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SUSTAINABLE WATER MANAGEMENT AND FOOD SECURITY IN KENYA: A CASE STUDY OF NYAKACH DIVISION IN KISUMU COUNTY

BY

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15TH SEPTEMBER 2015

DECLARATION

This Research Project is my original work and has not been presented for the award of a degree in any other University.

Sign Date

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This research project has been submitted for examination with my approval as the University Supervisor**.**

Sign Date

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DR. SHAZIA CHAUDHRY

DEDICATION

I dedicate this project to my family, most particularly to my husband Joseph Onyango, my son Rickjones Otieno and my daughter Rhinny Akinyi for the support they have given me throughout my education.

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ABBREVIATIONS

ARDP: Agriculture and Rural Development Policy

ASDS: Agricultural Sector Development Strategy

AWM: Agricultural Water Management

CAADP: Comprehensive Africa Agriculture Development Programme

CBA: Cost-Benefit Analysis

HRD: Human Resource Development

KFSNS: Kenya Food Security and Nutrition Strategy

MDGs: Millennium Development Goals

NAAIAP: National Accelerated Agricultural Input Access Program

NASEP: National Agricultural Sector Extension Policy 2012

NEPAD: New Partnership for Africa Development

NFSNP: National Food Security and Nutrition Policy

NGOs: Non-Governmental Organizations

NMK: Njaa Marufuku Kenya

SNNP: Southern Nation and Nationalities People

UN: United Nation

ABSTRACT

There is a great percentage of people who live in areas where there is water scarcity. About 2.8 billion people (more than 40%) of the world live in river basins faced with the problem. In addition, 1.6 billion people live in areas of economic water scarcity, where even though water is available, human, institutional and financial capital limit access to water. The purpose of this study was to explore the relationship between sustainable water management and food security in Kenya and especially in the case of Nyakach Division, Kisumu County. It was guided by the following objective: To assess the factors influencing unsustainable water management and food insecurity in Nyakach Division in Kisumu County, To evaluate likely effects of poor water management and issues in food security in Kenya and To examine community-led initiatives in managing water resources Nyakach Division in Kisumu County. The study aimed to test the following hypothesis: Water management donôt have significant positive influence on food security in Nyakach Division in Kisumu County and Community-led initiatives in managing water resources have ~~a~~ significant positive influence on sustainable water management and food security in Nyakach Division in Kisumu County. The study was anchored on liberal theory and was necessary for making decisions on sustainable water management and food security projects. This theory has developed a forceful case for autonomous, elected local authorities. First local government is grounded in the belief that there is value in the spread of power and the involvement of many decision-makers in many different localities. The second argument rests on the view that there is strength in the diversity of response. The study adopted a cross sectional survey. The study used both secondary and primary data. Secondary data was obtained from Library research which will be conducted by reviewing works related to the area of study. Descriptive statistics was used to analyse the data. The study findings was used to compile the report. The study established that Nyakach is part of Nyando basin which is prone to displacement of population due to floods and other natural calamities like landslides. The area has unstable soil formation and little water sources. It also has low accessibility to water coverage and lack of adequate sanitation and water resource management. Diarrhoea is a major cause of morbidity and mortality in this area contributing to deaths of children under 5 years of age which stands at 212/1000 births. The study also established that majority of respondents interviewed had experienced food insecurity. The study concludes that access to safe water is a fundamental human right just like food, but it should be recognized that a right to water does not mean free water. Water scarcity has a huge impact on food production. Without water people do not have a means of watering their crops and, therefore, to provide food for the fast growing population. Agriculture, is constantly competing with domestic, industrial and environmental uses for a scarce water supply. The Government should purpose to supply all homes in Nyakach and other affected areas with basic water requirement for preserving human survival and well-being.

CHAPTER ONE

INTRODUCTION TO THE STUDY

1.1 Introduction

Great challenges are signalled by the major poverty related indicators of Africa which are ahead for the realization of sustainable economic and social development.[1] As part of the poverty reduction agenda the many countries including those in East Africa have designed a food security strategy which addresses both the supply and the demand side of the water supply and food equation, that is, availability and entitlement respectively from both a national and household level perspective. Poverty reduction and its ultimate suppression in all its dimensions have been and still are the overriding development agenda.

The future of the worldôs water resources management and food security is a growing global concern. There are concerns that increasing human pressure over the complex and predetermined water resource has led to water and food scarcity.[2] In the coming years, the problem of water and food scarcity is expected to increase significantly, unless a sustainable awareness of resources management emerges. Water and food are not only a basic need, but are also centre-piece of sustainable development and a crucial part of poverty alleviation globally.

Sustainable water management and food security strategy has three main pillars which ensures; availability of food through increased domestic production, access to food for

[1] United Nations (2010). United Nations Water Conference- Resolutions in Report of the United Nations water conference, Mar del Plata, 14 March 1977. United Nations Publications.

[2] Aquastatï FAO(2012a)Total water withdrawal by sector. http://www.fao.org/nr/water/aquastat/dbase/AquastatWorldDataEng_20101129.pdf

food deficit households and emergency response capabilities.[3] Poor nutrition and lack of sustainable water has a significant contribution to the burden of disease experienced by indigenous Kenyans.[4] Sustainable water management and food security program is designed to address problems of shortfalls in sustainable water and food production, vulnerability to falls in consumption and incomes and consequent hunger that the country has faced repeatedly, through adaptation of development alternatives to bring about lasting solution. A number of factors have been noted to affect the supply and access of nutritious food and sustainable water for both urban and rural communities and increase vulnerability towards sustainable water management and food insecurity.[5]

1.2 Statement of the Problem

There is a great percentage of people who live in areas where there is water scarcity. About 2.8 billion people (more than 40%) of the world live in river basins faced with the problem. In addition, 1.6 billion people live in areas of economic water scarcity, where even though water is available, human, institutional and financial capital limit access to water.[6] This has led to consequent biodiversity loss and an exceptional transformation of freshwater ecosystems leading to food scarcity.

United Nations describes Kenya as a water scarce country where by the water demand exceeds renewable fresh water sources and currently ranks 21st for the worst levels of

[3] Madulu, N. (2012). Main socio-economic study for Kihansi River Catchment Management Plan. Research Report No. IRA/CST98.1, Dar es Salaam.
[4] Katui, K. M. (2012). *Drawers of water II 2002: Kenya country Report.* London, UK.

[5] World Health Organization (WHO) (2011).*Trade, Foreign policy, Diplomacy and Health - Food Security*

[6] World Bank (2012) 2012 World Development Report: Gender Equity and Development. The World Bank, Washington, DC.

access to potable water in the world.[7] Reduced availability of water resources especially the permanent rivers in the area has been caused by land use change and climate change which is brought about by drought. The access to water has remained a challenge in Nyakach Division in Kisumu County because it is a semi-arid area of Kenya. The County has experienced drought over the last 50 years which have had a negative impact on the standards of living of the communities.[8] Its population has increased rapidly over the years with an estimated growth of 4.5%.[9] The growth has led to the government to struggle to keep up with the dwellers pressure on water resources for agriculture, land and energy uses. The questions that arise therefore are what measures can be taken to ensure sustainable water management and food security in Nyakach Sub County in Kisumu County? What are the factors influencing unsustainable water management and food insecurity in Nyakach Division in Kisumu County? What are the likely effects of poor water management and issues in food security in Kenya? What are some of the community-led initiatives in managing water resources Nyakach Division in Kisumu County?

1.3 Objectives to the Study

The general objective of the study was to explore the relationship between sustainable water management and food security in Kenya and especially in the case of Nyakach Division, Kisumu County.

The Specific objectives were as follows:

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[7] Shah, T. and Lele, U. (Eds.) (2011) Synthesis of Workshop Discussions. Climate Change, Food and Water Security in Africa: Critical Issues and Cooperative Strategies in an Age of Increased Risk and Uncertainty. GWP, Stockholm and IWMI, Colombo.

[8] Government of Kenya, GoK, (2013). *District Development Plan, Kisumu (Kisumu County), 2008-2017*. Ministry of Finance and Planning, Government of Kenya, Nairobi, Government Printer, Kenya, 87 pp.

[9] Government of Kenya (GoK, 2010b): Interim Report on Irrigation and Drainage Master Plan, 2009. Ministry of Water and Irrigation, Government of Kenya (GoK), Nairobi.

i. To assess the factors influencing unsustainable water management and food insecurity in Nyakach Division in Kisumu County

ii. To evaluate likely effects of poor water management and issues in food security in Kenya.

iii. To examine community-led initiatives in managing water resources Nyakach Division in Kisumu County

1.4 Literature Review

In this section, literature review was presented and contains other global scholarly work done on the same study area which the study was built on as try to fill the gaps that will be identified.

1.4.1 Sustainable Water Management

Sustainable water management and food is a major concern which can be used to guide and organize the use of land and other water resources to ensure the sustainability of water, soil and the flux of water goods and services. The management of water organizes and guides the use of land, water, and other natural resources to provide the goods and services demanded by society, while ensuring the sustainability of the soil and water resources. The task is never easy even when there is only one resource to consider, but it is definitely simpler than having to deal with a water where resources and users are plentiful and dissimilar.[10] The joint efforts of technically educated planners and managers, decision makers, locally led advocacy groups, and other concerned stakeholders lead to the adoption of a water management

[10] Kay, M. (2011). *Smallholder Irrigation Technology: Prospects for sub-Saharan Africa.* International Programmeme for Technology and Research in Irrigation and Drainage, Knowledge Synthesis Report No. 3. IPTRID Secretariat, Food and Agriculture Organisation of the United Nations, Rome.

approach to land stewardship.[11] A water management approach to land stewardship incorporates soil and water conservation and land-use planning into a universal and rational framework. This is necessary because people are affected by the interface between water and other resources. People impact the nature and sternness of these connections when they use resources.

Projects of water management aim to arrive at ówin-winô solutions in which for example the preservation of water through creation of bunds leads both to increased rain fed crop yields and greater recharge of groundwater. The key essential hypothesis is that good land management will lead to increased availability of water resources for productive and domestic use.[12] Human population is enhanced by water contributes that are extremely to development and social well-being as both social and economic activities rely heavily on the quantity and quality of water. Water is a precious resource that needs to be protected and properly managed so that an adequate supply and acceptable quality of water can satisfy the increasing need for economic production.[13]

As indicated by Facon and Mukherji, over 70 evolving countries are being demoted from the world economy.[14] Cleaver pointed out that agriculture is now and will continue to be a key source of livelihood for low-income countries and the poor who

[11] Mengistu, A. (2007). *Socio economic assessment of the small scale irrigation schemes in Adami Tulu JidoKombolchaWoreda, Central rift valley of Ethiopia: A Msc thesis in Enviromental Economics and Natural resource groups.* Addis Ababa: Department of Enviromental Sciences, AAU.
[12] Moriarty, P. & Butterworth, J. (2003). *The productive uses of domestic water supplies: how water supplies can play a wider role in livelihood improvement and poverty reduction*. IRC, Thematic Overview Paper.
[13] MoFED. (2010). *The Federal Democratic Republic of Ethiopia: Growth and Transformation Plan (GTP) 2010-2014.* Addis Ababa: MoFED.
[14] Facon, T. & Mukherji, A. (2011). Improving the performance of public irrigation in South Asia. Paper presented at the GWP/IWMI Workshop on Climate Change, Food and Water Security in South Asia, Colombo 23ï 25 February 2011.

live there.[15] Water has been predicted to be the oil of the twenty-first century, meaning that successful water management will be the key to future economic growth and social wealth in both developed and developing countries.[16] Other countries requires significantly different considerations of water resource management. Limited and unreliable access to water is a determining factor in food productivity in many regions, a problem rooted in rainfall variability that is likely to increase with climate change.

Upgraded rural water governance is a powerful tool to diversify livelihoods and reduce vulnerability, especially for small crop producers, who are the communal farmers. Thus designers, planners, and managers can support rural livelihoods when dealing with water governance by appreciating the many institutional roles of water in rural livelihoods and giving rural users scope to convey and protect their livelihoods.[17] It is also dynamic to comprehend that when people have water dependent livelihood strategies, they create relationships for teamwork and control in order to attain and manage water systems.[18] How livelihoods survive under water scarcity is related to how people understand water scarcity, organize social action to remedy it, and act to defend their rights.

Samad emphasizes that the prospective of irrigation in developing countries in Europe is estimated at 37 million ha, with only 7.8 million ha currently receiving irrigation

[15] Cleaver, F. (2008). Incentives and informal institutions: Gender and the management of water, Agriculture and Human Values, 15:347-360.

[16] Organisation for Economic Co-operation and Development/Food and Agriculture Organization of the United Nations (OECD/FAO) (2012), OECDï FAO Agricultural Outlook 2012ï 2021, OECD Publishing, Paris: and FAO, Rome.

[17] Kolavalli, M. (2010). *Typology of irrigation systems in Ghana.*Colombo, Sri Lanka: International Water Management Institute. 35. (IWMI Working Paper 142).

[18] Muluken, L. (2005). Water Resources Development of Amhara Region and the Challenges.*A paper presented at Workshops on achievements and priorities in irrigation water mangement research and technology in Ethiopia with particular reference in Amhara Region,* (p. 18). Bahirdar.

water, representing 21% of the potential.[19] Of the total arable land, about one-third is irrigated by traditional systems. Overall irrigation efficiency in Iran ranges from 33-37%, lower than the average for both developing countries (45%) and developed countries (60%).[20]

Mahajan and Navin revealed that agriculture claims the largest share of the work force from a wider development standpoint. [21] As stated by Hertel, combinations of irrigation, drainage and flood control, water conservation and storage, on-farm water management and more recently, institutional support to improve sustainability, user operation and management and cost recovery, collectively, are called agricultural water management (AWM). The agricultural sector is important to a large percentage of the poor people who depend on it for their livings. Agriculture is still the key to development in many developing countries despite its small contribution to GDP.

By the year 2020, Iran's population will reach 90 million.[22] 160 million tons of agricultural production from irrigated land will be required for such an increase. This means that more than 90% of the renewable water in the country is used for agriculture, but the sector still cannot produce enough to meet the demands of the population. Agricultural production will have to increase to 160 million tons in order to supply adequate food in 2020. The productivity of water will have to increase to

[19] Samad, M. (2011). Irrigation management reforms: the Asian experience. Paper presented at the GWP/IWMI Workshop on Climate Change, Food and Water Security in South Asia, Colombo 23ï 25 February 2011.
[20] Mukherji, A. (2011). Paradox of poverty amid plenty of groundwater. Paper prepared for the GWP/IWMI Workshop on Climate Change, Food and Water Security in South Asia, Colombo 23ï 25 February 2011.
[21] Mahajan, V. & Navin, T. (2012). Microfinance in India: Growth, Crisis and the Future. BASIX, Hyderabad.
[22] Wang, J., Xu, Z., Huang, J. and Rozelle, S. (2006) Incentives to managers or participation of farmers in China's irrigation systems: which matters most for water savings, farmer income, and poverty?, Agricultural Economics 34: 315ï 330.

1.6 kgm-3.[23] Ayalew reported that the amount of used water for irrigated agriculture is 83 bm^3 and water productivity is 0.7 kgm-3.[24] Therefore, it is vital to focus on using water resourcefully through improved irrigation and water management.

1.4.2 Community-Led Initiatives in Managing Water Resources

Mengistu alleged that the most imperative goals of extension system for supporting sustainable water resource management in agriculture are: increasing social equality, increasing knowledge of farmer, development of farmer skills and need assessment based on the participatory approaches.[25] Kay pointed out that agricultural extension is a public service for Human Resource Development (HRD) in the agricultural sector.[26] Although extension is not the magic word that will change agriculture overnight. Nonetheless, extension will impact human capital development through agricultural literacy, thus enhancing economic growth.

A strategy for an effective stakeholder participation in water resources management is enhanced so that to better and deeply involve the water user at the most local level and a system that contributes to poverty reduction through improved and sustainable water resources management and proper land use. In case it goes through, it would involve empowering the local communities and their leaders in natural resources management, and consultation with them on their needs and the appropriate mechanisms they have to address those needs in water and food issues. One of the

[23] Demese, C., Getinet, G., Goshu, M. & Yaddesa, D. (2009). *Comprehensive Africa Agriculture Development Programme Ethiopia Study.*Addis Ababa: MoARD.
[24] Ayalew, Y. (2011). *Identification of Food Insecurity and Coping Strategies of Rural Households in North.*
[25] Mengistu, A. (2007). *Socio economic assessment of the small scale irrigation schemes in Adami Tulu JidoKombolchaWoreda, Central rift valley of Ethiopia: A Msc thesis in Enviromental Economics and Natural resource groups.* Addis Ababa: Department of Enviromental Sciences, AAU.
[26] Kay, M. (2011). *Smallholder Irrigation Technology: Prospects for sub-Saharan Africa.* International Programmeme for Technology and Research in Irrigation and Drainage, Knowledge Synthesis Report No. 3. IPTRID Secretariat, Food and Agriculture Organisation of the United Nations, Rome.

strategies proposed by Tsegaye and Tamene, is to put into consideration of customary law and models of water governance as a way of improving water resources in order to lessen the impact of future water scarcity. [27]

Inefficient resource management by actors within this sector, rather than by limited natural resources has led to the suffering of food production worldwide. Thus, it is important to give more considerations to human resources in the agricultural sector.[28] It is necessary to increase farmerôs competence in order to improve the efficiency and productivity of farming, since farmers and water users are the primary active human resources in the agricultural sector.

Woledeab asserted that, water management must take a holistic approach, linking social and economic development with the protection of natural ecosystems if there is need to be effective.[29] Tadel and Debel showed that to achieve water security, water must be everybody's business, but on the other hand the government monopoly in water management should not be replaced by a private monopoly.[30] Muluken showed that agriculture in most locations generates the lowest value added per unit of used water compared to other water-using sectors. Within the agricultural sector, however, there are numerous ways to improve the return on investments in water. Higher return on water investments will boost incomes for farmer.[31] Rukuni revealed that for

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[27] Tsegaye, Y. and Tamene, L. (2005). Small holder Irrigation and its Challenges in Ethiopia's Food Security Agenda: lesson from Ghana. *Center for Development Research*, Bonn, Germany.

[28] Hussain, I. (2005). *Pro-poor Intervention Strategies in Irrigated Agriculture in Asia. Poverty in Irrigated Agriculture: Issues, Lessons, Options and Guidelines (Bangladesh, China, India, Indonesia, Pakistan and Vietnam).* Project Final Synthesis Report. IWMI, Colombo.

[29] Woledeab, T. (2003).Irrigation Practices, State Intervention and Farmers' Life Worlds in Drought Prone area, Tigray, Ethiopia.*A paper extracted from Doctoral thesis.* Addis Ababa, Ethiopia.

[30] Tadel, F. & Debel, G. (2006). *An econometric analysis of the link between irrigation markets and poverty in Ethiopia: The case of smallholders vegetable and fruit production in the North Omo Zone.*

[31] Muluken, L. (2005). Water Resources Development of Amhara Region and the Challenges.*A paper presented at Workshops on achievements and priorities in irrigation water mangement research and technology in Ethiopia with particular reference in Amhara Region*, (p. 18). Bahirdar

improving irrigation management, efforts are focused on the empowerment of water users associations and their involvement in resource management.[32]

Kessler re-counted that yields of most crops can be increased by irrigation. Less risky and more continuous levels of rural employment and income can be attributed by irrigation.[33] Vishnudas also stated that, irrigated as compared to rain-fed agriculture is conducive to higher cropping intensities that improve yields, allowing the cultivation of higher-value crops and the use of sophisticated cultivation techniques.[34] Successful water management will be the key to future economic growth and social wealth in both developed and developing countries.

As stated by Svendsen, the water resource management crisis is the result of poor management rather than the modern technologies.[35] Technology-oriented management should be balanced with human-oriented management. Moriarty and Butterworth pointed out that equitable resource allocation, efficient and balanced resource use, participation of stakeholders in decision making and recognition of linkages and interactions among human and physical systems are key principles in integrated water resource management.[36] Population increases and improved living standards brought about by development will result in a sharp increase in food

[32] Rukuni, M. (2002).Addressing Growing Threats to Food Security.*The American Socitey for Nutritional Science.*

[33] Kessler, M. (2006). Decisive Key-factors Farm Households Soil and Water Conservation Investment. *Journal of Agriculture, Ecosystem and Environment* 65: 95-102.

[34] Vishnudas, S. (2006). Sustainable Watershed Management: Real or Illusion? A Case Study of Kerala State in India. PhD Thesis. Delft, Faculty of Watershed Management, Delft University of Technology, Netherlands, 165 pp.

[35] Svendsen, M. (2005). *Irrigation and River Basin Management: Options for governance and institutions.* Wallingford, UK: CABI Publishing.

[36] Moriarty, P. & Butterworth, J. (2003). *The productive uses of domestic water supplies: how water supplies can play a wider role in livelihood improvement and poverty reduction*. IRC, Thematic Overview Paper.

demand over the coming decades. Most of this increase will be met by the products of irrigated agriculture.

Vishnudas pointed out that, irrigated as compared to rain-fed agriculture is conducive to higher cropping intensities that improve yields, allowing the cultivation of higher-value crops and the use of sophisticated cultivation techniques.[37] Kessler reported that irrigation can increase the yields of most crops. Furthermore, irrigation leads to less risky and more continuous levels of rural employment and income.[38] Successful water management will be the key to future economic growth and social wealth in both developed and developing countries.

1.4.3 External Factors Influencing Sustainable Water Management

A damage of $26 billion is caused by soil erosion annually to productive soils of the African continent.[39] This is a great global concern as soil erosion leads to topsoil removal and to loss of both applied and native plant nutrients.[40] This has been the cause of reduced productivity in agriculture per unit area and high costs of production due to the rehabilitation of farmlands. According to Boye and Albrecht it leads to 5 million grams per hectare of productive topsoil being lost to lakes and oceans each year.[41] High and rapid population growth and imbalances in agricultural land

[37] Vishnudas, S. (2006). Sustainable Watershed Management: Real or Illusion? A Case Study of Kerala State in India. PhD Thesis. Delft, Faculty of Watershed Management, Delft University of Technology, Netherlands, 165 pp.
[38] Kessler, M. (2006). Decisive Key-factors Farm Households Soil and Water Conservation Investment. *Journal of Agriculture, Ecosystem and Environment* 65: 95-102.

[39] Doss, C. R. and Morris, M. L. (2001). ñHow does Gender affect Adoption of Agricultural Innovation? The Case of Improved Maize Technology in Ghanaò. *Journal of Agricultural Economics,* 25, pp 27-39.
[40] Mati, B. Morgan, R. P. C., Gichuki, F. N., Quinton, J. N., Brewer, R. T., and Liniger, H. P. (2000). Assessment of Erosion Hazard with the USLE and GIS: A Case Study of Upper Ewaso Ngiro North Basin of Kenya. *International Journal of Applied Earth Obvervation and Geoinformation,* 2 (2): 78-86.
[41] Boye, A. and Albrecht, A. (2003). Soil and Water Conservation by Crop Rotation with Leguminous Shrubs - A Case Study on Runoff and Soil Loss under Natural Rainfall in Western Kenya. World Agroforestry Centre (ICRAF), Nairobi, Kenya, 21 pp.

resources allocation is to blame, leading to mismanagement and over exploitation. Agricultural lands in the tropics and Sub-Saharan Africa face major land management problem which is threatening the economic productivity.

According to Haen and Blanken, customary practices play a critical role. They are still pertinent especially at the local level and blends well with the participatory or unified approaches required by new thinking in water resources management.[42] A great strength and foundation for improved water governance that has not been explored by the policy makers is presented. Water management programs has to follow a multisectoral approach for a better impact. This includes; a combination of bottom-up and top-down planning, monitoring and evaluation; clear procedures for environmental impact assessment of interventions including water and soil conservation, dams and reservoirs; networking among key stakeholders; consideration of both socio-economic and cultural aspects and natural processes; gender balance in decision making; embracing new approaches for sharing knowledge and learning; sustainable finance; competition mechanisms; capacity building at all levels; reforming governance; efficiency of water resource use; coping with hydrologic extremes and natural hazards; and the integrated management of water, vegetation, soils and sediments.[43]

In one instance vertical dimensions: encompassing both surface water and ground water quality at the water scale. In the other instance, the lateral dimension considering the varied land uses and land covers associated with agriculture,

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[42] Haen, H. and Blanken, J. (2011).*Commercialization of agriculture under population pressure; effects on production, consumption, and nutrition in Rwanda,* Research Report No. 85, Washington, D.C., International Food Policy Research Institute.

[43] Uphoff, N. (2009). Improving International Irrigation Mangement with Farmers Participation: Getting the process Right. In *Studies in Water Policy and Mangement.* West View Press

silviculture, mining, and hydrologic/habitat modification activities, as well as those associated with urbanization this includes land development, transportation, recreation. These land uses and activities give rise to varying degrees of nonpoint source pollution or polluted runoff, which is the major contributor to impaired waters.[44] Similarly, the Integrated Water Management Program proposes a framework for fostering interdisciplinary on-ground implementation activities. Interdisciplinary takes on a meaning of multiple dimensions and scales.[45]

Africa is faced by one of the several current and future critical issues which is water. About 25% of the contemporary African population experiences water stress, while 69% live under conditions of relative water abundance.[46] Supplies of water from rivers, lakes and rainfall are characterized by their unequal natural geographical distribution and accessibility, and unsustainable water use. Factors such as the degree to which water is potable and manageable, and the accessibility of sanitation is not justified by the relative abundance. The increased populations in Africa has led to the increased demand of water. Because of this, the continent is expected to experience water stress before 2025. By the year 2020s and 2050s, the African population which is at risk of increased water stress is proposed to be 75- 250 million and 350- 600 million people.[47] Correspondingly, Lucio noted that about one third of the worldôs

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[44] Rukuni M, Eicher C. & Blackie, K. (2006). *Zimbabwe's Agricultural Revolution, Revisited*, University of Zimbabwe Publications, Harare.

[45] Turner, B. (1994). Small Scale Irrigation in Developing Countries. *Land Use policy 11(4)* 251-261.

[46] Svendsen, S., Ewing, M. & Msangi, S.(2009). *Measuring irrigation performance in Africa*. IFPRI Discussion Paper 894. Washington, D.C.: International Food Policy Research Institute

[47] Gladwin, H. (2004). *Determinants of Food Security in Southern Ethiopia at household level.* Florida: Food and Rescource Economics Department, Institute of Food and Agricultural Sciences, University of Florida

population already lives in countries considered to be water stressed, where consumption exceeds 10% of the total supply.[48] He adds that two out of every three people on earth will live in this condition by 2025 if the present trends continue.

850 million people suffer hunger and abject poverty globally; two thirds live in Asia and a third in Africa.[49] Asia and Africa are the future battlefields for food, water, and energy security as they face a huge gap between people's resource needs and the available supply. Asia has relied on irrigation traditionally to increase agricultural productivity through rain-fed farming. However, groundwater development has begun to gather increasing attention. In contrast most developing countries farmers practise rainfed agriculture. There is the growth of interest in irrigation although it is in its early stages.

There was a revelation by Samad who did an assessment of community participation in water resources management in East Usambara area, Tanzania where he stated that majority of the people participate through various ways and that in every village there is a Village Environmental Committee that oversees environmental management activities.[50] These committees encompassed both males and female members, which is an indication that there is gender consideration in natural resource management. The study further revealed that indigenous knowledge and practices for managing forest and water resources have also been used in the past. Because of passing away of the elders who used to be the custodians of these practices, the practice was vanishing

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[48] Lucio, M. (2004). *Irrigation and cropping intensity.* International Association of Hydrological Sciences (International Association of Hydrological Sciences Press 2004

[49] Kolavalli, M. (2010). *Typology of irrigation systems in Ghana.*Colombo, Sri Lanka: International Water Management Institute. 35. (IWMI Working Paper 142).

[50] Samad, M. (2002). *Institutional alternatives in African smallholder irrigation: Lessons from international experience with irrigation management transfer.* Research Report 60. IWMI, Colombo.

very fast. Modern conservation measures were enhanced by the habit of young generation disregarding these practices in favour of the new practices.

According to Doss and Morris, the present type of community participation is not all that effective in bringing about substantial impact in natural resources management.[51] This originates from the fact that the involvement is only limited to activities that do not entail planning and decision making and hence not complying with what various national and international policies and resolutions advocate for as regards public participation in integrated water resource management.

A multi-criteria analysis which included environmental, economic, social and institutional component was used by Facon and Mukherji.[52] The studies do not fully explain why the differential impact occurs, however, good explanation of the impact is provided. Lack of peopleôs in project related decisions is the most common reason cited for poor impact. Poor planning and monitoring are the major factors behind sub-optimal results. The responsibility is passed on to the implementing agency either directly or indirectly. The influence of various stakeholders involved at various stages of the project cycle are not taken into consideration by the agency-centered explanation of differential impact.[53]

Substantial improvement in productivity and employment generations motivated the stakeholders to take the responsibility for protection of adjoining hilly forest catchment by forming village cooperatives. After a long time nature has been allowed

[51] Doss, C. R. and Morris, M. L. (2001). ñHow does Gender affect Adoption of Agricultural Innovation? The Case of Improved Maize Technology in Ghanaò. *Journal of Agricultural Economics,* 25, pp 27-39.

[52] Facon, T. & Mukherji, A. (2011). Improving the performance of public irrigation in South Asia. Paper presented at the GWP/IWMI Workshop on Climate Change, Food and Water Security in South Asia, Colombo 23ï 25 February 2011.

[53] Ibid

to spread its green protective cover on eroded barren hill slopes. All these have resulted in overall improvement in the standard of living as indicated by the increased number of tractors, television sets and availability of surplus milk for sale.[54] The significant contribution includes forceful demand of the communities for continuing the project even at higher rate of cost sharing because the project has brought back the lost smile and hope to the desperate section of the society. The study conducted by Mahajan and Navin on poverty Alleviation and Resource conservation through integrated water management in a fragile foot ï hill ecosystem shows that the construction of a large number of village ponds and water harvesting structures has improved the availability of water management for food production.[55]

According to Shah and Lele the adoption of new farming technology through maintainable land management practices enabled farmers and communities to adapt to climate change by increasing food production and conserving soil and water thus enhancing food security and restoring productive natural resources.[56] They further suggest to the fact that corresponding factors to soil conservation in the face of climate change aids in the strategy, application and adoption of sound practices of conservation.

Participatory Water Management for Sustainable Rural Livelihoods study conducted by Samad suggests that participatory water management programs made significant impact in terms of productivity gains in rain-fed areas which contributes to the raised

[54] Mukherji, A. (2011). Paradox of poverty amid plenty of groundwater. Paper prepared for the GWP/IWMI Workshop on Climate Change, Food and Water Security in South Asia, Colombo 23ï 25 February 2011.
[55] Mahajan, V. & Navin, T. (2012). Microfinance in India: Growth, Crisis and the Future. BASIX, Hyderabad.
[56] Shah, T. and Lele, U. (Eds.) (2011) Synthesis of Workshop Discussions. Climate Change, Food and Water Security in Africa: Critical Issues and Cooperative Strategies in an Age of Increased Risk and Uncertainty. GWP, Stockholm and IWMI, Colombo.

farm income and better livelihoods of the poor in fragile and high risk environments by ensuring food security.[57] Soil moisture content have been improved by water programs

Water scarcity threatens to change peopleôs options in production, employment and exchange, and the relations among these activities, in ways that will exclude the small producer.[58] According to Demese, there should be new action to recognize the roles water plays in rural livelihoods and peopleôs capacity to manage their water sustainably at the local level and with social justice. For example, in Ghana, new smallholder irrigation systems are being developed and old ones are receiving new support that can improve water supply and livelihoods for more people.[59]

A strong link between climate change and soil conservation is identified by a growing body of literature. For instance, Wang et al. designates that the effect of mean annual rainfall on the adoption of stone terracing varies based on agro-ecology type of a place.[60] Their findings showed that there is significantly higher productivity benefit of the technology in conserving moisture in drier areas compared to higher rainfall areas. Similarly, Ayalew study of a sample of farmers in the Nile basin indicate that there is a direct link between an increase in temperature and increasing the probability of

[57] Samad, M. (2011). Irrigation management reforms: the Asian experience. Paper presented at the GWP/IWMI Workshop on Climate Change, Food and Water Security in South Asia, Colombo 23ï 25 February 2011.

[58] Demese, C., Getinet, G., Goshu, M. & Yaddesa, D. (2009). *Comprehensive Africa Agriculture Development Programme Ethiopia Study.* Addis Ababa: MoARD.

[59] Hussain, I. (2005). *Pro-poor Intervention Strategies in Irrigated Agriculture in Asia. Poverty in Irrigated Agriculture: Issues, Lessons, Options and Guidelines (Bangladesh, China, India, Indonesia, Pakistan and Vietnam).* Project Final Synthesis Report. IWMI, Colombo.

[60] Wang, J., Xu, Z., Huang, J. and Rozelle, S. (2006) Incentives to managers or participation of farmers in China's irrigation systems: which matters most for water savings, farmer income, and poverty?, Agricultural Economics 34: 315ï 330.

using soil conservation by about 2.6%. The probability of adopting soil conservation practices in drier regions is higher than that of wetter regions.[61]

1.5 Knowledge Gaps

Ecological and natural resources degradation are caused by many forms of development activities. Ecosystems have been altered more rapidly and extensively within the last 50 years than in any other period in history. This has led to unprecedented transformation of freshwater ecosystems and consequent biodiversity loss leading to food scarcity. Many studies have been carried out in this field: Osman[62] carried out a study on identification of Food Insecurity and Coping Strategies of Rural Households in Northern Kenya.[63] Karis[64] also carried out a study on water scarcity and food insecurity; Strategies for coping with drought in eastern Kenya; Kangundo sub County in Machakos county. Syowia[65] carried a study on poor methods of agriculture and food insecurity and health in Kitui County. However there is no specific study which has been carried out on sustainable water management and food security in relation to Nyakach division in Kisumu County. Hence the current study aims to fill the gap.

1.6 Justification of the Study

This study points out the potential issues that influence water management and food security, the magnitude of land use change and analyzes the potential of water

[61] Ayalew, Y. (2011). *Identification of Food Insecurity and Coping Strategies of Rural Households in Norththern kenya.unpublished thesis;* Moi University

[62] Osman K. (2010). identification of Food Insecurity and Coping Strategies of Rural Households in Northern Kenya. Maseno university.

[63] Ibid

[64] Karis M. (2009).*water scarcity and food insecurity:* Strategies for coping with drought in eastern Kenya; Kangundo sub County in Machakos county.

[65] Syowia D.(2008). Poor *methods of agriculture, food insecurity and health in Kitui County*. Kenyatta university masters thesis.

harvesting as a coping and adaptation strategy to climate change and variability in Nyakach Division in Kisumu County. This study will help in creating awareness to the policy makers on the main sources of water in Nyakach Division in Kisumu County and how they can use it to ensure food security in the area. It is also hoped that Ministry of Agriculture in Kisumu county will use the result of this study to develop polices and strategies that would guide the planning and allocation of funds for implementation of Food Security Projects within the County.

Non-Governmental Organizations (NGOs) and other Development Partners dealing with food security and poverty eradication will also find the study useful.

The results of this study will be disseminated to University of Nairobi Libraries thus will contribute to the body of knowledge. The study is also important to scholars as the study will increase to the body of knowledge in this area. These study findings will also be generalizable to other sustainable water management and food security projects in other regions.

1.7 Study Hypothesis

H_{01}: Water management donôt have significant positive influence on food security in Nyakach Division in Kisumu County

H_{02}: Community-led initiatives in managing water resources have ~~a~~ significant positive influence on sustainable water management and food security in Nyakach Division in Kisumu County

1.8Theoretical Review

1.8.1 Liberal Theory

The study was anchored on liberal theory and is necessary for making decisions on sustainable water management and food security projects.[66] This theory has developed a forceful case for autonomous, elected local authorities. First local government is grounded in the belief that there is value in the spread of power and the involvement of many decision-makers in many different localities. The second argument rests on the view that there is strength in the diversity of response. That needs vary from locality to locality; as do wishes and concerns; local governments allow these differences to be accommodated. The third argument rests on the view that local government is local. This facilitates accessibility and responsiveness because councillors and officers live close to the decisions they have to make, to the people whose lives they affect and to the areas whose environment they shape. The theory further argues that its small scale makes local government more vulnerable to challenge than central government. Its visibility makes it open to pressure when it fails to meet the needs of those that live and work in its area. The forth argument rests on the view that local government has the capacity to win public loyalty. It can better meet local needs and win support for public service provision because it allows choice. It facilitates a matching of local resources and local needs.

Arnstein argues that genuine participation only starts taking place at the level of partnership which is an outcome of a negotiation process between powerless and power holders that entails the re-distribution of power and an agreement among the partners to share planning and decision-making responsibilities. The next two rungs,

[66] Arnstein, S. (1969). A ladder of citizen participation. *Journal of the American Institute of Planners*, 35 (4), 216-224.

delegated power and citizen control, describe the move from having genuine part in the decision-making process in a form of partnership to dominating that process and eventually holding full-managerial power. Indeed, manipulation attempts to give the so-called ñparticipantsò the illusion that they have a say in the decision-making process by making reference to attendance in committees or collecting signature lists.

Participation has become popular in development discourse and practice, particularly in the management of water resources. Greater involvement of people in decision making, implementation and evaluation of water management practices is expected to increase efficiency and equity in water projects. However, Samad have pointed out that community water management schemes may not be equitable and lead to further marginalization of the poor.[67] This is because water management projects generally view communities as homogeneous entities and overlook complex realities that influence access to and control over water resources.

1.9 Research Methodology

The study focused on factors of sustainability and management as a means to identifying sustainable water management and food security. In this light, this research work strived to present the research design which seeks to investigate the research question.

This study sought to achieve a more complex and fuller explanation of the impact of sustainable water management and food security. The study adopted a cross sectional survey.[68] Cross-sectional surveys attempts to go further than just providing

[67] Samad, M. (2002). *Institutional alternatives in African smallholder irrigation: Lessons from international experience with irrigation management transfer.* Research Report 60. IWMI, Colombo

[68] Denscombe, J. (1998). The Postgraduate Research Handbook. New York: Palgrave.

information on the frequency (or level) of the attribute of interest in the study population by collecting information on both the attribute of interest and potential risk factors. In this study, the populations of interest will be 3 administrators in the area, 150 householdsô heads and 5 water and food projects coordinators. (County water department and agriculture)

The study used both secondary and primary data. Primary data was collected through open ended questionnaire. Secondary data was obtained from Library research which was conducted by reviewing works related to the area of study. These include information from textbooks, daily newspapers, journals, articles, and published and unpublished thesis. The secondary data will be sourced from libraries, government departments and internet. Special reference to provisions of relevant policies and laws will be used. The relevant policies include: Current National Land Use Policy, The National Land Policy, The Kenya Vision 2030, The Agricultural Sector Development Strategy (ASDS) 2010ï 2020, The National Food Security and Nutrition Policy (NFSNP), The Kenya Food Security and Nutrition Strategy (KFSNS), Current National Spatial Plan and The Millennium Development Goals (MDGs).

Data was also generated using the Constitution of Kenya 2010, Supreme Law of Kenya, The Land Control Act, chapter 302, Laws of Kenya, The Physical Planning Act, Chapter 286, Laws of Kenya, The Registered Land Act, Chapter 300, Laws of Kenya Repealed in 2012, The Local Government Act, Chapter 265, Laws of Kenya, The Agriculture Act, chapter 318, Laws of Kenya, The Housing Act, chapter 117, Laws of Kenya, The Housing Bill, 2009, The Government Lands Act, chapter 280, Laws of Kenya (Repealed in 2012), The Sectional Properties Act, 1987 No. 21 of

1987, The Land Registration Act, 2012, The Land Act, 2012 and The National Land Commission Act, 2012

The information sought here will help to know what the existing and proposed policy and legal framework provides regarding agricultural land use conversions and how the policies and laws are likely to influence agricultural land use conversions. In addition, to establish what the regulatory framework mandates the relevant land institutions responsible for regulating agricultural land use conversions. The choice of this tool of data collection is guided by the time available and the objectives of the study. The questionnaire will provide a high degree of data standardization and adoption of generalized information amongst any population.

Data analysis seeks to answer the research questions and assist in determining the trends and relationships among variables. Descriptive statistics was used to analyze the data.

1.10 Chapter Outline

This project research is organized into five chapters: Chapter one is the introductory chapter that deals with the introduction, problem statement, purpose of the study, objectives of the study, the research questions, and significance of the study, research hypothesis, and methodology of the study.

Chapter two analyses causes and effects of poor water management and issues in food security. It is divided into the following subtopics: - Overview of Poor Water Management and Issues in Food Security, Poor Water Management and Issues in Food Security in Kenya, Water scarcity and food security linkages, Major Causes of Food Insecurity, Major Causes of Food Insecurity, Effects of poor water management

and issues in food, Integrating the Food Security, Climate Action, and Ecosystem and finally the conclusion.

Chapter three gives theoretical and historical discussions; in this chapter, an overview of water management and food security in Kenya: will be provided. Relevant aspects of sustainable water management and food security issues and theories will be addressed.

Chapter four have the issues critically analysed: In this chapter, the three hypotheses of will be critically analysed in a more scholarly perspective as well as other emerging issues. Chapter five present the conclusions. In this chapter the research will be concluded, recommendations will be made and final analogies of the research will be drawn.

CHAPTER TWO

CAUSES AND EFFECTS OF POOR WATER MANAGEMENT AND ISSUES IN FOOD SECURITY

2.0 Introduction

This chapter analyses causes and effects of poor water management and issues in food security. It is divided into the following subtopics: - Overview of Poor Water Management and Issues in Food Security, Poor Water Management and Issues in Food Security in Kenya, Water scarcity and food security linkages, Major Causes of Food Insecurity, Major Causes of Food Insecurity, Effects of poor water management and issues in food, Integrating the Food Security, Climate Action, and Ecosystem and finally the conclusion.

2.1 An Overview of Poor Water Management and Issues in Food Security

According to Shoham [69] the main basic human needs are water and food. This two necessities are important for survival and human rights cannot be enjoyed without them. The accessibility and availability of these two elements remains a dream for many people around the world because they cannot get them in the desired quantity and quality throughout a given year. Many developing countries and dry land ecosystems suffer from food and water insecurity is more common in those countries. A countryøs economic growth and development can only be enhanced by water. This is a life blood for human beings, agriculture, household economy and industry survival. Every individual needs it for survival. When a country is denied the necessity, it may lead to famines, sufferings, distress, war and chaos. The elementøs

[69] Shoham, J. (2011). Mapping vulnerability of Food Insecurity: Tentative guideline for WFP, Mimeo: London.

cultural and social meaning is deeply rooted in heritage and it is an identity. [70] It can be defined either in terms of existing and potential supply of water or in terms of present and future demands for water or both It can also be defined as a relative concept and therefore be regarded partly as a ñSocial constructò because determining water scarcity varies from country to country and region to region in a country and within the social construct, the scarcity is determined both by the availability and consumption pattern. Indeed, water is a natural resource unique to planet earth. Water scarcity is an imbalance between demand and availability and exists when the demand for water exceeds the supply. [71]

Approximately, one-sixth of the worldôs population obtains drinking water from unimproved sources, and in many developing areas, progress in expanding clean water coverage is modest, this report was given by the United Nations Development Program. [72] The unavailability of safe drinking water in most rural locations is one of the main causes of diarrhoea among children under the age of five. More than 90 percent of households consume this water untreated and that is why the negative health impact of contaminated water is exacerbated. Klemesu [73] states that agriculture is accountable for the largest extraction of water and thus considered the chief óculpritô under conditions of local absolute scarceness. Water is vital for all socio economic development and for maintaining healthy ecosystems. As population increases the utilization of groundwater and surface water for the domestic, industrial

[70] Campbell, D.J. (2007). *Strategies for coping with drought in Sahel: Study of recent population movements* . The department of Maradi, Niger. Unpublished Ph.D. Dissertation, Lark University, Niger.

[71] Campbell, D.J. (2007). *Strategies for coping with drought in Sahel: Study of recent population movements* . The department of Maradi, Niger. Unpublished Ph.D. Dissertation, Lark University, Niger.

[72] Ibid

[73] Klemesu, M. (2001). *Urban agriculture and food security nutrition and healt*h. Thematic paper 4.In: Bakker, N.et al. (eds). Growing cities, growing food: urban agriculture on the policy agenda. DSE, Fefdafing

sectors and agriculture exaggerate, leading to tensions, conflicts between users, and extreme pressure on the environment. Food policy must not lose sight of surging water scarcity. Water is a key element of agricultural production. Water insufficiency can cut production and badly impact food security worldwide.

2.2 Poor Water Management and Issues in Food Security in Kenya

Factors such as water scarcity, decline in agricultural productivity resulting from continuous land fragmentation are attributed by food insecurity. Most of the original large scale farms in Kenya have been sub-divided beyond economically sustainable agricultural production. Some 89% of the households in Kenya are living in less than 7.5 acres of land while 47 % live on farms less than 1.5 acres as a result of this fragmentations. According to WFP , farm family households in ASAL areas practise livestock production to mitigate crop losses. However, low numbers of livestock and their poor body conditions (as a result of extended trekking in search of water and pasture) has caused a 50% decline in their value. Furthermore, these households are also depending on undesirable mitigation strategies against their household food insecurity, such as charcoal production, which further degrade the environment and endanger future food production.[74] According to FAOôs study, there are few households in developing countries where gardens act as a major source of food to meet household consumption requirements. [75] Alamgir and Arorai[76] observes that there is desertion of indigenous drought resistant crops in ASAL areas due to changes in food tastes and preferences constraining drought resistant crop cultivation to mitigate crop losses.

[74] Ibid
[75] Ibid
[76] Alamgir, M. and Arorai, P.(2011) : Providing food security for all. Great Britain: International Fund for Agricultural Development (IFAD).

FAO[77] states that people living in dry land ecosystem of sub-Saharan Africa and Kenya in particular, continue to struggle with hunger, frequent famines and associated consequences such as loss of lives, savings and wealth, sicknesses, and hopelessness. Frequent incidences of food deficit has faced Kenya in recent times. So much that hunger is evidently one of the greatest problems facing the country today. Household food insecurity in Kenya is caused by inadequate farming area. It is only 18% of Kenyaôs territory which is suitable for farming.[78] Another cause is poverty. The 2007/08 United Nations Human Development Report[79] noted that almost 24% of Kenyans are living on less than one dollar a day, therefore not food sustaining. Droughts in ASAL areas of Kenya have brought about a decline in crop and livestock production among households in these regions. Moreover floods cause displacement of people making them vulnerable to household food insecurity. It is estimated that the 2006 floods affected 700,000 people in the country; most of them cut off from food help due to obstructed roads.

Erratic rainfall worsens household food insecurity in the country. Poor rains in 1996 prompted the GOK to declare a state of national disaster on January the 28th. According to Daily Nation Correspondents[80] the GOK in collaboration with the WFP is also feeding 1 million people under the Emergency Intervention Programme, while another 1 million are receiving direct government aid. In addition, the 2008 post-election violence disrupted the March/April agricultural production. The World Food Programme reported that 50% of farmers were not

[77] FAO (2005). Committee on World Food Security: *Conflict and Food Securit*y. Nairobi: Food and Agricultural Organisation.

[78] Kessler, M. (2006). Decisive Key-factors Farm Households' Soil and Water Conservation Investment. *Journal of Agriculture, Ecosystem and Environment* 65: 95-102.
[79] Ibid
[80] Ibid

sufficiently prepared for farming due to the post-election turmoil. In addition, erratic rainfall exacerbates household food insecurity in the country.

2.3 Water scarcity and food security linkages

In 2008, world food security came at its lowest recede in half a century. World food production is now consistently outpacing consumption.[81] Grain carryover stocks in mid-2007 were the lowest since records began in 1960; in 2007 the stocks were only 53 days of grain supply or only half of what was available in 2002. A daily dietary energy intake of 2700 kcal is a widely used indicator for measuring food security and to produce one kcal for the average diet one litre of water is needed. This means that about 2700 l/capita are required for daily food needs. Adverse climatic conditions and droughts in some major food producing countries including Australia, Georgia, and US were the key drivers. According to the Comprehensive Assessment of Water Management in Agriculture todayôs food production requires a consumptive water use of about 6800 km 3/year. Out of this, 1800 km 3/year are supplied by irrigated water (i.e. blue water resources). [82]To feed humanity by 2050 on 3000 kcal per person per day (the basis used by the Assessment, assuming worldwide growth in incomes and calorie consumption), an additional 5600 km 3/year will be required; out of which a maximum of 800 km 3/year will come from blue water resources (i.e. due to irrigation expansion and efficiency improvement) while the remaining 4800 km3 will have to come from new green water resources (e.g. from horizontal expansion or from turning

[81] Jacobs, P.T. (2009). Household food security status in Kenya- Africa. Agrekon, vol 48, No 42.

[82] IFPRI (2011). Sustainable Food Security for all by 2020 Report (2010): Addressing World Food shortage. Bonn: Germany. International Food and policy Research Institute.

evaporation into transpiration). There is a possibility that improved efficiency in rain fed areas will result in 1500 km 3/year.[83]

2.4 Major Causes of Food Insecurity

Carte[84] states that a major development problem is food insecurity which is caused by myriad of factors in the global, regional, national and local spheres of human life. In order to alleviate food insecurity globally, nationally and even locally several efforts have been put in place. Despite these efforts, the situation continues to prevail and sometimes even increase in the contemporary human society. Food insecurity is a complex phenomenon attributable to a range of temporally and spatially varying vulnerability factors such as the socio-economic and political environment, the performance of the food economy, care practice and the health and sanitation situation. These are taken as gauges and key vulnerability factors that causes hunger and that should be monitored in food insecurity evaluation.

2.4.1 Demographic conditions

According to Alamgir & Arorai[85] demographic conditions create vulnerability when size of population exceeds the carrying capacity of a particular area, and there is limited opportunity for out-migration or for development of physical, social and economic infrastructure so as to provide more productive alternatives to the dominant livelihood systems in the area. In case it occurs together with a low level of economic development in rural areas high share of rural population in the total may indicate the

[83] Ibid

[84] Carter, M.R. (2006). ñCredit constraints, Credit Unions and Small ï Scale producers in Guatemala,ò World Development, 24 (25), 1996, p.793-806.

[85] Alamgir, M. and Arorai, P.(2011) : Providing food security for all. Great Britain: International Fund for Agricultural Development (IFAD).

presence of this kind of vulnerability. A high proportion of dependent persons within a family, community, locality or nation also increase the risk of under-nourishment for these persons. The higher the population the higher the chances of food scarcity. This is caused by increased level of dependence per head and pressure on resources.

2.4.2 Environmental conditions

Bachmann & Earles [86] states that chronic exposure can be caused by environmental conditions in numerous ways. People living in areas where the natural resource base is poor or declining often have limited opportunities for earning their livelihood. Their situation is worsened if acts of man lead to pollution and environmental degradation. Variable climatic and geophysical conditions and biological threats create additional risk. Availability of arable land per capita usually declines with economic development, as more and more land is dedicated to non-agricultural use, and high-technology, high-yielding agricultural practices are introduced on the remainder. However, if availability of arable land per capita is declining solely as a consequence of population growth, without compensating improvements in productivity or in the performance of the national economy, the result is likely to be increasing levels of under-nourishment.

2.4.3 Economic conditions

Economic conditions can be monitored and assessed at various levels - national, sectoral, or zonal. According to FAO[87] the structure and performance of the national

[86] Bachmann, J, and R. Earles. (2010). Postharvest handling of fruits and vegetables. ATTRA horticulture technical Note. 19 pp. [Online]. http://www.attra.ncat.org. [Accessed on 12-01-2012]

[87] FAO (2000). *Committee on World Food Security*: Conflict and Food Security. Nairobi: Food and Agricultural Organisation.

economy and its components can cause the food insecurity situation of an entire nation through the performance of food markets. These are in turn affected by factors such as food prices, interest rates, inflation rates, labour market conditions, foreign exchange rates, and trade balances. The degree to which an economy is or is not varied will often determine whether or not employment and income-generating opportunities exist that would provide sufficient purchasing power to meet basic food needs to all segments of the population. Economic conditions can also create vulnerability and food insecurity if assets and incomes are distributed unevenly among the population, or if public and private sector investment is inadequate or skewed.[88] Also, the level of development and the dynamism of economic activities in rural areas often have a strong influence on the level of under-nourishment nationwide. Political conditions can affect food security positively or negatively. Political structures that encourage people's participation tend to reduce vulnerability. But, the presence of civil conflict is a vulnerability factor which can restrict employment and market opportunities, and may lead to loss of assets, destruction of social and physical infrastructure, and even displacement from their homes for affected households. Armed conflict and civil strife were major sources of food insecurity in the 1990s and will continue to be this century.[89]

Food sustainability is not achievable in the face of poverty. This is supported by the CESCR Committeeós assertion that the notion of sustainability is intrinsically linked to the notion of adequate food or food security, implying food being accessible for both present and future generations. The poor strive to survive from day to day and therefore food sustainability, which requires long-term availability and accessibility

[88] Ibid
[89] Wang (2003) ñEnvironmental Determinants of Child Mortality in Rural China: A Competing Risks Approachò World Bank, Washington D.C

remains a mirage to many. Consequently, with the poor farming methods, insufficient food production and shrinking land parcels of land, environmental conservation becomes least of their concerns. It has been argued that persistent hunger and food insecurity on one hand and economic disparities on the other can only breed resentment and instigate violence, putting the social fabric of the nation at risk. Poverty eradication is thus important so as to ensure that the country is not only food secure at the national level, but also at the household level.

Poverty and environment are inter-linked through four main dimensions: livelihoods, resilience to environmental risks, health and economic development. Across many communities in Kenya, agriculture has been the single largest source of livelihoods for most people especially the poor. For sustainable and economical agricultural practice, there are resources such as seeds and mechanisation that are required. However, due to poverty, many of the poor lack the finances to facilitate this and also engage in unsustainable agricultural practices. Access to agricultural loans and extension services (which often require collateral) as well as training on economical, sustainable and productive agricultural practices is out of reach for many of the poor rural folk. Unsustainable farming practices in many regions are causing land resources to degrade threatening future food security as well as the livelihoods of the poor rural people. Indeed, the UN Committee on Economic, Social and Cultural Rights (CESCR Committee) observed in the General Comment No. 12 that the roots of the problem of hunger and malnutrition are not lack of food but lack of access to available food, inter alia because of poverty, by large segments of the worldós populace.[90]

[90] Ibid

2.4.4 Government Policy

The government is responsible for failing to prevent the crises whenever food shortage or famine occurs in a given country. This is an important influence on vulnerability and food insecurity. Some researchers claim that government policy failures or inappropriate development strategies are responsible for the recurrence of food shortage and famine or for underdevelopment in a broader context.[91] In a nutshell food insecurity is a multi-disciplinary concept which takes into account of technical, economic, social cultural and political dimensions. Thus, the concept of food security must form part of the broader concept of food strategy, which in itself forms parts of a poverty reduction policies and socio-economic development strategy.

2.5 Effects of Poor Water Management and Issues in Food

2.5.1 The Effect of Shortage of Water Supply

Drewnowski [92] states that scarcity of water is one of the world's leading problems affecting more than 1.1 billion people globally, meaning that one in every six people lacks access to safe drinking water. One third of all nations suffered from clean water scarcity as of 2006, but Sub-Saharan Africa had the largest number of water-stressed countries than other place on the globe. Each individual living in the United States uses on average 100 to 175 gallons of water per day in the home, the average African family uses only 5 gallons of water per day. In Africa, the struggle for access to clean drinking water is one of today's most obvious examples of how water scarcity leads to the stalling and reversal of human progress. This vast disparity of

[91] Supplemental nutrition assistance program (2013): Examining the evidence to define benefit adequacy. The
National Academies Press;
[92] Drewnowski A, Specter S. (2007). Poverty and obesity: food insecurity. The American Journal of Clinical Nutrition. 79:6-16.

clean water availability and consumption is reflected in a number of different developmental aspects. These consequences include the effects on health, opportunities for women, children's education, agricultural practices, productivity, and development.

International water management states that 2.2 million people die every year globally from diarrhoea-related disease and at any given time fifty percent of all hospital beds in the world are occupied by patients suffering from water-related diseases. Infants and children are especially susceptible to these diseases because of their inexperienced immune systems. When infected with these waterborne diseases, those living in African communities suffering from water scarcity cannot contribute to the communityôs productivity and development because of a simple lack of strength. The Water Supply and Sanitation Collaborative Council (WSSCC) estimates that in Sub-Saharan Africa, treatment of diarrhoea due to water contamination consumes 12 percent of the countryôs health budget. With better water conditions, the burden on health care would be less substantial and a healthier workforce would stimulate economic growth and pull many people out of poverty. [93]

The Water Supply and Sanitation Collaborative Council (WSSCC) estimates that in Sub-Saharan Africa, treatment of diarrhoea due to water contamination consumes 12 percent of the countryôs health budget. With better water conditions, the burden on health care would be less substantial and a healthier workforce would stimulate economic growth and pull many people out of poverty. [94]Furthermore, economic resources are drained by the cost of medicine to treat waterborne diseases,

[93] Ibid
[94] Ibid

which takes away from resources that might have been used for food or school fees. This also takes a toll on the governmental funds.

Montoya[95]says that the most immediately apparent impact of water scarcity in Africa is on the continent's health. With a complete lack of water, humans can on average only live up to 3 to 5 days. This often forces those living in water deprived regions to turn to unsafe water resources, which then contributes to the spread of waterborne diseases including malaria, typhoid fever, cholera, diarrhoea, and can lead to diseases such as trachoma, and typhus. Additionally, water scarcity causes many people to store water in their households, which increases the risk of household water contamination and incidents of malaria and dengue fever spread by mosquitos. These waterborne diseases are not usually found in developed countries because of sophisticated water treatment systems that filter and chlorinate water, but natural, untreated water sources often contain tiny disease-carrying worms and bacteria. Although many of these waterborne sicknesses are treatable and preventable, they are nonetheless one of the leading causes of disease and death in the world.

According to National sanitation draft white paper Republic of South Africa[96] the effects of the poor water management problem are threefold: **Health effect**- the impact of the conditions, represented by the statistics presented above, on the health of the urban and rural poor is significant in terms of the quality of life, and the education and development potential of communities, although difficult to determine accurately. **Economic effect**- the effect on household economies is serious, keeping

[95] Montoya, Nilton (2010). The effects of climate change on water supply in the Piuray Ccorimarca Catchment Cusco- Peru. Thesis Report, Zurich: Swiss Federal Institute of Technology Zurich,.
[96] According to National sanitation draft white paper Republic of South Africa (2008). ñThe effects of the poor water managementò.

families in the cycle of poverty, illness, illiteracy and lost income. The national cost of lost productivity, reduced educational potential and curative health costs is a major drain on the local and national economy and **Environmental effects**- inadequate water supply leads to dispersed and diffuse pollution of water sources resulting in the water/faecal disease cycle for communities with untreated water supplies, and increased downstream water treatment costs.

Although the Millennium Development goals (MDGs) target 7(c) seeks to ñhalve by 2015 the proportion of people without access to safe drinking water and sanitationò (UNDP, 2005), it is anticipated that Sub-Saharan Africa will only reach the MDGs water target by 2040. But still, some 400 million of the people living in sub Saharan Africa will be left without access to safe water with a majority of them being women and children living in rural households. Competition for water has resulted in the collapse of water based ecological systems hence declining river flows and large-scale ground water depletion.[97] This is leading to an increased potential for conflict within and between countries with the rural populations being the most affected. Even though the water crisis is observed as a general problem for the rural population, women bare the greatest burden because of their socially gendered roles, which involve looking for and collecting water for their households. Because of their task of water provision at the households, the participation of women in education, income generating activities as well as in cultural and political engagements is often compromised. Consequently, this leads to material deprivation for women, their lack of voice, vulnerability to shocks and lack of capacity to cope

[97] Mukheibir, Pierre. (2010)."Water Acess, Water Scarcity, and Climate Change." Environmental Management,: 1027-1039.

with any form of crisis and hence widening the poverty gap and gender inequalities in developing countries. Therefore ensuring easy access to adequate amounts of good quality water by extending provision of water services to rural households in a coordinated and inclusive approach for all people is central to promoting gender equality. Such a step will also contribute to the protection of natural resources which is also essential for environmental sustainability as one of the pillars of the MDGs.

Death can be caused by poor water management. According to Trigoso[98]around 1.3 billion people in the developing world lack access to adequate quantity of clean water and approximately three billion people are without adequate means of waste disposal. It is estimated that 10,000 people die every day from water and sanitation related diseases while thousands suffer from a range of water and sanitation related illnesses. The effect of inadequate water and sanitation services falls primarily on the poor. The poor who are badly served by the formal sector make their own, often inadequate, arrangements to meet basic survival needs. Many fetch water from long distances or end up paying high prices to water dealers for very small quantity of water. Brocklehurst[99] states that in the last 50 years, the worldôs urban population has increased fourfold, and now around 50% of the worldôs population lives in urban centres. While urban populations grew rapidly, expansion of water supply and sanitation services did not. Spending on water supply and sanitation has not kept pace with growth, and there are dramatic differences in infrastructure expenditure between cities in low and high income countries. As a result, it is

[98] Rubio, Erika Trigoso.(2007). Climate Change Impacts and Adaptation in Peru: The Case of Puno and Piura.
Ocassional Paper, Washington: UNDP
[99] ibid

estimated that between 30% and 60% of the urban population in most nations is not being adequately served.

2.5.2 Effects of Food insecurity

Food insecure populations are also more likely to exhibit disordered eating patterns, have decreased household availability of healthful food groups and foods compared to food secure. Poor health, chronic disease, poor functional health, depression, altered nutrition-related laboratory values and decreased intake of healthful food groups has been caused by food insecurity.[100] Poor health, chronic disease, poor functional health, depression, altered nutrition-related laboratory values and decreased intake of healthful food groups has been caused by food insecurity.[101] Food insecure populations are more likely to have increased intake of less healthful nutrients. Food insecure children are more likely to have poor health compared to food secure children and children experiencing hunger, are more likely to show symptoms of decreased psychosocial functioning.

Food insecurity and/or lack of resources experienced early in life increases the chances of obesity, disordered and unhealthy eating patterns and food insecurity in adulthood.[102] Food insecurity seems to have a negative impact on various aspects of health and wellbeing.[103] Individuals living in food insecure households are more likely than those in food secure households to rate their own health has poor or fair

[100] Smith, P. J., *Food Security and Political Stability In The Asia-Pacific Region*, Asia-Pacific Center For Security Studies, September 11, 1998 Honolulu, Hawaii.

[101] Smith, P. J., *Food Security and Political Stability In The Asia-Pacific Region*, Asia-Pacific Center For Security Studies, September 11, 1998 Honolulu, Hawaii.

[102] Millennium Project (2005) Background Paper of the Millennium Project task Force on Water and Sanitation.

[103] Shoham, J. (2011). Mapping vulnerability of Food Insecurity: Tentative guideline for WFP, Mimeo: London.

and have lower physical and mental health . Food insecure individuals, especially women, are more likely that their food secure counterparts to be obese, gain weight, and have cardiovascular disease and diabetes.

Poor health, chronic disease, poor functional health, depression, altered nutrition-related laboratory values and decreased intake of healthful food groups has been caused by food insecurity.[104] Given that food insecure populations may lack ability to afford food, food insecure households may change dietary practices or use certain food-related behaviours to delay hunger and manage resources. Strategies such as using coupons and leftovers, freezing meals, and participating in food assistance programs may be beneficial, but other strategies may be detrimental to health. Changing frequency of shopping, borrowing money, putting off payment bills, choosing food over other expenses, limiting certain ócostlyô ingredients, pawning, eating expired foods or engaging in illegal shopping practices are only some of the many practices that food insecure individuals and families use to provide food when resources are constrained.

According to Vadez [105] theories, such as the energy density hypothesis, claim that individuals with limited resources will be more likely to purchase more energy dense, less nutritious foods that promote weight gain. How and why food insecurity contributes to increased health risk and altered behaviours is complicated and multifactorial. Additionally, food insecure individuals who receive food stamp benefits may purchase foods in a cyclical pattern, purchasing the majority of foods

[104] Smith, P. J., *Food Security and Political Stability In The Asia-Pacific Region*, Asia-Pacific Center For Security Studies, September 11, 1998 Honolulu, Hawaii.

[105] Vadez, V. (2010). Developing drought tolerant crops: Hopes and challenges in an exciting journey. *Funct. Plant Biol.* 2014, *41*, vi vi.

immediately after receiving benefits. This can lead to general overconsumption and purchase of foods after receiving monetary resources and increased purchase of low-cost/energy-dense foods when resources are limited. This practice may contribute to increased intake at that point in time and depleted resources later in the month. Ultimately, certain changes in dietary practices and behaviours utilized in an effort to alleviate the strain food may exacerbate negative health significances.

2.6 Integrating the Food Security, Climate Action, and Ecosystem

2.6.1 Restoration Agendas

In the rainforests of the Congo Basin and Madagascar, the savannah woodlands of southern Africa, and many African coastal peri-urban zones, land conversion for agriculture is a major threat to globally and nationally important biodiversity resources Biomass energy, long important in traditional forms, is now being developed as a substitute for fossil fuels, largely in the form of ethanol and biodiesel for industry and transport. Biofuels are almost certainly going to play an increasing role in land use, but so far they have been managed essentially as another extractive industry, rather than as a strategic component of long-term sustainable land use.

According to Pruss-ustun [106] in the face of looming water shortages, and with crop and grazing land constituting a large and growing portion of critical watersheds, it is becoming a priority for lands under agricultural use to be managed in ways that enhance watershed function. This means the retention of riparian vegetation; the retention of other natural or planted vegetation to slow movement of water across fields and micro-watersheds; the maintenance of year-round vegetative cover to

[106] Pruss-ustun L. (2006). Environmental health and child survival ,Epidemiology, Economics, Experiences.

protect soils from erosion, and the maintenance of soil organic matter and physical structure to facilitate infiltration of rainfall.

In the rainforests of the Congo Basin and Madagascar, the savannah woodlands of southern Africa, and many African coastal peri-urban zones, land conversion for agriculture is a major threat to globally and nationally important biodiversity resources Biomass energy, long important in traditional forms, is now being developed as a substitute for fossil fuels, largely in the form of ethanol and biodiesel for industry and transport. Biofuels are almost certainly going to play an increasing role in land use, but so far they have been managed essentially as another extractive industry, rather than as a strategic component of long-term sustainable land use.

In Africa, the environmental dimensions are acute. A GIS-based analysis of four countries in East Africa that overlaid spatial data on farming systems, poverty, watershed function, biodiversity, and carbon sequestration and storage found that many of the sub-regions most important for agricultural production and livelihoods were also critically important for watersheds and habitats, and were important stores of carbon.[107]

Complicating both policy and action is the fact that food production and rural incomes are no longer the sole objectives for agricultural land use. Many agricultural regions are critically important for the provision of ecosystem services as well particularly watershed protection, biodiversity conservation, and climate regulation. Yet agriculture, in its current form and practices, is now recognized to be a major threat to ecosystems. There are widespread efforts to slow the advance of the ñagricultural frontierò to minimize increased production in high-value biodiversity habitats or

[107] National council for population and Development (NCPD, 1989).Kenyaôs Fertility Transition: How Low it Go?

watersheds, and to reduce the release of agricultural inputs and pollution in high-input/high-yield systems.

Historically, there has been a major disconnect between policymakers who are concerned about ñnourishing the worldò (both generally and to reduce acute and chronic hunger) and newer voices seeking to mobilize action in the land use sector for ecosystem conservation and climate mitigation and adaptation. The various models for agricultural, food security, climate, and ecosystem conservation, and the policies to promote them, are in serious conflict, which threatens to cancel out progress on production, food security, climate, or environmental goals. While some part of the conflict is due to disagreements over values, much is due to incomplete knowledge of the facts or the broader picture. Much is also due to the perception that sectoral conflicts are unavoidable, and that in a zero sum, trade-off scenario, oneôs own top priority (food supply, food security, ecosystem health, and climate action) must take precedence.

Today, the only well-established technologies for large-scale reversal of greenhouse gas concentrations are the sequestration and storage of carbon in agricultural soils and in above-and below-ground vegetation (such as perennial grasses and tree crops) through the restoration of degraded watersheds, grazing lands, and farm and community forests. Investing in sequestration in Africa not only offers opportunities to attract large-scale carbon finance for sustainable agriculture and land management, but can generate significant co-benefits for local livelihoods and ecosystem resilience, and enhance capacity for adaptation to climate change.[108]

[108] Vishnudas, S. (2006). Sustainable Watershed Management: Real or Illusion? A Case Study of Kerala State in India. PhD Thesis. Delft, Faculty of Watershed Management, Delft University of Technology, Netherlands, 165 pp.

2.6.1 Empowering Farmers and Communities

The World Bank [109] states that top-down planning and design is still the norm, and donors still need detailed project plans upfront, before funds are released that would enable meaningful community input into design. Most funders allocate resources to governments or large NGOs rather than to farmer or community groups directly, and there is little funding for long-term engagement between farmers and agricultural scientists. While there are exciting, successful examples of community-led development at a large scale in areas like infrastructure, management of communal resources, and running child and maternal nutrition programs, they are less widely found in agriculture This challenge is particularly acute in two areas: empowering farmers to be leading actors in agricultural innovation systems and processes, and empowering women to fully engage and access such systems and processes.

The international agricultural development community in the last few decades, has come to recognize the value of local farmer knowledge, the value of community organization to accelerate innovation, and the importance of structuring investments and programs to explicitly engage socially and economically marginal groups.[110] This evolution has accompanied political democratization in many countries, particularly at local and sub-regional levels where organized farmers can have influence. Community organization has been instrumental in promoting innovation in marginal areas and in urban agriculture, in part because formal research and extension systems are rarely present. But these insights have largely not translated into major structural changes in public, civic, or private programs.

[109] World Bank (2013) World Development Report: Gender Equity and Development. The World Bank, Washington, DC.

[110] ibid

2.7 Conclusion

Urgent actions are needed in taking accomplishments to fulfil the responsibility to achieve food security for present and future generations. Attaining food security is a multifaceted task for which the primary accountability rests with individual governments and they need to develop an enabling environment and have policies that ensure peace, as well as social, political and economic stability and equity and gender equality. [111]Nevertheless, it is necessary for all the relevant stakeholders to support the Government in this task and within the global framework, governments should also cooperate actively with one another and with United Nations organizations, financial institutions, intergovernmental and non-governmental organizations, and public and private sectors, on programmes directed toward the achievement of food security for all.

[111] Relief Society of Tigray (REST) Senaele and Seglamen Surrounding Rural Water Supply, Hygiene and Sanitation Development 2011.

CHAPTER THREE

WATER MANAGEMENT AND FOOD SECURITY IN KENYA: AN OVERVIEW

3.1 Introduction

This chapter will contain a theoretical as well as historical view related to the study. Aspects of sustainable water management and food security issues will be analysed globally and then narrowed to Kenya.

The following section presents the theoretical and historical perspective of sustainable water management and Food security and its Relevance to Developing countries.

3.2 Sustainable Water Management

According to Gibbon land and water allocation between sectors will become an increasingly challenging political decision, with notable social and economic implications, as cities expand into agricultural areas and as commerce and industry require additional water supplies.[112] Smallholder farmers in peri-urban areas will be at risk of losing access to land and water to support their agricultural livelihoods. Persistent work is needed in policy and investment arenas, particularly in lower income countries, to extend and ensure access to water for household use and agricultural production. Several authors have shown that developing countries with a food deficit are characterized by a large fluctuation in agricultural production.[113]

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[112] Gibbon, H. (2011). Forest and Woodland Management in East and Central Africa: Emerging models for improvement in livelihoods and natural resource management in Kenya and Zambiaó, 17th *Commonwealth Forestry Conference 2005*, Colombo Sri Lanka.

[113] Brown, O., and Crawford, A. Rising Temperatures, Rising Tensions: Climate change and the risk of violent conflict in the Middle Eastó, 2009, International Institute for Sustainable Development.

Climatic change (change in rainfall and temperature at the country level) is a major determinant of agricultural production in Sub- Saharan African.[114] Therefore, one may wonder whether climatic variability is also worth including in determinants of food security in a production-based approach.

The volume of water withdrawn for irrigation, globally, will increase from 2.6 billion km^3 in 2005ï 2007 to an estimated 2.9 billion km3 in 2050, with most of the net increase occurring in lower income countries.[115] The irrigation requirement (that is the consumptive use portion of irrigation withdrawals) is estimated to increase from 1.27 billion km3 to 1.34 billion km^3.[116] Generally, there are sufficient freshwater resources to support this modest increase, although substantial water scarcity will persist in the Near East and North Africa, South Asia, and elsewhere. Water scarcity will intensify in areas where current rates of surface water and groundwater withdrawals are not sustainable, such as the North China Plain and portions of Central and South Asia.[117]

About 25% of the contemporary African population experiences water stress, while 69% live under conditions of relative water abundance.[118] However, this relative abundance does not take into account other factors such as the extent to which that water is potable and accessible, and the availability of sanitation. Despite considerable improvements in access in the 1990s, only about 62% of Africans had access to

[114] International Fund for Agricultural Development, *The future of world food and nutrition security: Investing in smallholder agriculture – an international priority*, May 2012. Page 2.
[115] Inter-American Institute for Cooperation on Agriculture, *IICA's Definition of Food Security*, March, 2009. Page 1. Available at http://www.iica.int/esp/programas/SeguridadAlimentaria/Documents/SeguridadAlimentarias_Quees_Eng.pdf [Accessed on 17/07/2014].

[116] Mechlem, K. (2004), Food Security and the Right to Food in the Discourse of the United Nations. European Law Journal, 10: 631ï 648
[117] Smith, P. J., *Food Security and Political Stability In The Asia-Pacific Region*, Asia-Pacific Center For Security Studies, September 11, 1998 Honolulu, Hawaii.

[118] Asefa, S., ǪEnhancing food access in Africa: The Botswana experienceó *Studies In Comparative International Development*, Volume 26, Issue 3 , pp 59-83, Springer-Verlag, Fall 2005.

improved water supplies in the year 2000. Many analysts have suggested that there will be sufficient water to produce the food needed in 2050 to support a global population of 9 to 10 billion, provided we allocate and manage water wisely, and we achieve notable gains in agricultural productivity.[119] Wise allocation and use involves understanding the role of water in crop and livestock production, and also in municipal, commercial, and industrial uses, and in the provision of ecosystem services. The demands for water will continue increasing with the size of the global population, with rising incomes, and with successful efforts to extend water supply and sanitation to all residents of urban and rural areas, particularly in lower income countries.

Most developing countries are particularly vulnerable to climatic change (especially climatic variability) because their economies are closely linked to climatic sensitive sectors such as agriculture. Millions of people in developing countries depend on agricultural production.[120] This vulnerability is particularly high in Africa where agricultural production is the primary source of livelihoods for 66% of the total active population.[121] The World Development Report has established that 39% of people on fragile (arid and semi-arid) lands live in Africa.[122] They are consequently threatened by climate change and climatic variability. Indeed, climatic variability has a negative effect on crop production. For example, higher average temperatures and changing rainfall patterns negatively impact farm yields, reduce household and national food

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[119] Brown, O., and Crawford, A., "Give Peace (and the climate) a Chance", November 6, 2009, International Institute for Sustainable Development.
[120] Horenstein, N. (2009). Women and Food Security in Kenya", *PPR Working Paper Series*, Women in Development Division, World Bank, June, WPS 232.
[121] Brown, O., and Crawford, A., "Climate Change and Security in Africa: A Study for the Nordic-African Foreign Ministers Meeting", March 2009, *International Institute for Sustainable Development*.
[122] World Health Organisation, "Trade, foreign policy, diplomacy and health", *Food Security*, available at http://www.who.int/trade/glossary/story028/en/ [Accessed on 17/07/2014].

availability and agricultural income. Poor harvests threaten food security. Rainfall variability contributes to underinvestment and hence to long-run agricultural stagnation and rural poverty in countries that are dependent on rain-fed agriculture. This leads to a decrease in food availability and accessibility.

3.2.1 Irrigation and Household Food Security

In the mid-1980s, researchers realized that food insecurity may appear in regions where food may be available but not accessible because of the erosion of peopleôs entitlements.[123] There are many socio economic factors that may influence householdsô accessibility to food. Several authors use alternative indicators as such under-five mortality rate, child malnutrition and the proportion of undernourished children. The under-five mortality rate partially reflects the fatal synergy between inadequate dietary intake and unhealthy environments. It gives an idea of the severity of food insecurity. The child malnutrition measures the prevalence of underweight in children under the age of five, indicating the proportion of children suffering from weight loss. The proportion of undernourished, as estimated by the Food and Agriculture Organization (FAO), reflects the share of the population with inadequate dietary energy intake, i.e. the proportion of people who are food energy deficient.[124]

Bruinsma shows that the proportion of undernourished and the prevalence of underweight in children are both limited in that they do not reveal premature death, which is the most tragic consequence of hunger and under nutrition.[125] The same level of child malnutrition in two countries can have quite different effects on the

[123] Cabero-Roura, L. & Rushwan, H. An update on maternal mortality in low-resource countries. *Int. J. Gynecol. Obstet.* 2014, *125*, 175ï180.
[124] Furbank, R. Phenomicsð Technologies to relieve the phenotyping bottleneck. *Trends Plant Sci.* 2011, *16*, 635ï644.
[125] Bruinsma, J. *The Resource Outlook to 2050: By How Much do Land, Water and Crop Yields Need to Increase by 2050? FAO Expert Meeting on How to Feed the World in 2050*; Food and Agriculture Organization: Rome, Italy, 2009.

proportion of malnutrition-related deaths among children, depending on the overall level of child mortality. Kabat thinks that this limit of the indicator of child malnutrition is mitigated if they take in account of the under-five mortality rate.[126] Mortality takes into account causes of death other than malnutrition, and that the actual contribution of child malnutrition to mortality is not easy to track because the proximate cause of death is frequently an infectious disease.

According to Sumner the indicators of child malnutrition and of infant mortality cover a category of population (children). Recent studies refer to the Global Hunger Index (GHI) as measure food insecurity.[127] The GHI is a statistical tool to measure and monitor hunger in the world by country and by region. It captures three dimensions of hunger: i) insufficient availability of food, ii) shortfalls in the nutritional status of children, and iii) premature mortality caused directly or indirectly by under nutrition. The GHI combines the percentage of people who are food energy deficient, which refers to the entire population, with the two indicators that deal with children under five. This index seems to be the best indicator to measure food security. However, this indicator is not available over a long period of time.[128]

However, democracy would spread the penalty of food insecurity to the ruling groups and political leaders. This gives them the political incentive to try to prevent any threatening food insecurity. Maurice also thinks that a free press and the practice of democracy contribute greatly to bringing out information that can have an enormous impact on policies for food insecurity prevention (for example, information about the

[126] Kabat, P. Future water resources for food production in five South Asian river basins and potential for adaptation A modeling study. *Sci. Total Environ.* 2013, *468*, S117ï S131.

[127] Sumner, A. Estimating the scale and geography of global poverty now and in the future: How much difference do method and assumptions make? *World Dev.* 2014, *58*, 67ï 82.

[128] Springer, N. & Duchin, F. Feeding nine billion people sustainably: Conserving land and water through shifting diets and changes in technologies. *Environ. Sci. Technol.* 2014, *48*, 4444ï 4451.

nature and impact of new production techniques on food supply).[129] The author concludes that a free press and an active political opposition constitute the best early-warning system for a country threatened by famines. Vadez consider that democracy is hypothesized to play a major role in the reduction of food insecurity.[130]

According to these authors, a more democratic government affects large revenues in education, health services and income redistribution. This contributes to reduce the problems of food insecurity in the areas affected. Bryan also suggest that a more democratic government may be more likely to respond to the needs of all of its citizens, womenôs as well as menôs.[131] With respect to food security, the analyses of Pasuquin and Oberthür, among others, conclude that democracy is very important in averting food insecurity.[132] More democratic governments may be more likely to honour human rights including the rights to food and nutrition and to encourage community participation, both of which may be important means for reducing child malnutrition.

Affholder established a relationship between civil conflicts and hunger in developing countries.[133] Indeed, in the countries in conflict, population, households and individuals suffer disruptions in livelihoods, assets, nutrition and health. The Combatants frequently use hunger as a weapon by cutting off food supplies and productive capacities, starving opposing populations into submission, and hijacking

[129] Maurice, J. New goals in sight to reduce poverty and hunger. *Lancet* 2013, *382*, 383ï 384.
[130] Vadez, V. (2010). Developing drought tolerant crops: Hopes and challenges in an exciting journey. *Funct. Plant Biol.* 2014, *41*, vï vi.
[131] Bryan, B. Influence of management and environment on Australian wheat: Information for sustainable intensification and closing yield gaps. *Environ. Res. Lett.* 2014, *9*, 044005, doi:10.1088/1748-9326/9/4/044005.
[132] Pasuquin, J. & Oberthür, K. Closing yield gaps in maize production in Southeast Asia through site-specific nutrient management. *Field Crops Res.* 2014, *156*, 219ï 230.

[133] Affholder, F. The yield gap of major food crops in family agriculture in the tropics: Assessment and analysis through field surveys and modelling. *Field Crops Res.* 2013, *143*, 106ï 118.

food aid intended for civilians. Warfare disrupts markets and destroys crops, livestock, roads and land. Deliberate asset-stripping of households in the conflict regions may cause those households to lose other sources of livelihood as the ongoing conflict leads to breakdowns in production, trade and the social networks.[134] The disruption of markets, schools and infrastructure removes additional resources required for food production, distribution, safety and household livelihoods. These consequences aggravate food insecurity in the countries in conflict.

Sonnino have estimated the extent of food production losses due to conflict by examining trends in war-torn countries of Sub-Saharan Africa during 1970 to 1994 and found that food production was lower in the war years by a mean of 12.3%.[135] This decrease in food production has significant impacts on food availability because in these countries, a majority of the workforce earns their livelihood from agriculture. In addition, in eight of the countries, two-thirds or more of the workforce are engaged in agricultural activities. Kouser based on some empirical studies confirms that reliable and adequate irrigation increases employment, that is Landless laborers as well as small and marginal farmers have more work on more days of the year, which ultimately contributes to food security.[136]

A study conducted in 10 Indian villages in different agro-climatic regions shows that increasing irrigation by 40 percent was equally effective in reducing poverty (reducing food insecurity) as providing a pair of bullocks, increasing educational level and increasing wage rates.[137] Irrigation has significantly contributed to boosting

[134] Monjardino, M. & Llewellyn, R. Are farmers in low-rainfall cropping regions under-fertilising with nitrogen? A risk analysis. *Agric. Syst.* 2013, *116*, 37ï 51.
[135] Sonnino, A. Agricultural biotechnologies in developing countries and their possible contribution to food security. *J. Biotechnol.* 2011, *156*, 356ï 363.
[136] Kouser, S. Genetically modified crops and food security. *PLoS ONE* 2013, *8*, 1ï 7.
[137] Wright, B.D. Grand missions of agricultural innovation. *Research Policy* 2012, *41*, 1716ï 1728.

India's food production and creating grain surpluses used as drought buffer. A study by Castellanos confirms that access to reliable irrigation water can enable farmers to adopt new technologies and intensify cultivation, leading to increased productivity, overall higher production, and greater returns from farming.[138] This in turn opens up new employment opportunities; both on farm and off-farm, and can improve incomes, livelihood, and the quality of life in rural areas.

The same study identified five key dimensions of how access to good irrigation water contributes to socioeconomic uplift of rural communities.[139] These are production, income and consumption, employment, food security, and other social impacts contributing to overall improved welfare. According to a study carried out on five irrigation schemes in Zimbabwe, the schemes were found to act as sources of food security for the participants and the surrounding community through increased productivity, stable production and incomes.[140] The same study reported that farmers participating in irrigation schemes never run out of food unlike their counterparts that depend on rain-fed agriculture.

Hellegers disclosed that in Kenya for the two decades agricultural production has not been able to keep pace with the increasing population.[141] To address this challenge the biggest potential for increasing agricultural production lies in the development of irrigation. According to the same study, irrigation can assist in agricultural diversification, enhance food self-sufficiency, increase rural incomes, generate

[138] Castellanos, M. Nitrogen fertigation: An integrated agronomic and environmental study. *Agric. Water Manag.* 2013, *120*, 46ï 55.

[139] Yan, E. The use of GRACE data to monitor natural and anthropogenic induced variations in water availability across Africa. *Earth Sci. Rev.* 2014, *136*, 289ï 300.

[140] Ramillien, G. Validation of GRACE-derived terrestrial water storage from a regional approach over South America. *Remote Sens. Environ.* 2013, *137*, 69ï 83.

[141] Hellegers, P. Climate-smart tank irrigation: A multi-year analysis of improved conjunctive water use under high rainfall variability. *Agric. Water Manag.* 2015, *148*, 52ï 62.

foreign exchange and provide employment opportunity when and where water is a constraint. Shah concluded that the major contributions of irrigation to the national economy are food security, employment creation, and improved foreign exchange earnings.[142]

A study by Chen states that in Ethiopia, the construction of small-scale irrigation schemes has resulted in increased production, income and diet diversification in the Oromia and Southern Nation and Nationalities People (SNNP) regions.[143] According to this study, the cash generated from selling vegetables and other produce is commonly used to buy food to cover the household food demand during the food deficit months. The same study further added that during an interview conducted with some farmers, it was disclosed that the hungry months reduced from 6 to 2 months (July and August) because of the use of small scale irrigation.

Moreover, the increase in diversity of crops across the schemes and the shift from cereal livestock system to cereal-vegetable-livestock system is starting to improve the diversity of household nutrition through making vegetables part of the daily diet. A study conducted by Aslam also identified that in Tigray region irrigated agriculture has benefited some households by providing an opportunity to increase agricultural production through double cropping and by taking advantage of modern technologies and high yielding crops that called for intensive farming.[144]

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[142] Shah, T. (2011). Towards a managed aquifer recharge strategy for Gujarat, India: An economistôs dialogue with hydro-geologists. *J. Hydrol.* 2014, *518*, 94ï 107.
[143] Chen, J. Assessment of deep groundwater over-exploitation in the North China Plain. *Geosci. Front.* 2011, *2*, 593ï 598.

[144] Aslam, Z. Managing salinity and waterlogging in the Indus Basin of Pakistan. *Agric. Water Manag.* 2008, *95*, 1ï 10.

3.2.2 Agricultural Water Development

An essential part of sustainable human development is food production. Sustainable agricultural water management objectives include attaining food security and maximizing food water productivity in rain-fed and irrigated agriculture.[145] A majority of global population growth is occurring in developing countries, some of which rely heavily on rain-fed agriculture. Therefore, rain-fed agriculture must expand and/or see increased productivity to feed the growing population. Irrigation provides a water supply buffer during dry periods, reducing the risks to purely rainfed agriculture. Though irrigation led to notable production gains in India and China over the past decades, it was coupled with increased dependency on unrenewable water resources in many regions.[146]

Few of the Green Revolution nations prioritized sustainable agricultural water use with increasing yields and meeting food security goals.[147] Therefore, while the Green Revolution more than doubled crop yields, resulting in greater food security, lower food prices, and improved social and economic conditions, it also had many unintended environmental consequences. Government subsidies for water and energy (for pumping water) have led to wider adoption of irrigation and higher crop yields, however the low costs provide little incentive for farmers to conserve water and adopt more efficient irrigation methods. In many agricultural regions, greater than 100% of

[145] Mechlem, K. (2004), Food Security and the Right to Food in the Discourse of the United Nations. European Law Journal, 10: 631ï 648

[146] Ayalew, Y. (2011). *Identification of Food Insecurity and Coping Strategies of Rural Households in North.*

[147] Bruinsma, J. *The Resource Outlook to 2050: By How Much do Land, Water and Crop Yields Need to Increase by 2050? FAO Expert Meeting on How to Feed the World in 2050*; Food and Agriculture Organization: Rome, Italy, 2009.

the renewable water resources are used for irrigation each year.[148] These regions must assess alterative irrigation support policies and agricultural water management strategies in order to sustain production in the future.

Quantification of agricultural practice impact on water resources will help prevent these negative impacts under future development. Doss and Morris present case studies for Tunisia and China using an indicator method for evaluating agricultural management strategies. Their framework accounts for water reuse and crop production economics.[149] Preece used optimization of social, environmental, and economic benefits to define agricultural plans.[150] While leaving natural areas uncultivated was environmentally sustainable, it provided little support for human development. The optimization method recommended mixed use: leaving part of the land in its natural condition, and converting part of it for cultivation. Despite the demonstrated success, optimizing agricultural development and environmental water resources is not typical.

Improving water productivity and reducing risk in rain-fed crops by using supplemental irrigation are the various types of solutions. Sumner suggests a transition from Green Revolution to Blue Revolution, where productivity is measured in crop production per unit water.[151] In much of the developing world, irrigation systems are less than 50% efficient. Increasing irrigation productivity requires

[148] Ramillien, G. Validation of GRACE-derived terrestrial water storage from a regional approach over South America. *Remote Sens. Environ.* 2013, *137*, 69ï 83.

[149] Doss, C. R. and Morris, M. L. (2001). ñHow does Gender affect Adoption of Agricultural Innovation? The Case of Improved Maize Technology in Ghanaò. *Journal of Agricultural Economics,* 25, pp 27-39.

[150] Preece, R. (1994). *Starting Research – An Introduction to Academic Research Dissertation Writing*. Great Britain. Pinther.

[151] Sumner, A. Estimating the scale and geography of global poverty now and in the future: How much difference do method and assumptions make? *World Dev.* 2014, *58*, 67ï 82. Sumner, A. Estimating the scale and geography of global poverty now and in the future: How much difference do method and assumptions make? *World Dev.* 2014, *58*, 67ï 82.

improvements to technical, managerial, institutional, and agronomic methods. In rain-fed agricultural regions, improvements in rainwater capture, selection of drought-resistant crops, and alternate tillage practices will be critical to feeding growing populations. Using rainwater harvesting for supplemental irrigation to mitigate the impact of dry spells, combined with soil fertility management, can more than double rain-fed crop yields. Though the practice is not broadly used, there is widespread potential for water harvesting for supplemental irrigation in many rain-fed agricultural regions.[152]

3.2.3 Regional Framework

Few of the Green Revolution nations prioritized sustainable agricultural water use with increasing yields and meeting food security goals.[153] Therefore, while the Green Revolution more than doubled crop yields, resulting in greater food security, lower food prices, and improved social and economic conditions, it also had many unintended environmental consequences. Government subsidies for water and energy (for pumping water) have led to wider adoption of irrigation and higher crop yields, however the low costs provide little incentive for farmers to conserve water and adopt more efficient irrigation methods. In many agricultural regions, greater than 100% of the renewable water resources are used for irrigation each year. [154] These regions must assess alterative irrigation support policies and agricultural water management strategies in order to sustain production in the future.

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[152] Hertel, T. (2010). The global supply and demand for agricultural land in 2050: a perfect storm in the making? Presidential Address presented at the Annual Meeting of the Agricultural and Applied Economics Association. Denver, 25ï 27 July 2010.

[153] Bruinsma, J. *The Resource Outlook to 2050: By How Much do Land, Water and Crop Yields Need to Increase by 2050? FAO Expert Meeting on How to Feed the World in 2050*; Food and Agriculture Organization: Rome, Italy, 2009.

[154] Ramillien, G. Validation of GRACE-derived terrestrial water storage from a regional approach over South America. *Remote Sens. Environ.* 2013, *137*, 69ï 83.

The Protocol to the African Charter on Human and Peoples' Rights on the Rights of Women in Africa guarantees the right of women to food security and requires States Parties to facilitate womenós enjoyment of this right to nutritious and adequate food.[155] The EAC Climate Change Policy was formulated with the overall aim contributing to sustainable development in the East African Region through harmonized and coordinated regional strategies, programmes and actions to respond to climate change. The East African Community Treaty 1999 which is a multi-sectoral treaty states that the overall objectives of co-operation in the agricultural sector are the achievement of food security and rational agricultural production within the Community.[156]

Africa as a continent has attempted to put in place measures so as to deal with the problem of food security for its people. There exist regional instruments that attempt to bring together the efforts of various countries so as to adequately address the problem of food in security for their people.[157] The Comprehensive Africa Agriculture Development Programme (CAADP) was established as part of New Partnership for Africa Development (NEPAD) in July 2003 with the objective of improving and promoting agriculture across Africa. CAADP aims to eliminate hunger and reduce poverty through agriculture so that by the year 2015, the following can be achieved: dynamic agricultural markets within and between countries and regions in Africa; farmers being active in the market economy and the continent becoming a net

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[155] Wang, J., Xu, Z., Huang, J. and Rozelle, S. (2006) Incentives to managers or participation of farmers in China's irrigation systems: which matters most for water savings, farmer income, and poverty?, Agricultural Economics 34: 315ï 330.

[156] Tadel, F. & Debel, G. (2006). *An econometric analysis of the link between irrigation markets and poverty in Ethiopia: The case of smallholders vegetable and fruit production in the North Omo Zone.*

[157] United Nations (2010). United Nations Water Conference- Resolutions in Report of the United Nations water conference, Mar del Plata, 14 March 1977. United Nations Publications. Sales No.E.77.II.A.12.

exporter of agricultural products; a more equitable distribution of wealth for rural populations; Africa as a strategic player in agricultural science and technology; and environmentally sound agricultural production and a culture of sustainable management of natural resources in Africa.[158]

3.3 Food Security and Its Relevance to Developing Countries Context

Agriculture will continue to be the largest user of developed water resources in most countries, often accounting for 70% or more of water withdrawals from rivers, reservoirs, and aquifers.[159] Increasing demands for water in cities and industries, and for environmental flows, will reduce the volume of water available for agriculture in many areas. Yet, globally, the volume of water transpired in crop and livestock production must increase between now and 2050, if we are to increase food production. Farmers in many regions must adapt to having less water available for irrigation, while facing increasing demands for their products. Innovations in technology and investments in education and training with regard to managing water in both irrigated and rain-fed settings are needed to achieve sustainable agricultural production.[160]

Horenstein suggested that agriculture must produce more food with less water in future, given the increasing demands for water in competing sectors.[161] While

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[158] Facon, T. & Mukherji, A. (2011). Improving the performance of public irrigation in South Asia. Paper presented at the GWP/IWMI Workshop on Climate Change, Food and Water Security in South Asia, Colombo 23ï 25 February 2011.

[159] Wang, J., Xu, Z., Huang, J. and Rozelle, S. (2006) Incentives to managers or participation of farmers in China's irrigation systems: which matters most for water savings, farmer income, and poverty?, Agricultural Economics 34: 315ï 330.

[160] Lucio, M. (2004). *Irrigation and cropping intensity.* International Association of Hydrological Sciences (International Association of Hydrological Sciences Press 2004

[161] Horenstein, N. (2009). Women and Food Security in Kenyaó, *PPR Working Paper Series*, Women in Development Division, World Bank, June, WPS 232.

compelling at first read, this phrase is not sufficiently precise, as it does not distinguish between the water diverted and applied to farm fields, and the water transpired in the process of generating crop yields. Much of the water applied in irrigation runs off the ends of farm fields or percolates into shallow groundwater, where it is available for use again in irrigation or for some other purpose. Only the water consumed by crops in the process of transpiration, and the water that evaporates from plant and soil surfaces, are ñlostò from the system at this point in the hydrologic cycle. Opportunities for saving water through investments in technology are limited by the extent to which water is lost in each setting.[162]

The distinction between water diverted and water transpired is important when considering water requirements for food production. The relationship between crop yield or biomass and the amount of water transpired is largely linear for a given cultivar and production setting.[163] Thus, in a given setting, absent a technological advance, higher yields can be generated only by transpiring more water. Similarly, more water will be transpired in agriculture as planted areas are expanded in pursuit of higher aggregate production. Advances in crop production technology, including genetic enhancement, can modify the yield-transpiration relationship, such that more output is produced per unit of water transpired. Yet, absent major advances in technology, the amount of water transpired in agriculture will increase between now and 2050.[164]

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[162] Tafesse.H. (2007). Socio-economic and Institutional Determinants of Small Scale Irrigation schemes utilization in Bale Zone,Oromiya National Regional State. *A Master Thesis, Alemaya University*.

[163] Cleaver, F. (2008). Incentives and informal institutions: Gender and the management of water, Agriculture and Human Values, 15:347-360.

[164] Mengistu, A. (2007). *Socio economic assessment of the small scale irrigation schemes in Adami Tulu JidoKombolchaWoreda, Central rift valley of Ethiopia: A Msc thesis in Enviromental Economics and Natural resource groups.* Addis Ababa: Department of Enviromental Sciences, AAU.

The water required to support additional transpiration in 2050 can come from several sources, including new development of surface water and groundwater resources for use in agriculture, and better efforts to capture and re-apply surface runoff and utilize shallow groundwater directly in crop production.[165] Farmers also can reduce evaporation and improve distribution uniformity by replacing surface irrigation methods with drip systems and micro-sprinklers, where feasible, and they can minimize transpiration by non-beneficial plants by removing vegetation from irrigation canals. Such efforts to optimize water use are consistent with the notion of sustainable agricultural intensification, in which higher yields are achieved with given resources, while reducing negative impacts on the environment and enhancing natural capital.[166]

Competing demands in other sectors and public demands for environmental amenities will limit the amount of new development of surface water and groundwater for agriculture in many regions.[167] Yet, many farmers can improve water management in ways that reduce non-beneficial evaporation and increase the portion of applied water that is transpired beneficially by crops. Farmers also can increase the amount of crop yield obtained per unit of water transpired by assuring that other essential inputs are available in adequate supply. Agricultural productivity generally is higher when high-

[165] Boye, A. and Albrecht, A. (2003). Soil and Water Conservation by Crop Rotation with Leguminous Shrubs - A Case Study on Runoff and Soil Loss under Natural Rainfall in Western Kenya. World Agroforestry Centre (ICRAF), Nairobi, Kenya, 21 pp.

[166] Mati, B. Morgan, R. P. C., Gichuki, F. N., Quinton, J. N., Brewer, R. T., and Liniger, H. P. (2000). Assessment of Erosion Hazard with the USLE and GIS: A Case Study of Upper Ewaso Ngiro North Basin of Kenya. *International Journal of Applied Earth Obervation and Geoinformation,* 2 (2): 78-86.

[167] Vishnudas, S. (2006). Sustainable Watershed Management: Real or Illusion? A Case Study of Kerala State in India. PhD Thesis. Delft, Faculty of Watershed Management, Delft University of Technology, Netherlands, 165 pp.

quality seeds, soil moisture, plant nutrients, and farm chemicals are applied in sufficient amounts and at the appropriate times during the season.[168]

Food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO).[169] Food security has three key dimensions. First, food availability or food supply. Food supply availability is a pre-condition for food access. At the national level, food supply availability has two sources: i) domestic food production and net of food exports; and ii) food imports. Therefore policies that promote the expansion of domestic food production and facilitate international food trade are potentially pro-food security policies.[170]

Second, purchasing power for food access by households. Access to food requires households to have adequate purchasing power (real income) for food acquisition through markets. While in the short-run this is not the case for the poorest households in LAC, medium-term policies that promote higher sustainable real income for the poor are without doubt pro-food security.[171] Real food demand capacity is also affected by food prices which are influenced by domestic interaction between supply and demand, by international prices, and by policies that shape domestic and international food price transmission. Third, food consumption and utilization. Food

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[168] Svendsen, S., Ewing, M. & Msangi, S.(2009). *Measuring irrigation performance in Africa*. IFPRI Discussion Paper 894. Washington, D.C.: International Food Policy Research Institute

[169] Shah, T. and Lele, U. (Eds.) (2011) Synthesis of Workshop Discussions. Climate Change, Food and Water Security in Africa: Critical Issues and Cooperative Strategies in an Age of Increased Risk and Uncertainty. GWP, Stockholm and IWMI, Colombo.

[170] Brown, O., and Crawford, A., ÇClimate Change and Security in Africa: A Study for the Nordic-African Foreign Ministers Meetingó, March 2009, *International Institute for Sustainable Development*.

[171] Affholder, F. The yield gap of major food crops in family agriculture in the tropics: Assessment and analysis through field surveys and modelling. *Field Crops Res.* 2013, *143*, 106ï 118.

security also requires access to adequate, safe and nutritious food. This, in turn, depends on several economic and sociocultural factors. In particular, poverty, education, gender disparities, geographical location, available sanitary conditions, and cultural practices are important factors that affect food consumption patterns.[172]

Consequently, policies that increase the level of education of the population, promote better dietary habits, and improve sanitary and health services are also pro-food security policies. In addition, safety net programs for vulnerable groups are crucial for food access.[173] Safety net programs assist populations with inadequate purchasing power to gain food access. Safety net programs can provide additional purchasing power through cash transfers and/or provide food directly to vulnerable groups. In both cases, safety net programs have an effect on food demand and food supply. Cash transfers can directly affect the demand for food as program beneficiaries use the cash to increase their food purchases in local markets. Food transfers also affect food demand, as programs must purchase the food to be transferred. If induced demand of safety net programs has an impact on prices, this might also induce food supply response.[174]

In a broader sense, the concept of food security can be associated with all factors underlying the economic circuit of an economy, including both the agricultural and

[172] Economic and Social Development at the United Nations, World Summit for Social Development, Copenhagen, 2010.

[173] Hussain, I. (2005). *Pro-poor Intervention Strategies in Irrigated Agriculture in Asia. Poverty in Irrigated Agriculture: Issues, Lessons, Options and Guidelines (Bangladesh, China, India, Indonesia, Pakistan and Vietnam).* Project Final Synthesis Report. IWMI, Colombo.

[174] Hellegers, P. Climate-smart tank irrigation: A multi-year analysis of improved conjunctive water use under high rainfall variability. *Agric. Water Manag.* 2015, *148*, 52ï 62.

non-agricultural sector.[175] Understanding the concept of food security from a broader economic perspective is important to distinguish between direct policies oriented to promote agriculture development and indirect policies oriented to promote rural labor in a broader sense and increase household income, which also contribute to ensure food security. It further helps to identify the mechanisms through which the different policies can reduce food insecurity and to better assess the impact of these policies across time. Policies to promote agricultural development, for example, might involve short, medium, and long-term programs, while policies to promote sustainable rural income growth typically require an important number of medium- and long-term policies.[176]

The food world is facing a formidable challenge to secure the global supply required to feed the world in 2050.[177] Current global imbalances in food supply and demand are set to increase due to a complex of factors, including population growth, increasing wealth, dietary shifts to more animal proteins and a rise in urbanisation. Agriculture is not only expected to produce more food, but also more raw materials for biofuels, biochemicals and fibres. According to the Food and Agriculture Organisation, an estimated one billion people around the world are undernourished and the world population will grow by more than three billion by 2050.[178] World

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[175] Bierkens, M. Global depletion of groundwater resources. *Geophys. Res. Lett.* 2010, *37*, L20402, doi:10.1029/ 2010GL044571.

[176] Bryan, E., et al., ŲAdapting agriculture to climate change in Kenya: Household strategies and determinantsó *Journal of Environmental Management*, Volume 114, 15 January 2013, Pp. 26ï 35. Available at http://www.sciencedirect.com/science/article/pii/S0301479712005415 [Accessed on 17/09/2014].

[177] Samad, M. (2002). *Institutional alternatives in African smallholder irrigation: Lessons from international experience with irrigation management transfer.* Research Report 60. IWMI, Colombo

[178] Mukherji, A. (2011). Paradox of poverty amid plenty of groundwater. Paper prepared for the GWP/IWMI Workshop on Climate Change, Food and Water Security in South Asia, Colombo 23ï 25 February 2011.

agricultural crop output must almost double to nourish this growing population and to meet required non-food purposes. There will be acute pressure to use less water in order to feed this rising population. Water is at the heart of the global resource security challenge. As the world is heading for a projected 40 percent gap in the ratio of supply and demand of freshwater by 2030, water scarcity will have significant repercussions for agriculture, both agronomical and economical.

Moreover, the food sector is becoming more interlinked to other sectors; an increase in energy prices will, for example, immediately lead to higher food prices. A continuing threat to global food security will slow economic growth, disproportionately hit the urban and rural poor (particularly those in low income countries), strain public finances and raise geopolitical tensions.[179] Successful efforts to supply sufficient food will include closing yield gaps in lower income countries, in part by increasing the use of better seeds and fertilizer, improving resource management, and enhancing the technology of crop production through advances in genomics and phenomics. In addition, public officials must choose policies and investments that encourage increases in agricultural productivity on large and small farms, and in irrigated and rainfed settings. Yet, even with success in producing sufficient food, globally, food insecurity will remain a serious issue in some regions and countries where per capita food consumption will remain inadequate.[180]

Global incomes are expected to rise substantially by 2050, yet areas of notable poverty will persist in some countries, particularly in sub-Saharan Africa. The per

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[179] Rukuni M, Eicher C. & Blackie, K. (2006). *Zimbabwe's Agricultural Revolution, Revisited*, University of Zimbabwe Publications, Harare.

[180] Doss, C. R. and Morris, M. L. (2001). ñHow does Gender affect Adoption of Agricultural Innovation? The Case of Improved Maize Technology in Ghanaò. *Journal of Agricultural Economics,* 25, pp 27-39.

capita annual income in 2050 likely will remain below $1000 in 15 of the 98 lower income countries examined by Alexandratos and Bruinsma.[181] Average daily food consumption might remain below 2700 kcal per person in 16 of the 98 countries. Those 16 countries will be home to a population of 800 million. By comparison, an estimated 4.7 billion people (52% of global population) will live in countries with national daily averages of more than 3000 kcal per person in 2050, up from 1.9 billion (28%) in 2011.[182] The agricultural sector is a critical mainstay of local livelihoods and national GDP in some countries in Africa.

Estimates of the increase in food production required to ensure food security in 2050, from the global perspective, range from 60% to 100% above the production achieved in 2005.[183] Those proportions are notably higher than the rate of increase in population to 2050, due largely to the increasing demands and changing preferences for food, that come with higher incomes. Household and per capita food consumption will increase in many countries, and many residents will consume more meat and vegetables. Those commodities, particularly beef, generally require more water and other productive inputs than grains, per calorie of food consumed.[184] The increasing demand for meat will place additional pressure on limited water resources in some regions. The projected increases in food demand, when realized, will reflect

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[181] Muluken, L. (2005). Water Resources Development of Amhara Region and the Challenges.*A paper presented at Workshops on achievements and priorities in irrigation water mangement research and technology in Ethiopia with particular reference in Amhara Region*, (p. 18). Bahirdar

[182] Ayalew, Y. (2011). *Identification of Food Insecurity and Coping Strategies of Rural Households in North.*

[183] Kay, M. (2011). *Smallholder Irrigation Technology: Prospects for sub-Saharan Africa*. International Programmeme for Technology and Research in Irrigation and Drainage, Knowledge Synthesis Report No. 3. IPTRID Secretariat, Food and Agriculture Organisation of the United Nations, Rome.

[184] Madulu, N. (2012). Main socio-economic study for Kihansi River Catchment Management Plan. Research Report No. IRA/CST98.1, Dar es Salaam.

substantial improvement in food and nutritional security for those households with sufficient income to afford adequate food supplies.

As in the present, much of the food and nutritional insecurity that persists in 2050 will be found largely in poor households in countries with lower gross incomes and in areas where depleted or degraded natural resources no longer support viable livelihood activities for smallholders.[185] The primary cause of food insecurity will be the persistent poverty that prevents households from gaining access to sufficient food and nutrition, particularly during periods of notable scarcity and high prices. Thus, the policies and investments most likely to enhance food security will be those that promote economic growth and increase incomes, particularly in rural areas, where many of the worldôs poor are engaged in agriculture. Substantial public and private-sector investments and policy interventions are needed between now and 2050, particularly in agriculture, to reduce poverty, increase incomes, and ensure food security for all.[186]

The extent and severity of food insecurity in 2050 likely will correspond to the extent and depth of dollar-based poverty. In 2007, an estimated 47% of the worldôs poor earning less than $1.25 per day lived in South Asia, while 31% and 17% lived in sub-Saharan Africa and South Asia and the Pacific, respectively.[187] Just 2.3% of the worldôs poor earning less than $1.25 per day lived in Latin America and the Caribbean. Projecting future poverty levels and geographic distribution is imprecise,

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[185] Moriarty, P. & Butterworth, J. (2003). *The productive uses of domestic water supplies: how water supplies can play a wider role in livelihood improvement and poverty reduction*. IRC, Thematic Overview Paper.

[186] Tsegaye, Y. and Tamene, L. (2005). Small holder Irrigation and its Challenges in Ethiopia's Food Security Agenda: lesson from Ghana. *Center for Development Research*, Bonn, Germany.

[187] Turner, B. (1994). Small Scale Irrigation in Developing Countries. *Land Use policy 11(4)* 251-261.

given the many factors that influence livelihoods and incomes. Facon and Mukherji examine several scenarios reflecting alternative assumptions regarding economic growth. They suggest that the number of poor earning less than $2.00 per day might increase or decline by 2030, yet they do not expect extreme poverty to be eradicated. In their most optimistic scenario, 300 million persons will live in extreme poverty in 2030.[188] The authors suggest also that even if the number of poor earning less than $2.00 per day decreases, the number of moderately poor persons might increase. In their view, it is likely that 50% to 70% of the global population in 2030 might earn less than $10 per day.[189]

3.4 Conclusion

The National Accelerated Agricultural Input Access Program (NAAIAP) is a pro-poor, food security and poverty alleviation government initiative that is aligned with Vision 2030 and other government policy documents. It provides targeted agricultural inputs subsidy to smallholder resource poor farmers. The core objective of NAAIAP is to improve farm inputs access and affordability for small-scale farmers to enhance food security at household level and generate incomes from sales of surplus produce. The National Agricultural Sector Extension Policy 2012 (NASEP) provides for effective management and organization of agricultural extension in a pluralistic system where both public and private service providers are active participants. It provides a point of reference for service providers and other stakeholders on standards, ethics and approaches, and guides all players on how to strengthen coordination, partnership and collaboration. The Program is however said to be facing

[188] Facon, T. & Mukherji, A. (2011). Improving the performance of public irrigation in South Asia. Paper presented at the GWP/IWMI Workshop on Climate Change, Food and Water Security in South Asia, Colombo 23ï 25 February 2011.
[189] Furbank, R. Phenomicsð Technologies to relieve the phenotyping bottleneck. *Trends Plant Sci.* 2011, *16*, 635ï 644.

challenges due to limited information on crop nutrients requirements, characteristics of soils and high level of variation in soil properties that are experienced across many sub counties where the program operates.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND INTEPRETATION

4.1 Introduction

This chapter covers data presentation and analysis of the data collected through questionnaires and Secondary data collected through evaluation of textbooks, daily newspapers, journals, articles, and published and unpublished thesis. The secondary data was also sourced from libraries, government departments and internet. In order to simplify the discussions, the researcher provided tables that summarize the collective reactions and views of the respondents. Special reference to provisions of relevant policies and laws was used. The relevant policies include: Current National Land Use Policy, The National Land Policy, The Kenya Vision 2030, The Agricultural Sector Development Strategy (ASDS) 2010ï 2020, The National Food Security and Nutrition Policy (NFSNP), The Kenya Food Security and Nutrition Strategy (KFSNS), Current National Spatial Plan and The Millennium Development Goals (MDGs).

4.2 Response Rate

The targeted sample size was 3 administrators in the area, 150 householdsô heads and 5 water and food projects coordinators. (County water department and agriculture) as calculated through a proportion of 10%. The total sample obtained comprised of 158 respondents.

Table 4.1: Questionnaire return rate

Target population	Sample	Returned	Percentage
Administrators	3	3	100
Householdsô Heads	150	150	100
Water and food projects coordinators	5	5	100
Total	**158**	**158**	**100**

Those filled and returned questionnaires were 158 respondents making a response rate of 100%. According to Mugenda and Mugenda [190] a response rate of 50% is adequate for analysis and reporting; a rate of 60% is good and a response rate of 70% and over is excellent. This means that the response rate for this study was excellent and therefore enough for data analysis and interpretation.

4.3 Demographic Information

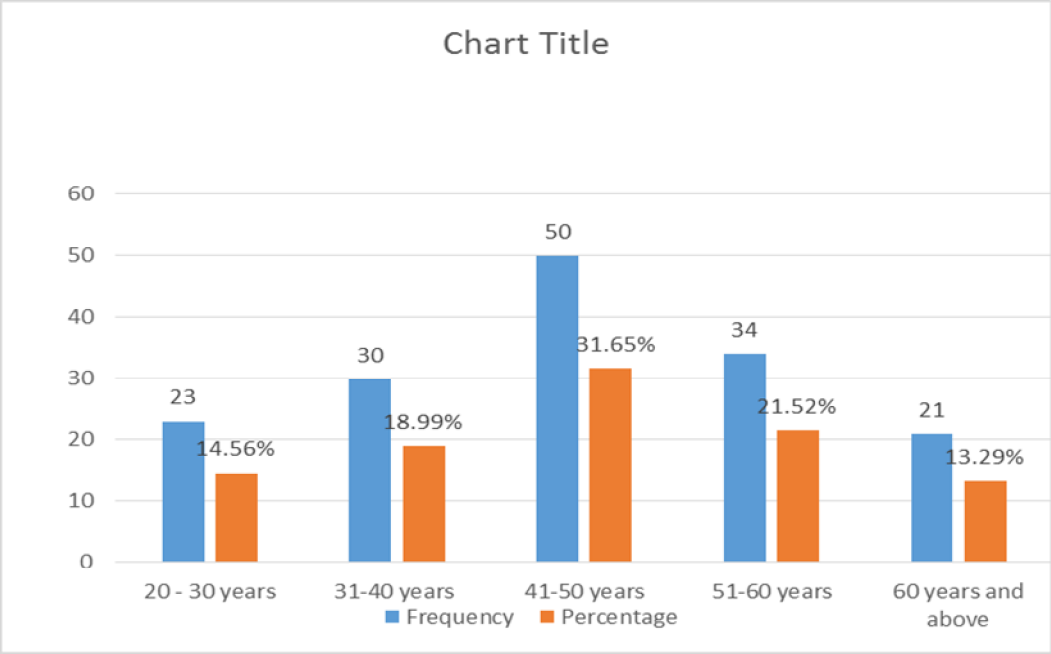
The study sought to establish the demographic information in order to determine whether it had influence on sustainable water management and food security in Kenya. The demographic information of the respondents included Age and education levels of the respondents.

[190] Mugenda, O. M & Mugenda, A. G. (2003).*Research Methods. Quantitative and Qualitative Approaches.* Nairobi: Act press.pp 32

4.3.1 Age Bracket of the respondents

The researcher sought to investigate whether the age bracket of the respondents affected the sustainable water management and food security in Kenya. The results are displayed on figure 4.1

Figure: Age Bracket of the respondents

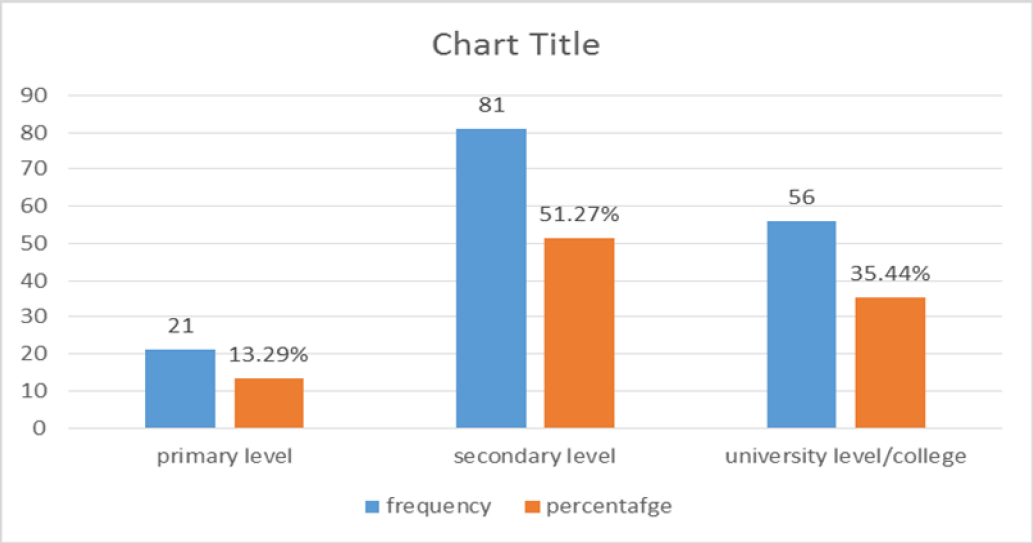


Majority of the respondents (31.65%) aged between 41-50 years, followed by the age 51-60 years with 21.52%. 18.99% of the study respondents were aged 31-40 years. 14.56% were of age 20 - 30 years with only 13.29% aged 60 years and above. The findings implies majority of administrators in the area, householdsô heads and water and food projects coordinators

4.3.2 Respondents' Education level

The researcher sought to investigate the education levels of the respondents to see whether it had effect on the topic sustainable water management and food security in Kenya. The findings are displayed on the table below.

Figure 4.2: **Education level**



The findings revealed that majority 51.27% had secondary education, 35.44% of the study respondents had primary education with the least percentage (13.29%) having university/college education. This implies that majority of administrators in the area, householdsô heads and water and food projects coordinators had secondary education.

4.3.3 Characteristics of the study area

According to the findings Nyakach is part of Nyando basin which is prone to displacement of population due to floods and other natural calamities like landslides. The area has unstable soil formation and little water sources. It also has low accessibility to water coverage and lack of adequate sanitation and water resource management. Diarrhoea is a major cause of morbidity and mortality in this area contributing to deaths of children under 5 years of age which stands at 212/1000 þirths. The area is inhabited by the Luo who are typically patrilineal and

virilocal (living in manôs family place). The main economic activities of the people are subsistence agriculture and fishing as well as unorganized sand harvesting. [191]

4.4 Respondents understanding on Food insecurity

According to the key informants[192] food insecurity is defined as the uncertainty of having, or the inability to acquire, enough food for all household members to sustain active, healthy living because of insufficient money or other resources. The findings also reveal that these characteristics reveal that food insecurity is closely associated with insufficiency of resources. Food insecurity has been found to be strongly correlated with many other measures of deprivation including low and fluctuating incomes, lack of savings, past and present unemployment and unstable employment and lower levels of social capital.[193] Poor health, including physical disabilities, has a negative association with an individualôs ability to acquire food, and thus increases the level of food insecurity, especially with the elderly.

Table 4.2: food insecurity

Statement	Yes	No
household ever run out of money to buy food	**66%**	**34%**
Relying on a limited number of foods to feed children	**65%**	**35%**
There are cases of eating less than expected because there is not enough money for food	**58%**	**42%**
Relate food insecurity and infectious diseases	**69%**	**31%**

The researcher sought to investigate whether there was food scarcity in Nyakach constituency. Of the study respondents interviewed 66% indicated that their household had ever ran out of money to buy food. 65% of the total number of

[191] FAO (2011). Committee on World Food Security: Conflict and Food Security. Kisumu: Food and Agricultural Organisation.p.13

[192] An interview with administrators in the area,12 July 215 Nyakach sub county

[193] An interview with householdsô heads and water and food projects coordinators 12 July 215 Nyakach sub county

respondents indicated that they were relying on a limited number of foods to feed their children. However majority 58% indicated that there had experienced cases of eating less than expected because there is not enough money for food.

4.4.1 Food Insecurity and Infectious Diseases

Based on the study findings 69% of the study respondents indicated that there was a relation between food insecurity and infectious diseases. However, a study by Okumu[194] with a total of 480 respondentôs, interviews were conducted to assess the nature of food insecurity in Luo individuals on the Nyakach Plateau. The overwhelming majority of people surveyed were food-insecure. Determined by people responses to the eight primary questions of the hunger scale questionnaire (HSQ), 5.63% of patients were designated as food-secure, while the remaining 94.37% were found to be food insecure. Most of the data analysis compared food security (no affirmative responses) against food insecurity (any affirmative response) due to the severity of the Nyakach Plateauôs hunger crisis and the large proportion of food-insecure people. Okumu findings indicated that of the 480 people surveyed, 187 people were diagnosed with a minimum of one infectious disease. More than one-third (38.96%) of the sample population had at least one case of infectious disease. A total of 17 different types of acute infectious diseases were found in the sample. These diseases, in decreasing order of prevalence, included malaria (8.54%), worms (6.88%), bronchitis (6.25%), upper respiratory infection (4.79%), conjunctivitis (3.96%), sinusitis (2.92%), pneumonia (2.71%), ear infection (2.50%), toothache/cavities or vaginitis (1.88%), cellulitis or urinary tract infection or gonorrhoea (1.04%), acute diarrhoea or pharyngitis (0.63%), and typhoid or amoebas

[194] Okumu, C. H. (2011).Agricultural Growth, Rural Poverty and Ecological Degradation in Kenya. Maseno
University Press.

(0.42%). Within the sample population, malaria had the largest prevalence of an individual infectious disease at 8.54%, followed closely by worm infection at 6.88%. When considered as a group, however, acute respiratory infections sinusitis, bronchitis, upper respiratory infection, pneumonia, and tonsillitis - affected the largest proportion of the population at 17.29%.

4.5 understanding the link between water management and food insecurity

According to the key informants[195] Water is key to food security. Crops and livestock need water to grow. Agriculture requires large quantities of water for irrigation and of good quality for various production processes. While feeding the world and producing a diverse range of non-food crops such as cotton, rubber and industrial oils in an increasingly productive way, agriculture also confirmed its position as the biggest user of water on the globe. Irrigation now claims close to 70 percent of all freshwater appropriated for human use.[196] In 2008, the Universal Declaration of Human Rights affirmed the right of everyone to adequate food. However, access to adequate food in the rural areas of many developing countries depends heavily on access to natural resources, including water, that are necessary to produce food. The UN General Assembly declared access to clean drinking water and sanitation as a human right on 28 July 2010. But the right to water in the context of the right to food is a complex question. While drinking and cooking water would be protected, water for food production would probably not be covered under the minimum needs in arid areas. There is enough water available for our global future needs, but this world picture hides large areas of absolute water scarcity which affects billions of people, many of whom are poor and disadvantaged. Major changes in policy and management, across

[195] An interview with water and food projects coordinators 10 July 215 Nyakach sub county

[196] Hellegers, P. (2015). Climate-smart tank irrigation: A multi-year analysis of improved conjunctive water use under high rainfall variability. *Agric. Water Manag.* 2015, *148*, 52ï62.

the entire agricultural production chain, are needed to ensure best use of available water resources in meeting growing demands for food and other agricultural products.[197]

4.6 Water Resources Management in the Nyakach

The study sought to investigate trends in Water Resources Management in the Nyakach area. According to the findings [198] water resources broadly include surface water, groundwater and all water based resources i.e. fisheries and other resources that owe their existence to water. Any water body under or upon land in the country is vested in the Government. Water resources management is the whole set of technical, institutional, managerial, legal and operational activities required to plan, develop, operate and manage water resources.[199] The Department of Water is charged with the responsibility of management and development of water resources. The development plan has the express aim of ensuring that potable water is made available at a reasonable distance to all households through the establishment of water supply infrastructure. Safe water coverage is generally low in the country; in Nyanza, it still stands at 42%. Many children born alive die before their fifth birthday and more than 50% of them, die from diarrhoea and other preventable water related diseases.[200] The new water development policy encourages more active involvement of the private sector and communities in the development and management of the water resources. Inexpensive and sustainable technologies are being encouraged. There is an increase in waterborne diseases due to discharge of domestic sewage effluents especially in

[197] Ibid
[198] An interview with administrators 11 July 215 Nyakach sub county
[199] An interview with water and food projects coordinators 10 July 215 Nyakach sub county
[200] Mwanzia H. (2015). *Sustainable Food Security for all by 2020 Report: Addressing World Food shortage.* Bonn: Kenya. International Food and policy Research Institute.

Nyakach Sub County. According to the findings organic and agro-chemical pollution has increased. Budgetary constraints have been one of the main bottlenecks in the development of the water sector. Flooding in the reaches of Nyando Basin is a big problem to the Nyakach communities. The Department of Water had put in place several plans to address this issue. Dyke construction has been ongoing though slowly due to inadequate funds. Construction of check dams would control flooding and provide water for irrigation. [201]

Contrary to what is argued by some interviewers, agricultural intensification does not necessarily imply a deterioration of environmental quality. Instead, it is the mismanagement of inputs, such as inappropriate water use, overgrazing, and excessive, insufficient, or untimely applications of fertilizer and pesticides, which cause damage to the environment. Agriculture, forestry, fisheries and aquaculture, together with the bio-based industries, are integral parts of an economy and society. Relying on the use of limited natural resources, these sectors produce and process biological resources to satisfy the demand of consumers and a wide range of industries for food, bio-energy and bio-based products. These sectors enhance self-reliance and provide jobs and business opportunities essential for economic growth.[202]

4.6.1 Poor Water management, fish farming and food insecurity

The researcher sought to establish the effect of poor water management on fish farming. From the findings it was noted that majority of the respondents were of the opinion that poor water management had crawled down the farming industry. This was commonly attributed by unregulated solid and liquid waste from surrounding industries. These waste has introduced multiple environmental problems like

[201] Ibid
[202] Ibid

pollution, water hyacinth infestation, anoxia and alien species among others. [203] According to water and food projects coordinators in Nyakach sub county, the major environmental issues today are the growing concern about the water quality suitable for use by humans and animals. It is a known fact that the water quality condition is constantly being threatened by pollution.[204] The discharge of large quantities of wastes has been largely influenced by industrialization, urbanization, population increase and green revolution. These have resulted in widely distributed sources of pollution and thereafter, have created significant problem on the rivers and lakes to assimilate contaminants and increase their pollution loads. This environmental problem contribute greatly to lack of employment, lack of adequate fish for consumption hence food insecurity.

This findings concur with [205] Kenya has a 536 km long stretch of Indian Ocean coastline, multiple freshwater bodies and a long fishing history with the Luhyia, Luo and Abasuba ethnic groups actively fishing for more than five centuries. In 2011, capture fisheries directly employed 62,232 fishermen. The Kenyan capture fisheries sector comprises mainly artisanal practices; offshore marine waters are exploited by vessels from Distant Water Fishing Nations. Kenyaôs capture fisheries hence mainly depend on freshwater inland capture fisheries. In 2011 80% of Kenyaôs capture fisheries were comprised by Lake Victoriaôs harvest of approximately 133,800 tonnes. Lake Victoria one of the East African Great Lakes, is the world´s second largest freshwater lake. Its surface area is 68,800 km, with only 6% in Kenya. [206]

[203] An interview with householdsô heads 12 July 215 Nyakach sub county
[204] Ibid
[205] Katui, K. M. (2012). *Drawers of water: Kenya country Report.* May 2012. Page 20.
[206] 1bi p.24

According to the findings, Kenyaôs capture fisheries are at risk: Overfishing of marine fish resources is reported in some areas. Also, increasing fishing efforts on Lake Victoria combined with multiple environmental problems like pollution, water hyacinth infestation, anoxia and alien species introduction led to declining trend in catches for most fish species (apart from catfish and omena (Rastrienobola argentea). This could be an indicator for reduced fish stocks in the lake directly threatening food security and income for livelihoods of lakeside communities. The countryôs aquaculture sector could be a means to create employment and reduce pressure on capture fisheries. [207]

4.4.1.1 Flooding during the 2006 short rains season

According to a study by Wagesho and Kusters[208] Close to 60 percent of the households in flood-affected areas of the Lake Region are dependent on fish, either directly or indirectly, as a source of food and income. However, fish production has declined significantly over the past few years, due to deforestation, lower water levels and overfishing. Fish prices for all species have increased markedly as a result of this low production and due to a significant shift in demand from beef and goat to fish and chicken following an outbreak of RVF in several districts of the country. However, fish production continued to decline during the flood period. Reduced fish output coupled with crop and asset losses have therefore exacerbated food insecurity among many households. Polluted flood waters flowing into Lake Victoria interfered with fish reading and pushed the plankton on which fish feed into deeper waters, causing fish to move to cleaner areas away from shore that are inaccessible to most local fishermen. Floods also destroyed roads leading to beaches, thereby reducing

[207] An interview with householdsô heads and administrators 10 July 215 Nyakach sub county
[208] Wagesho, N. and Kusters, K. (2013). Loss and damage from flooding in the Gambela region, Ethiopia. Int. J Global Warming, Vol. 5, No. 4, pp. 483-497.

fishermenôs access. Parts of the Lake were covered with water hyacinth weed, pushing fish further away from shore and making them even less accessible to small scale fishermen.[209]

4.6.2 Poor Water management and crop farming

The researcher sought to investigate the effect of poor water management in Nyakach division. Based on the findings it was found that Water is still the number one constraint in many isolated villages in Nyakach Sub County, however, disproportionate time is still spent on fetching water especially in the dry season. The respondents indicated that water in sufficient quantities is needed for small-scale irrigation, vegetable gardens, domestic water, nurseries and apiary. Improved management of water resources to afford people opportunity to manage the serious soil erosion problem while improving productivity at no extra cost is of lacking in Nyakach. Development of local water resources to provides great opportunity for landscape afforestation through development of communal and farm based nurseries is a challenge in this area. Many farmers are lacking in basic agronomic skills. Most will be found planting low yielding eedvarieties, at incorrect spacing and up and down hill due to uncertainty of the future damage by flood and lack of enough water. Timing of operations such as weeding is often sub-optimal and done when the crops have been suppressed by weeds for too long and are unlikely to regain any significant momentum for growth. Noxious weeds, such as striga, are left to grow and seed instead of applying the simple and sustained management of simply pulling them out before they seed.[210] Very few farmers use commercial fertilizers because of its cost and the risk involved. Further very few use manure and those who do, applying

[209] Ibid
[210] An interview with house heads in Nyakach sub county 10th July 2015

sufficient quantities because of unavailability. These factors enormously contribute to low crop yields for majority of the farmers leading to food insecurity in Nyakach constituency.

4.6.3 Link between Population Growth, Food Scarcity and Poor Water Management

Based on the study findings it was noted that Nyakach area is highly populated. This caused pressure on the natural resources including water. However the findings revealed that prevalent and increasing hunger and poverty, increasing demand for food due to population growth and dietary changes and unsustainable management of natural resources, along with climate change and the threat of increasing food price volatility, call for renewed joint policy action to achieve the goal of sustainable food security for all in the sub county.[211] As the population continues to grow, water becomes scarcer, soil erosion accelerates and the negative consequences of climate change become more visible, doomsday prophecies have once again found fertile grounds. The key informants stated that there is poor food supplies and unsustainable management of natural resources in Nyakach Sub County. Sustainable management of natural resources is essential to make food systems sustainable. According to the house holds interviewed[212] natural resources are not currently managed sustainably. Widespread soil erosion and nutrient mining; waterlogging and salinization; deforestation; contamination of surface and ground waters; overuse of water; and rapid increases in greenhouse gas emissions by the food system are illustrations of unsustainable use of natural resources especially water.

[211] Ibid p.81
[212] Ibid p. 83

The researcher sought to establish ways in which the challenges associated with water management could be solved. The findings revealed that the time to improve governance for sustainable management of natural resources at every level is now and it requires shared understanding of the issues, adequate assessment and monitoring tools and appropriate institutions and policies to engage all stakeholders, including locals who are also the largest producers of the agricultural products we consume in our daily life.[213] Therefore, the achievement of larger production of food per unit of land, water and labor is essential to meet future food demands.

According to the findings, ensuring food security goes beyond securing sufficient supply. It also requires social and economic access to safe and nutritious food. Food consumption has an impact on human health and the environment. The challenge that we face today is how to meet consumersô needs and preferences while minimizing the related impact on health and the environment. Natural resource sector and agriculture have always had and maintained an important role in this process: the two sectors supply reliable, healthy and nutritious food as well as feed for animals and non-food products for a wide range of industries, shape and take care of our landscapes, provide public goods, and keep the countryside alive by providing jobs. The same way natural resources are critical to agricultural production; farm households also frequently depend on them to meet other needs, such as fuel, construction materials, and supplemental foods. Thus rural livelihoods are intricately linked to the condition of natural resources.

[213] An interview with Mr. Bob and Osman K administrators in Nyakach sub county 13th July 2015

4.7 Community-led initiatives in managing water resources in Nyakach Division in Kisumu County

4.7.1 Elements of a community Action Plan for the Nyakach

The researcher sought to establish various Community-led initiatives in managing water resources in Nyakach Division in Kisumu County on Crop management many farmers are lacking in basic agronomic skills. It was noted that most farmers were attending community based training on agriculture which would help them to yield more crop harvest. Before the training had begun had been noted that majority of farmers were planting low yielding seed varieties, at incorrect spacing and up and down hill. Timing of operations such as weeding was often sub-optimal and done when the crops had been suppressed by weeds for too long and are unlikely to regain any significant momentum for growth. Noxious weeds, such as striga, are left to grow and seed instead of applying the simple and sustained management of simply pulling them out before they seed. Very few farmers use commercial fertilizers because of its cost and the risk involved. Further very few use manure and those who do, apply it in sufficient quantities because of unavailability. These factors enormously were contributing to low crop yields for majority of the farmers. More hope of addressing farm productivity should device methods of dealing with each of these observations and the attendant constraints. It is now possible for farmers to grow more productive, more disease resistant crops. Farmers must be made aware of these opportunities if they are to move from the current cycle of poverty. [214]

On livestock management it was also noted that there are great opportunities for improved livestock management by the locals. The changing extension approach and

[214] Ibid

restructuring mean that the staff is even less available to every farmer, and farmers often express the feeling that they have been abandoned. Simple livestock health and management information is seriously lacking. Ways are being devised by the community heads to reach out farmers with the right information. Farmers had noted that large improvements could still be made in milk, beef and chicken production. Dairy goats rather than the higher consuming, low-producing Zebu cattle could better serve many areas. Moreover, much can also be done in non-traditional systems such as bee keeping which is highly productive given its low labour requirement.

On Agroforestry; it was noted that the community was ready to work with other partners, the respondents indicated that the Ministry can contribute to natural resource management (NRM) and poverty alleviation through passing messages on agroforestry. This would include promoting trees that bear fruits\either for sale or for home consumption Trees can play an important role in soil conservation. Another important element of tree planting initiated was diversification into high-value fruit trees for sale. Current involvement of the Ministry in NRM and Poverty Alleviation is through the following programmes: The Lake Basin Development Authority which is a government parastatal under the Ministry which implements integrated rural development projects aiming at poverty alleviation in the Lake region. Within the Lake Victoria Environment Management Project, (LVEMP) the Ministry coordinates the Integrated Soil and Water Component. The Ministry has an extension programme, the National Agriculture and Livestock Extension Programme (NALEP) which aims to empower the land users by availing technical information and imparting better organizational capability for improved agricultural production. The Kenya Agriculture Research Institute, which falls within the Ministry, is also carrying out relevant research (mainly adaptive research) to remove constraints encountered in

agricultural production. The Department of Fisheries of MOARD assists the fishermen in improving the marketability of the fish catch from the Lake. This is considered an important income generating activity for the area. The Ministry is also works with the farmers in developing sustainable small-scale irrigation schemes.[215]

4.8 Conclusion

The chapter provided key insight into the state of water management and food insecurity Nyakach Sub County in Kisumu. While Kisumu has made considerable progress in recent years, problems persist. Sadly, water-borne diseases such as cholera, dysentery and typhoid contribute to numerous deaths every year. Kisumuôs water production is not keeping pace with its rapid population growth, while the existing infrastructure is operating at between 85 and 93% of its design capacity.[216] The greatest challenges lie in the peri-urban areas and informal settlements, where the water source is often unreliable and sanitation systems are insufficient. To make matters worse, water prices in those areas tend to be beyond reach, since vendors typically charge rates 50% higher than those offered by the utility company.[217] As a result, residents often rely on shallow wells and boreholes, where the chances of cross-contamination are high. In addition, sewer bursts and blockages a major source of groundwater contamination, waterborne diseases and environmental pollution are common in Kisumu especially in Nyakach Sub County.

Fortunately, the county of Kisumu is already taking a number of critical steps to make improvements in its water supply and sanitation systems. Several projects have been initiated in partnership with NGOs and foreign development agencies. Agence

[215] Report by Kenya National Bureau of Statistics 2015 may.
[216] ibid
[217] Otiende, B. (2014). The economic impacts of climate change in Kenya: cost of adaptation. [Online] weadapt.org/knowledgebase/files/758/4e25a4b8c8bf61C-kenya-riparian-floods-case-study.pdf.

Francaise de Development (AFD) has pledged a KShs 1.7 billion (ú20 million) soft loan to improve water supply and sanitation services. The first phase of this project has been completed, leading to several improvements for the county; among them, an extension of the water network to the informal settlements, the construction of water kiosks and the rehabilitation of water treatment plants to meet their original design capacity.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents summary of the findings, conclusions based on the findings and recommendations there-to on sustainable water management and food security in Kenya. The chapter also presents recommendations for further studies.

5.2 Summary of Findings

The study explored the relationship between sustainable water management and food security in Kenya and especially in the case of Nyakach Division, Kisumu County. It was guided by the following specific objectives: To assess the factors influencing unsustainable water management and food insecurity in Nyakach Division in Kisumu County, to evaluate likely effects of poor water management and issues in food security in Kenya and to examine community-led initiatives in managing water resources in Nyakach Division in Kisumu County. The study used both secondary and primary data. Descriptive statistics was used to analyse the data. The study established that Nyakach is part of Nyando basin which is prone to displacement of population due to floods and other natural calamities like landslides. The area has unstable soil formation and little water sources. It also has low accessibility to water coverage and lack of adequate sanitation and water resource management. Diarrhoea is a major cause of morbidity and mortality in this area contributing to deaths of children under 5 years of age which stands at 212/1000 births. The area is inhabited by the Luo who are typically patrilineal and virilocal (living in manôs family place).

The study also established that majority of respondents interviewed had experienced food insecurity. 66% of the respondents indicated that household had ever ran out of money to buy food. 65% of the total number of respondents indicated that they were relying on a limited number of foods to feed their children. Based on the findings majority 58% indicated that there had experienced cases of eating less than expected because there is not enough money for food. The findings also revealed that there was association between food insecurity and infectious diseases. Based on the study findings 69% indicated that there was a relation between food insecurity and infectious diseases. However, a study by Okumu[218] concur with current findings. Okumu noted of the 480 people surveyed where majority were food insecure, 187 people were diagnosed with a minimum of one infectious disease. More than one-third (38.96%) of the sample population had at least one case of infectious disease. A total of 17 different types of acute infectious diseases were found in the sample. These diseases, in decreasing order of prevalence, included malaria (8.54%), worms (6.88%), bronchitis (6.25%), upper respiratory infection (4.79%), conjunctivitis (3.96%), sinusitis (2.92%), pneumonia (2.71%), ear infection (2.50%), toothache/cavities or vaginitis (1.88%), cellulitis or urinary tract infection or gonorrhoea (1.04%), acute diarrhoea or pharyngitis (0.63%), and typhoid or amoebas (0.42%). Within the sample population, malaria had the largest prevalence of an individual infectious disease at 8.54%, followed closely by worm infection at 6.88%.

[218] Okumu, C. H. (2011).Agricultural Growth, Rural Poverty and Ecological Degradation in Kenya. Maseno University Press.

5.3 Discussion of the findings

5.3.1 To assess the factors influencing unsustainable water management and food insecurity

On causes of poor management and food insecurity food it was noted that, insecurity is a major development problem that is caused by myriad of factors in the global, regional, national and local spheres of human life. Demographic conditions create vulnerability when size of population exceeds the carrying capacity of a particular area, and there is limited opportunity for out-migration or for development of physical, social and economic infrastructure so as to provide more productive alternatives to the dominant livelihood systems in the area. Based on the findings it was noted that high share of rural population in total may indicate vulnerability, particularly if it occurs together with a low level of economic development in rural areas. High proportion of dependent persons within a family, community, locality or nation also increase the risk of under-nourishment for these persons. The higher the population the higher the chances of food scarcity. This is due to pressure on resources for instance water used in irrigation as well as increased level of dependence per head. This pose a challenge to water management hence leading to food scarcity in Nyakach Sub County.

From the findings water management becomes a problem when people living in areas where the natural resource base is poor or deteriorating often have limited opportunities for earning their livelihood. Their situation is worsened if acts of man lead to pollution and environmental degradation. Variable climatic and geophysical conditions and biological threats create additional risk. The findings further reveal that the effects of climate change and associated extreme weather events

threatened sustainable development and impacts negatively on agricultural sector in the sub county. Flooding and droughts experienced affect food production, water supply, housing access, livestock production and general livelihoods of the people. It has been asserted that reductions in crop yields and increasingly unpredictable weather patterns may lead to higher prices for food and greater food insecurity, and increase the stakes for control over productive agricultural land. Some respondents claim that government policy failures or inappropriate development strategies are responsible for the recurrence of food shortage and famine or for underdevelopment in a Nyakach Sub County. Food insecurity is a multi-disciplinary concept which takes into account of technical, economic, social cultural and political dimensions.

The findings also revealed that unexpected natural calamities are also considered to cause poor water management and food insecurity. From the findings, as a result of floods 2006, fish production declined significantly due to deforestation, lower water levels and overfishing. Fish prices for all species had increased markedly as a result of this low production. However, fish production continued to decline during the flood period. Reduced fish output coupled with crop and asset losses have therefore exacerbated food insecurity among many households. Polluted flood waters flowing into Lake Victoria interfered with fish reading and pushed the plankton on which fish feed into deeper waters, causing fish to move to cleaner areas away from shore that are inaccessible to most local fishermen. According to the findings floods also destroyed roads leading to beaches, thereby reducing fishermenôs access. Parts of the Lake were covered with water hyacinth weed, pushing fish further away from shore and making them even less accessible to small scale fishermen.

5.3.2 Effects of Poor Water Management and Issues in Food

Based on the findings, the most immediately apparent impact of water scarcity in Nyakach area is on the health. With a complete lack of water, humans can on average only live up to 3 to 5 days.[219] The findings shows that it is due to this situation that forces those living in water deprived regions to turn to unsafe water resources, which then contributes to the spread of waterborne diseases including malaria, typhoid fever, cholera, diarrhoea, and can lead to diseases such as trachoma, and typhus. Additionally, the findings reveal that water scarcity causes many people to store water in their households, which increases the risk of household water contamination and incidents of malaria and dengue fever spread by mosquitos. According to Warner[220] these waterborne diseases are not usually found in developed countries because of sophisticated water treatment systems that filter and chlorinate water, but natural, untreated water sources often contain tiny disease-carrying worms and bacteria. Although many of these waterborne sicknesses are treatable and preventable, they are nonetheless one of the leading causes of disease and death in the world.

The findings further reveal that, food insufficiency has been associated with poor health, chronic disease, poor functional health, depression, altered nutrition-related laboratory values and decreased intake of healthful food groups.[221] Given that food insecure populations may lack ability to afford food, food insecure households may

[219] Warner, K. & Zakieldeen, S. A. (2012). Loss and Damage due to climate change: an overview of the UNFCCC negotiations. ECBI Background paper. Oxford: European Capacity Building Initiative (ECBI).
[220] Warner, K., van der Geest, K. and Kreft, S. (2013). Pushed to the limit: Evidence of climate change-related loss and damage when people face constraints and limits to adaptation
[221] Smith, P. J., *Food Security and Political Stability In The Asia-Pacific Region*, Asia-Pacific Center For Security Studies, September 11, 1998 Honolulu, Hawaii.

change dietary practices or use certain food-related behaviours to delay hunger and manage resources.

5.4 Conclusion

The study concludes that access to safe water is a fundamental human right just like food, but it should be recognized that a right to water does not mean free water. Unless people value something properly, they tend to waste it. The proportion of households with access to safe water in the study area is quite low, below even the national average and the residents have to contend with multiple sources to meet the daily water demand. Additionally, with this information on water use, the total water requirement of the households can be determined more accurately and the water company would have a better sense of how much water to produce. While continued emergency food and non-food interventions are necessary, food insecurity in the Lake Region including Nyakach constituency is chronic. Droughts, floods and reduced fish output compound key underlying factors such as the impact of HIV/AIDS and lack of education critical determinants of food security in the region. The scale of the HIV/AIDS pandemic has far exceeded response capacities, and an urgent, systematic approach to reduce the impacts of HIV/AIDS is urgently required. In addition, structural interventions to prevent flooding and activities that mitigate the impact of droughts are required in the Lake Region to mitigate the impact of shocks on food security.

5.5 Recommendations

5.5.1 Government of Kenya

According to the findings water scarcity has a huge impact on food production. Without water people do not have a means of watering their crops and, therefore, to provide food for the fast growing population. Agriculture, is constantly competing with domestic, industrial and environmental uses for a scarce water supply. The study therefore recommends that, in attempts to fix this ever growing problem, many more effective methods of water management should be employed in Nyakach Sub County.

The Government should purpose to supply all homes this basic water requirement for preserving human survival and well-being. Basic human needs of water and sanitation should be enjoyed by all members of society irrespective of monetary circumstances. To expanded access to safe water services there is need for upfront investment on rehabilitation and extension of existing water network in addition to upgrading of treatment plant, thus reducing the cost of maintenance and unaccounted for water and making better use of economies of scale. Public investment in the water network could be the route to achieve reduction in unaccounted for water and hence increasing accessibility to safe water services**.**

5.5.2 County government

For Kisumu City to attain Mark 7C (formerly Target 10) of Millennium Development Goal 7 to cut in half, by end of this year, the proportion of persons without access to safe drinking water and basic sanitation the water supply and sanitation infrastructure must be rehabilitated and expanded. In addition, particular attention needs to be paid to improving water and sanitation in low-income areas including Nyakach Sub

County and reducing disparities between wealthy and poor households in terms of access to clean water and environmentally sound sanitation facilities.

5.5.3 Better management of natural resources

The study established that enhanced administration of natural resources in agricultural landscapes is of paramount importance. Principles for managing soils, water resources, rangelands, fisheries, wetlands, forests and woodlands are already well known in the scientific world and increasingly by development organizations. Contextualizing those into feasible practices on the ground has proven challenging and when done sector by sector, have found in some cases to be not well aligned with each other. There is much to do to encourage better integration of natural resource management practices, beginning at landscape scale but even to the level of the field, where opportunities for synergistic investments are often missed. Linkages must be strengthened vertically between farmers, field agents and policy makers and also horizontally within these stakeholder groups to encourage the sharing of learning.

In too many cases, there are competing approaches to management (e.g. high purchased input systems, organic farming, and conservation agriculture) rather than understanding potential complementarities or conditions under which different approaches may be best. All stakeholders should pay more attention to the longer run health of natural resources and ecosystems to be able to rationally weigh choices. Resource productivity varies highly across regions, countries and at sub-national level. Calculations are most commonly made for land productivity or crop yields. Yield growth has been positive over the past 30 years, but displaying a decreasing rate in developing countries and being stagnant in sub-Saharan Africa. Gaps remain in actual versus potential yields in developing countries, especially in sub-Saharan

Africa. There are many reasons for the existence of yield gaps, but poor resource management is a key factor. Calculations of efficiency of use of other individual resources or combinations of them are not systematically available. Nor are calculations at higher ends of the food chain e.g. resource use per unit of nutrition consumed. As resources become scarcer land area, phosphorus, water, e.g. such information will be increasingly important to inform decisions related to resource management. A significant portion of food produced is lost or wasted post-harvest with some estimates being as much as 30%. Losses in immediate storage and handling in sub-Saharan Africa are high but less elsewhere. Food waste is high at the consumption level notably in developed countries. Such losses increase the gross amount of food production needed and thus also the amount of land and other resources required producing a given level of food consumed. Efforts to reduce loss and waste will be needed to improve resource efficiency.

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APPENDICES 1: QUESTIONNAIRE

Instructions

(*Please read the instructions given and answer the questions as appropriately as possible*). It is advisable that you answer or fill in each section as provided. Make an attempt to answer every question fully and honestly.

Section A; Background Information

1. What is your gender?

   Male [ ] Female [ ]

2. Indicate your age group (years)

   21-30 [ ] 31-40 [ ] 41-50 [ ]

   above 50 [ ]

3. Indicate your level of education

   O level [ ] Diploma [ ]

   Degree [ ] Masters and above [ ]

Section B: Sustainable Water Management and Food Security in Kenya

4. Whatôs your understanding of the word Food insecurity?

é é

é é é é .é é

é é é é é é

5. Does your household ever run out of money to buy food? Explain

é é

é é ..

é é

é é é .

6. Do you ever rely on a limited number of foods to feed your children because you are running out of money to buy food for a meal? Explain

é é

é é ..

é é

é é é .

6. Do you ever eat less than you should because there is not enough money for food? Explain

é é

é é ..

é é

é é é .

7. Do you relate food insecurity and infectious diseases? If yes explain é ..

é é

8. Briefly explain your understanding on the link between water management and food insecurity?

é é

é ..

9 what are the main sources of water in this area and who is in charge of water supply in this area?

é é

é é ..

é é

é é é .

10. What are the main challenges associated with water management in this area? Suggest ways in which these challenges can be solved.

é é

é é ..

é é

é é é .

11. How does poor water management affect the following activities?

a) Fish farmingé é

b) Crop farmingé é

Suggest ways in which these challenges can be solved.

12. How does drought and other extreme weather events contribute to food insecurity?

é é

é é ..

é .

13. Does Food insecurity affect school attendance and learning capacity for children? Explain

é é

é é

é é é .

14. Do you think rapid population Growth contribute to Food Scarcity and Poor Water Management? Explain

é é

é é

é é é .

15. Explain some of community-led initiatives in managing water resources in Nyakach Division in Kisumu County?