2015. The reduction of hunger can only materialize at the advent of assuring households of food security. This is equally in line with the poverty eradication and wealth creation strategy paper for the Republic of Kenya (GoK, 2003). The paper identified empowerment of women groups as a strategy which can effectively enlist their participation in agricultural activities and assure households of food security.



Plate 4.10 Tree Nursery for Women Group Members to Undertake Agro Forestry Activities for Income Generation



Plate 4.11 Tissue Culture Banana Nursery for Women Group Members to Encourage Adoption of the Technology

Plates 4.11 and 4.12 show a tree nursery and a tissue culture banana nursery which was evidence of the concerted efforts in the study area as regards the ability to have the local community adopt the non-traditional approach in the crops propagation. This was key in livelihoods diversification and the capacity to mitigate the effects of climate change.



Plate 4.12 Women Group Greenhouse with a Background of Sweet Potato Vines in Kambirwa Area

Evidence of the greenhouse in the study area belonging to a group of women farmers was an indication of the resolve with which they had approached the prevailing climate change situation with as pertains to the mitigation practices that they employed. It was also confirmation of the community assertiveness with regards to the ability to

acknowledge and embrace technology thus a pointer to the effectiveness of the approach in mitigating the vagaries of climate change.

4.5.3 Ways of Mitigating the Challenge of Food Insecurity Attributed to Climate Change

The respondents had varied responses as pertains to the approaches which can be used to mitigate against the challenge of food insecurity attributed to climate change. They were of the view that sensitizing the greater communities of the risks pertaining to climate change with a view of having them adopt current best practices applicable in agricultural production would serve the populace good. This would greatly mitigate against the risk of food insecurity attributed to the capacity to produce in adversity. Capacity building as pertains to individual skills impartation on the suitable approaches for harnessing water resources for agricultural activities was equally cited as a good approach to ensure that the communities mitigated the effects of climate change.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

Most of the respondents perceived the difference in rainfall and temperature levels to be profound thus confirmation that over a period of time, there had been noticeable variation in terms of the rainfall amounts and the temperature levels. Most of the respondents deemed the effects of rainfall and temperature levels variation on agricultural production capacity to have been great and significantly affected the agricultural production capacities negatively. Depressed rainfall had occasioned the members of most of the women groups' crop losses attributed to the adverse weather. Increased temperatures had led to immature maturation of crops in the farms. High temperatures lead to wilting of harvested fresh produce occasioned farmers losses in the area. The farmers had suffered losses after investing in fresh produce production attributed to high temperatures which negated their abilities to deliver the produce in the requisite manner.

The study established that most of the respondents were entirely dependent on rainfall for their agricultural production activities exposing the community to the risks of loss at the advent of rain failure negatively impacting on the capacity to realize good harvests attributed to dependence on rainfall. Most of the respondents confirmed that there had been often instances of crop failure among the members of the study community exposing their families to food insecurity because the families had been entirely dependent on the rains for their agricultural production activities. The households suffered in the event of failure to have their crops doing well in the farms due to adverse weather conditions owing to dependence on rain fed agriculture.

Evidence from the study further confirmed that most of the respondents had incidences of receiving relief food as a measure of coping against food insecurity in the households. Most of the respondents confirmed that they had gotten assistance from organizations in ensuring that the food security realization strategies were effective thus confirmation that the women groups liaised with other organizations to bolster their intervention activities in the quest of enhancing their food security situations.

Responses from the study showed that most of the respondents considered there to have been improvement of their agricultural production activities by virtue of participation

in the group activities thus confirmation that membership in the women groups had impacted positively on the households' economic mainstays. Most of the respondents considered the membership into the women group as having enabled technology transfer on agricultural best practices which had assured their households of food security and positively impacted on the knowledge of climate change awareness and drought tolerant crop cultivars. Engagement in afforestation activities to combat desertification, greater agricultural production activities and increased assertiveness in the members leading to greater participation in agribusiness activities as it was confirmed by most of the respondents. This vindicated the women groups as regards playing active roles in the livelihoods of the members.

5.2 Conclusions

The study drew the following conclusions:-

- i) The climate change phenomenon had occasioned considerable suffering to the farmers due to irregularly distributed rainfall sometimes in form of hailstorms, unpredictable fluctuating temperatures that results in destruction of crops while on the farmlands. Depressed rainfall and drought had negative implications on the capacity of the women group members to realize optimal harvests and this had heavily compromised the households' food security. Situations of crops is made worse by the fact that the crops mature before due time leading to depressed harvests a situation that has compromised food security in the area as well as eroding farmers' gains.
- ii) Most of the families were entirely dependent on rains for their agricultural production activities exposing them to risk of crop failure in the event of adverse weather conditions. Dependence on rainfall for agricultural production had a ripple effect on the food security situation owing to depressed amounts. High temperatures in the study area had negative implications on the physiology of plants causing abortion of flowers before their due time and compromising households' food security.
- iii) The local community had been negatively affected by the challenge of food security something that the study points to the failure of the government in ensuring that there are strong policies and legislations that can guide the residents on best practices, adherence to globally accepted standards among others. Members of the

local community had not derived the much needed benefits in terms of the capacity to ensure sustainable agricultural production activities to enhance their households' food security. Some of the households within the study area had suffered from food insecurity mainly accelerated by the ravages of climate change despite membership in women groups thus negating their essence.

- iv) Membership in the women groups had enabled members get the requisite skills and current technologies to carry out agricultural production activities. Knowledge dissemination on current best practices of agricultural production was done in the women groups. The women groups served as interfaces of sharing information between members with an aim of facilitating knowledge dissemination. Participation in group activities had enhanced the capacity of the members to acquire knowledge on climate change and skills on drought tolerant cultivars to adopt and enhance their food security. Women groups acted as effective agents of change in terms of member empowerment and activities carried out collectively were of great benefits to the individual members' food security situation. Some of the coping strategies that had been employed to check the prevailing conditions include the engendering of food production whereby the female population members are given greater focus with regard to participating in agricultural production activities. Planting drought tolerant cultivars which withstand the vagaries of weather equally may positively affect the food security situation. Practicing irrigation and avoiding over-reliance on rain fed agriculture may equally be a good practice which may stem the tide of food insecurity. Engaging in best practices with regard to technology adoption in the realms of food production may also positively impact on the food security situation.

5.3 Recommendations

The study had the following recommendations:-

- i) Legal provisions should be put in place by the national and county governments to ensure that farmers have access to information on climate change as a measure of forestalling losses accruing from the agricultural production activities. Farmers should be provided the requisite information as pertains to the emerging trends and expected situations of rainfall and temperature thus able to effectively plan their production activities. This may positively affect the adoption of sustainable farming

practices despite the ravages of climate change thus cushioning the farmers from the risk of loss. This may positively affect the household food security situation.

- ii) The county governments should employ an integrated approach to invoke the participation of women in the agricultural production to engender food production and assure security by provision of incentives to women. This is will ensure synergy by the government agencies having diverse approaches in activities carried out to assure livelihoods improvement for enhanced food security in the households. An integrated multi-agency program involving the Ministry of Agriculture, the Departments of Social Services and the Departments of Gender would positively impact on the ideals of engendering agricultural production as a measure of enhancing the households' food security is ensured.
- iii) The Ministry of Agriculture should work harder to ensure that the farmers have access to information on drought tolerant crops which can withstand the harsh weather conditions. This is by way of carrying out sensitization activities and leading the crusades for their adoption. This is a measure that may greatly cushion the farmers from the risk of crop failure despite the situation of climate change occasioned by the crops resilience. This may bolster the households' food security situation and assure them of the capacity to be sufficient despite the climate change phenomenon.
- iv) County governments should enact legislation to ensure that water as a resource is harvested and harnessed in the requisite manner. This may play a great role in the reduction of dependence on rain fed agricultural production practices and assure food security even in the event of rain failure. This may play a big role in mitigating the risks accrued from climate change and enhance the communities' household food security situations.

5.4 Suggestion for further study

The researcher suggests that a similar study with a bigger scope should be carried out in Murang'a County with emphasis to areas with similar agro- ecological zones. This is with a view of finding out if the circumstances in Gikindu Division in Murang'a East Sub County identifies to the other areas. The researcher also proposes that a study on gender asymmetries as a factor influencing household food security should be carried

out. This is with a view of confirming the extent to which the gender dispositions affect the food security situations as pertains to spousal responsibilities.

REFERENCES

- Aslam, B (2011) *Policy Programmes For investment in Irrigation and their Impact on Food Security Situation*. A working paper for the World Bank
- Batisti, D. S., Naylor, R. L. (2009). *Historical Warnings of Future Food Insecurity with Unprecedented Seasonal Levels*. *Science* 323. 240-244
- Baylis, M., & Githeko, A. K. (2006). *The Effects of Climate Change on Infectious Diseases of Animals. Report for the Foresight Project on Detection of Infectious Diseases*. Department of Trade and Industry UK Government.
- Bench, R. (2011). *Women the Key to Food Security. Food Policy Statement on the Africa Growth and Opportunities Act and its Impact on Women Empowerment*. Washington DC . International Food Policy Research Institute
- Black, R. et al., (2008). *Demographics and Climate change: Future Trends and their Policy Implications for Migration*, Working Paper T-27, Development Research Centre on Migration, Globalisation and Poverty
- Bouwer, L. M (2011). *Have Disaster Losses Increased Due to Anthropogenic Climate Change?* *Bulletin of the American Meteorological Society*, January 2011, 92, 39–46.
- Brown, M. & Funk, C., (2008). *Food Security under Climate Change*, *Science*, (319)
- CBS, (2013). *Economic Outlook for Kenya. A Report for the Central Bureau of Statistics*.
- CBS, (2016) *Household Economic Survey for Murang'a East Sub County*, Government Printer, Nairobi, Kenya
- CGIAR, (2013). *Achieving Food Security in the Face of Climate Change. A Working Paper for the Consultative Group on Agricultural Research*.
- Challabi, R. (2007) *Impacts of Climate Change on Indirect Human Exposure to the Vagaries of Climate Variability*. *Agriculture Environ Perspective*.
- Challinor, A. J., Ewert, F., Arnold, S., Simelton, E. & Fraser, E. (2009). *Crops and Climate Change: Progress, Trends, and Challenges in Simulating Impacts and Informing Adaptation*. *Journal of Experimental Botany*, 60, 2775–2789.
- Chrietensen, J. H. Hewitson, B., (2007). *The Physical Science Basis: Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, U. K. P. 849-940.
- Cline, W. R., Taylor, R. L. (2007). *Global Warming and Agriculture. Impact Estimates by Country*. Washington D. C. Peterson Institute.
- Coulibaly, U. M. (2011). *Women's Income and Boy Child Anthropometric States in South America*. *World Development Journal* No. 22 (4).
- Craine JM, Nippert JB, Elmore AJ, Skibbe AM, Hutchinson SL, Brunsell NA (2012) *Timing of climate variability and grassland productivity*. *Proceedings of the National Academy of Sciences of the United States of America*, 109, 3401–3405.

- Craufurd, P. Q. & Wheeler, T. R. (2009). *Climate Change and the Flowering time of Annual Crops*. *Journal of Experimental Botany*, 60, 2529–2539.
- CSAE (2013). *A Report for the Centre for the Study of Africa Economies in Oxford*. A working paper for CSAE
- CSCCW, (2012). *Central Stakeholders Climate Change Workshop Deliberation Held in Nyeri: A Working Paper for the Central Stakeholders Climate Change Workshop*.
- DFID (2011). *Food Security, Poverty and Women, Lessons from the Success Stories in Rural Asia. A Working Paper for the DFID*.
- DFID, (2011) *Women Agricultural Producer Groups and their Role in Facilitating Economic Growth in Argentina. A Working Paper for the DFID*.
- Dinar A, Hassan R, Mendelsohn R, Benhin J (2008) *Climate Change and Agriculture in Africa: Impact Assessment and Adaptation Strategies, Earthscan*
- FAO, (2008). *Climate Change. Implications to Food Safety*. Rome: FAO.
- FAO, (2011). *Focus on Women and Food Security. A Working Paper for the Food and Agriculture Organization*.
- FAO, (2011). *Gender Dimensions in the Right to Food. Food and Agricultural Organization Report on the Situation in Bolivia*.
- FAO, (2012). *Gender in Agriculture Source Book. Agriculture and Development Confirmation Edition*. Washington D. C. The International Bank for Reconstruction and Development.
- FAO, (2013). *Gender Dimensions in the Right to Food. Food and Agricultural Organization Report on the Situation in Africa*.
- Feenstra, G. (2016). *Sustainable Agricultural Research and Education Program*. University of California Press, Davis
- FEWNET, (2009). *Famine Early Network Report on the Rainfall Forecast in the East Africa Region and Statistics from 1960-2025. A Working Paper for the Famine Early Warning Network*.
- Foley, A. M. (2011). *Solutions for a Cultivated Planet Nature*. 478; 337-342.
- Foster, D. S. (2007). *Historical Warnings on Weather Variability and its Impact on Food Security. Agricultural Environ Health Perspective*.
- Fredrich, A. (2011). *Gender and the Distribution of Wealth in Developing Countries. A Working Paper for the World Institute of Development Economics*.
- Funk C, Dettinger M D, Michaelsen J C, Verdin J P, Brown M E, Barlow M and Hoell A (2008), *Warming of the Indian Ocean threatens eastern and Southern African food security but could be mitigated by agricultural development, PNAS, Vol 105, no.32, pp 11081-11086*
- Funk C., and Brown, M. E., (2009). *Declining global per capita agricultural production and warming oceans threaten food security*, 1:3, p. 271-289.

- Fuschs, A. Wolf, H. (2011). Concept and Unintended Consequences of Weather Index Insurance. The Case of Mexico. *American Journal of Agricultural Economics*. 93 (2) 505-511.
- Garnett, T. (2008). *Fruit and Vegetables and UK Green House Gas Emissions: Exploring the Relationship*. Food Climate Research Network Survey: Centre for Environmental Strategy. University of Surrey.
- Godfray H C J, Beddington J R, Crute I R, Haddad L, Lawrence D, Muir J F, Pretty J, Robinson S, Thomas S M, and Toulmin C (2010), Food Security: The Challenge of Feeding 9 Billion People, *Science* vol 327, no 5967, pp 812-818.
- GoK (2003). *Poverty Reduction and Wealth Creation Strategy Paper*. A Policy Paper for the Republic of Kenya
- GoK (2010). *A Report of the Central Bureau of Statistics for the National Census Carried out in the Year 2009*. A Report of the Government of Kenya
- GoK (2012) Integrated Development Strategy for Murang'a East Sub-County.
- GoK, (2010). *The Constitution of Kenya*. Government Printer, Nairobi, Kenya.
- GoK, (2012). *Integrated Development Strategy for Murang'a East Sub-county*. Government Printer, Nairobi, Kenya.
- GoK, (2013). Murang'a County Integrated Development Plan.
- Government of Kenya (GoK) (2007), Integrated Household Budget Survey 2006 in UNEP (2009), Kenya: *Atlas of Our Changing Environment, United Nations Environment Programme*
- Guitausson, M. A., Haslan, D. W., (2011). *Global Food Losses and Food Waste*: Rome, Italy Food Agriculture Organization of the United Nations.
- Hansen J W and Indeje M (2014), Linking Dynamic Seasonal Climate Forecasts with Crop Simulation for Maize Yield Prediction in Semi-Arid Kenya, *Agricultural and Forest Meteorology*, vol 125, issues 1-2, pp 143-157
- Hansen J W, Challinor A, Ines A, Wheeler T and Moron V (2014), Translating climate forecasts into agricultural terms: advances and challenges, *Climate Research*, vol 33, pp 27-41
- Herrero M, Thornton PK, Notenbaert A et al. (2010) Smart investments in sustainable food production: revisiting mixed crop-livestock systems. *Science*, 327, 822– 825.
- Hess, U. Hazell, P., (2009). Innovations in Insuring the Poor. Sustainability and Scalability of Index Based Insurance for Agriculture and Rural Livelihoods, 2020 Vision. *International Food Policy Research Institute*.
- Hlavinka P, Trnka M, Semeradova D, Dubrovsky M, Zalud Z, Mozny M (2009) Effect of drought on yield variability of key crops in Czech Republic. *Agricultural and Forest Meteorology*, 149, 431–442.
- Huho, M. J., Maundu, A.. (2013). *Impacts of Climate Change on the food Security Situation in Kenya*. Doctoral Dissertation, Maseno University.

- Hurkman WJ, Vensel WH, Tanaka CK, Whitehead L, Altenbach SB (2009) Effect of high temperature on albumin and globulin accumulation in the endosperm proteome of the developing wheat grain. *Journal of Cereal Science*, 49, 12–23.
- Hutton, R. J. & Landsberg J. J. (2000) Temperature Sums Experienced Before Harvest Partially Determine the Post-Maturation Juicing Quality of Oranges Grown in the Murrumbidgee Irrigation Areas (MIA) of New South Wales *J. Sci. Food Agric.*
- IFAD, (2011). Rural Poverty Report. New Realities, New Challenges, New Opportunities for Tomorrow Generation. Rome Italy: *International Fund for Agricultural Development*.
- IPCC (2012) Managing the risks of extreme events and disasters to advance climate change adaptation. In: *A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge, NY, USA*.
- IPCC, (2007). *Intergovernmental Panel on Climate Change. Climate Change 2007 Synthesis Report. Contribution Working Groups 1, 11, 111 to the Forth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva IPCC.
- Kamande, M. (2012). Strategies for Developing the Banana Value Chain: A Working Paper for Africa Harvest.
- Kanyenji B M (2012) Turkana Sorghum Germplasm response to pre and Post-Flowering moisture stress, *Kenya Agriculture Research Institute (unpublished)*
- Kauchak, A. (2012). Household Food Security and its Impact on Peace and Economic Stability. *A Discussion Paper for the Institute of Policy Analysis and Research*.
- Kauri, P. (2011). Entrepreneurial Perspectives for the Development of Agriculture in Rural Movement Producer Groups. *A Working Paper for the International Fund for Agriculture Development*.
- Kombo.K. Tromp(2009) *Proposal and Thesis Writing*. Masola Publishers, Nairobi Kenya.
- Larborte, A. G. Muya, P. F., (2011). Food Production Trends and Future Outlook. *European Journal on Agronomy*.
- Lipper, L. Mann, W. (2010). Climate Smart Agriculture Policies, Practices and Financing for Food Security, Adaptation and Mitigation, Rome Italy: *UN Food and Agriculture Organization Working Paper*.
- Lloyd SJ, Kovats RS, Chalabi Z (2011) Climate change, crop yields and under nutrition: development of a model to quantify the impacts of climate scenarios on child under nutrition. *Environmental Health Perspectives*, 119, 1817–1823.
- Lobell DB, Banziger M, Magorokosho C, Vivek B (2011) Nonlinear heat effects on African maize as evidenced by historical yield trials. *Nature Climate Change* 1, 42–45.

- Lolwa, D. (2011). Strengthening the Capacity of Women in Agricultural Production: The Need for Financial Literacy Training. *A Working Paper for the Food and Agricultural Organization*.
- Mandago, P., Kenduiywo, R., (2011). Economic Shocks attributed to Climate Change, The Need for a Proactive Approach in the Mitigation Strategies. *A Working Paper for the Tegemeo Institute*.
- Martin V, Chevalier V, Ceccato P et al. (2008) The impact of climate change on the epidemiology and control of Rift valley fever. *Revue Scientific Technique, Office International des Epizooties*, 27, 413–426.
- Mbogori, R. M. (2013). Climate Change and its Effects on Household Food Security. *A Working Paper for the Kenya Institute of Public Policy and Research Analysis*.
- MoA, (2013). Synergy and Purpose Driven Partnership with the Private Sector Players in Growing Agricultural Production. *An Internal Paper for the Ministry of Agriculture*
- Mohammed AR, Tarpley L (2009) High nighttime temperatures affect rice productivity through altered pollen germination and spikelet fertility. *Agricultural and Forest Meteorology*, 149, 999–1008.
- Mugalavai, E. M. (2013). Effects of Drought on Climate Change in Kenya. *International Journal on Climate Change: Impacts and Responses: Vol 2: Issue 2*. Pg 61-72.
- Mugweru, A. (2010). Risk Mitigation Mechanisms in the Event of Climate and Weather Variability. *A Working Paper for the Consultative Group on Agricultural Research*.
- Munich Re (2011) TOPICS GEO, Natural Catastrophes 2010, Analyses, Assessments, Positions. Munich Re, Munich, Germany.
- Muteru, A. R. & Jaoko, P. (2012). Climate Change Mitigation. The Need to Invest in Training and Capacity Building in the Kenya Research Forums. *A Working Paper for the Kenya Institute of Policy and Research Analysis*.
- NEMA (2012). A Report on the agro ecological zones in mount Kenya region. A working paper for the national environment management agency
- NRC (1981) Effect of Environment on Nutrient Requirements of Domestic Animals. Sub-committee on Environmental Stress, National Academy Press, Washington DC.
- Orodho, J. (2009) *Research Methods*. Institute of open learning Kenyatta University, Nairobi, Kenya.
- Porter JR, Semenov MA (2005) Crop responses to climatic variation. *Philosophical Transactions of the Royal Society B*, 360, 2021–2035.
- Prapti, N., Elno, B. (2013). Impact of Climate Change on Food and Nutrition in Kenya. *International Journal on Social Services and Humanities*.
- Raleigh C, Jordan L (2010) Climate change and migration: emerging patterns in the developing world. In: Chapter 4 in “Social Dimensions of Climate Change:

Equity and Vulnerability in a Warming World” World Bank, Washington DC, USA.

- Ramirez-Villegas, J., Challinor, A.J., Thornton, P.K., & Jarvis, A. (2013). *Implications of Regional Improvement in Global Climate Models for Agricultural Impact Research*. *Environ Res Lett*
- Rao KPC, Ndegwa WG, Kizito K, Oyoo A (2011) Climate variability and change: Farmer perceptions and understanding of intra-seasonal variability in rainfall and associated risk in semi-arid Kenya. *Experimental Agriculture*, 47, 267–291.
- Rarieya M and Fortun K (2009) Food security and seasonal climate information, Kenyan challenges, *Sustain Sci*, 5, pp 99-114
- Reema, A. (2010). *We are poor but so many. The story of self-employed women in India*. New York, Oxford University Press.
- Republic of Kenya (2003). *Annual Progress Report: Investment Programme for Economic Strategy for Wealth and Employment Creation 2003-2009*.
- Rowhani P, Lobell DB, Linderman M, Ramankutty N (2011) Climate variability and crop production in Tanzania. *Agricultural and Forest Meteorology*, 151, 449–460.
- Sewa, R. (2010). *Linkages Between Financial Services Inclusion and Economic Growth Capacity: An Asian Perspective* Economic and Political Weekly
- Speranza CI, Kiteme B, Ambenje P, Wiesmann U, Makali S (2010) Indigenous knowledge related to climate variability and change: insights from droughts in semi-arid areas of former Makueni District, Kenya. *Climatic Change*, 100, 295–315.
- Thornton, P. K. & Herrero, M (2009). The inter-linkages between rapid growth in livestock production, climate change, and the impacts on water resources, land use, and deforestation. *World Bank Policy Research Working Paper, WPS 5178*. World Bank, Washington, DC, USA.
- Thornton, P. K., Jones P. G., Ericksen, P. J. & Challinor, A. J. (2011). Agriculture and food systems in sub-Saharan Africa in a four-plus degree world. *Philosophical Transactions of the Royal Society Series A*, 369, 117–136.
- Thornton PK, Lipper L, Baas S et al. (2013) How does climate change alter agricultural strategies to support food security? Background paper for the conference “Food Security Futures: *Research Priorities for the 21st Century*”, 11-12 April 2013, Dublin.
- Tubiello F N, Soussana J-F and Howden S M (2007), Crop and pasture response to climate change, *Proc Natl Acad Sci U S A.*, 104(50), pp 19686–19690
- Were, A. (2011). Kenya’s Performance Experience and Institutionalization of Access to Food as a Basic right. *A Working Paper for the UNICET*. New York.
- Wheeler T R, Craufurd P Q, Ellis R H, Porter J R and Prasad P V V (2010). Temperature variability and the yield of annual crops, *Agriculture, Ecosystems & Environment*, Vol 82, Issues 1-3, pp 159-167

- WHO (2012) Carbon prints reduction as a measure to stem climate change effects . *A report for the world health organization*
- WHO, (2008). WHO Guidelines for Safe use of Water and Grey Water. Vol. 11. Wastewater in Agriculture.
- WHO, (2010). Inherent Risks from the Use of Contaminated Water for Irrigation Purposes. *A working paper for WHO*
- Yiamma, A. Afukor,. M.A (2011). Gender Perspectives on the Conventions on Biodiversity, Climate Change and Desertification. *A Working Paper for the Food and Agriculture Organization.*

APPENDIX I: Questionnaire for Women Group Members

The study seeks to find out the effects on household food security and the coping strategies by women groups in Gikindu Division, Murang'a East sub-county, Kenya. Kindly give correct answers to the best of your ability. Your identity will be treated with utmost confidence.

1. How old are you?

20-25 years

26-35 years

36-45 years

46-55 years

56-65 years

Any other _____

2. Kindly indicate your highest level of education

Primary

Secondary

Tertiary

Graduate

Any other _____

3. Indicate your marital status

Married

Divorced

Single

4. How long have you been a member of your women group?

Less than 1 year

1-5 yrs

6-10 yrs

11-15 yrs

16-20 yrs

Any other _____

5. How long have you been a leader in your group?

Less than 1 year

1-5 yrs

6-10 yrs

Any other _____

6. How long has your group been in existence? Kindly indicate

7. Are you aware of climate change?

To a high degree

To a fair degree

To a low degree

8. How did you get the information about climate change? Kindly indicate

9. Have there been initiatives to sensitise the members of your group about climate change?

Often

Rarely

Not at all

10. Who has carried out the initiative of disseminating climate change information?

Kindly indicate _____

11. Would you consider the information as worthwhile?

To a high degree

To a fair degree

To a low degree

Rainfall and Temperature Variability

12. Have you noticed a difference in the rainfall and temperature levels in comparison to the previous years?

Very much

Fairly

Not at all

13. Kindly indicate if you have noticed incidences of increased or reduced rainfall and temperature levels and has it affected your agricultural production activities?

14. Has the variation in rainfall and temperature levels affected your agricultural production capacity?

To a great extent

To a fair extent

Not at all

15. In what particular ways has the variation in temperature and rainfall levels affected your agricultural production activities? Kindly indicate

16. Kindly indicate your level of agreement with the following attributes as regards to the effects of temperature and rainfall variability on household food security

SA – Strongly Agree

A – Agree

U – Undecided

DA – Disagree

SDA – Strongly Disagree

	SA	A	U	DA	SDA
Variation in rainfall amounts has led to increased rainfall levels leading to hailstones which affect the agricultural production negatively	5	4	3	2	1
Depressed rainfall has always occasioned the members of own group crop losses	5	4	3	2	1
Increased temperatures lead to immature maturation of crops in my farm	5	4	3	2	1
High temperatures leads to wilting and drying of transplanted crops leading to great losses	5	4	3	2	1
High temperatures lead to wilting of harvested fresh produce occasioning farmers losses in the area	5	4	3	2	1

17. Has the variability of rainfall and temperature affected the food production levels of the members of your women group?

Yes

No

Impacts of rainfall and temperature variability on food security

18. What crops do you and the fellow group members grow in your farms? Kindly indicate

19. Are you dependent on rainfall to grow their produce?

Always

Sometimes

Not at all

20. In the event of rain fed agriculture, what happens to you when the rains fall?

Kindly explain

21. Have you had instances of incurring total crop failure in any planting season?

Often

Rarely

Not at all

22. Kindly indicate your level of agreement with the following attributes as regards to the effects of rainfall and temperature variability on food security

SA – Strongly Agree

A – Agree

U – Undecided

DA – Disagree

SDA – Strongly Disagree

	SA	A	U	DA	SDA
The rainfall failure has had occasion of causing me total crop failure and exposing my failing to food insecurity	5	4	3	2	1
Dependence on rain fed agriculture has caused members of our group to have low yields at the event of poor rains	5	4	3	2	1

High temperatures have occasioned the risk of falling flowers and the aborting reducing the yields	5	4	3	2	1
Heavy rains have led to leaching of soil nutrients leading to soil infertility and poor yields thus food insecurity	5	4	3	2	1
The variation in rainfall and temperature has not affected may agricultural production in any way and food security is assured in my household	5	4	3	2	1

23. Has the variation in rainfall and temperature levels affected the food security situation for your household and those of other group members?

Yes

No

24. Has the membership of your group ever been exposed to the pain of relief food provision?

Often

Rarely

Not at all

25. Would you consider your households as food secure?

To a high degree

To a fair degree

To a low degree

26. What are the reasons for your answer as regards your food security situation? Kindly explain_____

27. What strategies have your employed to ensure that the households of the members of your women group are food secure? Kindly explain

28. a) Have you had assistance from any organization in the strategies that you have employed to ensure that your households are food secure?

Yes

No

b) If yes, kindly indicate which organization?

Role of Women Groups

29. What were the initial objectives of your group formation? Kindly indicate

30. What drew the members of your group into agricultural activities? Kindly indicate

31. Has the participation of your group in agricultural production activities affected the economic mainstays of your households?

To a high degree

To a fair degree

To a low degree

32. Kindly indicate your level of agreement with the following attributes as regards to the effects of rainfall and temperature variability on food security

SA – Strongly Agree

A – Agree

U – Undecided

DA – Disagree

SDA – Strongly Disagree

	SA	A	U	DA	SDA
Membership into the women group has enabled technology transfer on agricultural best practices which has assured my household of food security	5	4	3	2	1
Membership into the women group has positively impacted in my knowledge of climate change awareness and drought tolerant crop cultivars thus affecting the food security of my household positively	5	4	3	2	1

Membership in the women group has facilitated the engagement in afforestation activities in our area combating desertification and checking climate change	5	4	3	2	1
Membership in the women group has facilitated greater agricultural production activities by the members	5	4	3	2	1
Membership in the women groups has facilitated increased assertiveness in the group members leading to greater participation in agribusiness activities	5	4	3	2	1

33. Has the membership in the women groups facilitated increased food security in the households?

Yes

No

34. How can the challenge of food insecurity attributed to climate change be mitigated in a better manner? Kindly explain

Thank you for your cooperation

APPENDIX II: Focus Groups Discussion Questions for Group Leaders

1. How long has your group been in existence?
2. What influenced you to agricultural production activities?
3. Are you aware of climate change?
4. Have you noticed variations in the rainfall and temperature levels in the area?
5. Has the variation of rainfall and temperature levels affected your household food security situation?
6. What coping strategies has the group employed for mitigating to food security risk situation?
7. Have you derived benefit from your membership in the women group?
8. Would you consider your household as more food secure owing from the membership into the group?
9. What other benefits have you derived from the membership in the women group?
10. How can the climate change effects on household food security be mitigated in a better manner?

APPENDIXIII: Interview Schedule for Divisional Agricultural Officer

1. How long have you served as the divisional agricultural officer?
2. Do you interact with the farmers in your division at a personal level on a regular basis?
3. Do you have a constant interaction with the members of the women groups undertaking agricultural production activities?
4. Has your office disseminated climate change information to the groups?
5. What form does your office use in the climate change information dissemination approach?
6. How has the rainfall and temperature variability affected the household food security situation?
7. Has the membership of the local community and in particular the women groups developed any coping mechanisms?
8. Would you consider the membership to the women groups as having impacted on the members agricultural production activities?
9. Has the membership into the women groups impacted on the household food security situation?
10. How can the local community and in particular the women groups be assisted to effectively taken charge of their households food security situations in a better manner?

APPENDIX IV: Observation Checklist

1. Observe the level of climate change awareness and assertiveness of women group members during the focus group discussions
2. Carry out physical visits to the willing group members.
3. Look at the type of crops that they are farming.
4. Check at the level of adaptation of drought tolerant crops.
5. Look at their capacity to harvest rainwater from the roof, water pans and other mediums.
6. Observe their soil conservation practices like the putting of terraces, gabions and the ploughing methods.
7. Look at the level of afforestation activities undertaken in the farms.
8. Check for any tree nurseries in the households.
9. Find out the energy in use at the households and their levels of adoption of sustainable energy use.

APPENDIX V: Murang'a Temperature Data From 1995 To 2014

YR	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	MEAN
1995	12.7	13.1	15.1	16	15.6	13.4	12.6	12.7	13.6	14.9	15.1	14.3	14.09167
1996	12.8	14	15.1	15.8	15.6	14.9	13.2	11.8	12.8	13.9	15.2	13.3	14.03333
1997	12.9	11.1	15	15.6	15.2	13.9	12.9	12.9	12.8	14.5	23.3	23.4	15.29167
1998	16.5	15.2	15.4	16.6	15.8	13.8	12.7	13.4	13.8	14.1	14.6	14.4	14.69167
1999	12	11.3	12.7	16.0	15.1	13.5	12.1	12.6	12.1	26.9	13.7	12.4	14.20333
2000	11.7	9.8	14.2	15.4	14.1	13.5	12.3	12.6	13	28	13.5	13.7	14.31667
2001	14.7	14.8	14.5	16	15.2	13.4	12.7	11.9	13.5	27	14.3	14	15.16667
2002	13.8	13.2	15.2	16.3	15.4	13.5	12.2	13.6	13.3	26.1	14.1	13.8	15.04167
2003	13	12.6	14.3	16.1	16.2	14.2	12.6	12.5	13.8		14.8	14.7	14.07273
2004	14.3	14.6	15	16.3	14.8	12.8	11.2	12.6	13.8	26.2	14.4	13.2	14.93333
2005	13.6	13.3	15.7		16		12.8		13.5	27.1	14.5	14.4	15.65556
2007	15	14	14.8	16.1	16	14.1	13.5	13.9	13.4	26.8	14.2	13.5	15.44167
2008	13.6	13.3	15.8	15.8	15	13.5	13.3	13	14	18	14.7	14.6	14.53125
2009	12.9	13.9	14.7	16.5	15.8	14	11.5	12.9	14.1	26.9	14.5	13.6	15.10833
2010	14.2	16.4	15.5	17	16.1	14.3	12.7	12.8	12.9	15.3	15.6	13.9	14.7250
2011	12.3	12	14.7	16.7	16	14.3	11.7	13.5	14.2	15.7		14.9	14.18182
2012	10.8	11.9	13.4	16.2	15.4	14	13.3	12.4	13	15.4	15.2	14.8	13.8166
2013	14.2	13.4	15.3	15.9	14.7	13.4	11.9	12.8	13.0	14.2	15.3	14.4	14.03874
2014	14.4	14.6	15.8	15.3	15.0	14.3	12.9	13.0	13.2	15.7	15.9	14.2	14.52341

APPENDIX VI: Murang'a Precipitation Trends From 1983 To 2014

YR	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	MEAN
1983	1	127.3	124.3	243.5	15	30.3	0	10.1	0.4	167.5	84.4	170.2	81.16667
1984	5.3	1.2	23.5	67.4	0.9	0.9	29.5	2.7	7.6	157.9	125.6	81.6	47.70833
1985	4.5	97.7	145.6	399.6	58.5	11.9	2	0	5.2	5804	105.7	21.5	75.88333
1986	15.9	0	123	346.1	125.2	12.1	1.2	1.1	1.5	45.1	227.3	72.4	80.90833
1987	5.7	3.6	6.3	159.9	103.3	137.5	18.6	33.9	0	2.8	119.8	18.6	50.833333
1988	48.6	19.1	173.9	271.3	118.9	48.4	13.1	8.6	35.2	62.6	136.4	189.8	93.825
1989	165.6	34.1	116.8	314.9	78.9	7.4	30.3	23	49.6	109.4	150.2	128.6	100.7333
1990	68	79	318.5	268.9	97.3	3.6	3.3	4.1	61.4	72.2	178.2	172.4	110.575
1991	67.7	6.2	98	195.2	141	17.8	2.7	7.4	0.3	40.8	157.5	61.2	66.31667
1992	4.6	0.5	13.6	324.2	78.3	7.4	31.8	1.7	5.3	32.9	173.1	110.2	65.3
1993	162.8	129.7	11.6	78.3	86.5		4	1.6	3.8	40.7	193.2	87.7	72.71818
1994	0	28	54.7	187.3	56.8	9.7	5.6	20.3	6.2	167.9	319.3	56.2	75.91667
1995	11.4	49.2	129.9	153.7	40	10.7	6.2	31	3.6	171.2	137.3	162.5	75.55833
1996	20.8	76.4	161.4	52.4	49.6	36.3	28.7	1.5	0.2	0	375.2	63.1	72.10833
1997	0	0	59.3	487.2	91.8	9.8	1.8	63.6	0.9	238.8	416.6	229	133.2333
1998	297.7	236.1	180.9	176.4	356.5	131.9	61.7	8	2.7	10.5	92	13	130.6167
1999	9.7	2.6	0	264.3	10.3	2.3	21.8	11.1	2.6	29.1	318.8	221.6	74.51667
2000	3.5	0	18.8	7.4	29.4	5	5.9	2.2	7.9	11.5	136.1	62.1	29.775
2001	358.4	32.7	170.2	106	66.5	4.6	0.8	16.1	1.7	48.7	233.1	20.7	88.3
2002	16.3	22.1	227.5	313.4	250.5	3.7	2.2	5.5	80.2	83.1	137.7	243.1	115.4457
2003	14.2	3	93.5	215.9	254.3	1	3.6	17.3	0	83.3	180.9	44.2	75.93333
2004	40.6	74.7	47.9	376.2	120.9	1.2	0	0	20.9	78.2	129.3	98.7	82.38333
2005	21.4	1	52.3	245.1	259.2	10.9	7.5	1.9	5.5	38.1	144.8	2.1	65.81667
2006	17.5	28.7	100.7	196.7	185.4	9.4		21.7	22.7	33.6	374.1	226.7	110.5727
2007	30.8	102.4	24.1	239.3	85	3.3	147.7	13.7	20.2	55.9	55.9	25.6	55.95
2008	104.8	27.1	100.4	271	7.4	6.4	28.3						77.91429
2009	49.3	19	51.5	173.7	91.4	10.1	1.1	1.7	0	134.5	119.2	94.2	62.11667
2010	138.2	113.5	209	176.8	133.5	24.9	4.8	6.3	1.3				89.74444
2011	10.8	47.9	0	109.6	72.2	50.3	1	10.7	39.4	135.2	177.2	63.2	59.70833
2012	0	20.9	0	248.5	182.6	38.1	7.5	41.4	19.9	50.8	177.1	168.4	79.4
2013	73.3	0	214.1	429.4	20.6	9.1	1.6	6.6	9.9	0.7	112.3	109.7	82.28333
2014	0.0	96.3	127.4	97.2	40.3	36.2	3.1	34.9	29.0	22.3	197.3	98.3	65.24167