PARTICIPATORY GEOGRAPHIC INFORMATION SYSTEM (PGIS) IN COMMUNAL LAND RESOURCE MAPPING: CASE OF RIVER TANA DELTA IN TANA RIVER COUNTY, KENYA.

BY

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DECLARATION

This project paper is my original work and has not been presented for a degree in any other University.

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DEDICATION

This research project is dedicated to Dad, John Ochieng, mum Paschalia Ochieng and my spouse Lily Ochieng with whom the impetus to strive to greater heights resonates.

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ACRONYMS

The following are acronyms used in this research project

CRA	Commission of Revenue Allocation
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organization
GIS	Geographic Information Systems
GIT&S	Geographic Information Technologies and Systems
GPS	Global Positioning Systems
GoK	Government of Kenya
HA	Hectares
IEBC	Independent Electoral and Boundaries Commission
IWRM	Integrated Water Resource Management
LU	Livestock Unit
LUP	Land Use Plan
MRC	Mekong River Commission
NGO	Non-Governmental Organization
NRM	Natural Resource Management
OECF	Overseas Economic Cooperation Fund
PGIS	Participatory Geographical Information Systems
PRA	Participatory Rural Appraisal
PRA/PLA	Participatory Rural Appraisal/ Participatory Learning and Action
RTD	River Tana Delta
SEA	Strategic Environmental Assessment
SPSS	Statistical Package for Social Scientists
TARDA	Tana and Athi River Development Authority

TDDC	Texas Digestive Disease Consultants
UN	United Nations
UNICEF	United Nations Children's Fund

DEFINITION OF TERMS

Economic Activity:	Act of producing, buying or selling, products or services (English Dictionary)
Georeference :	The process whereby you relate a physical map or raster image of a map with actual locations. (Hackeloeer *et al* 2014)
Kamongo	*Proptopterus* fish
Laga	Seasonal River
Livelihoods	Consists of capabilities, Assets and activities required for means of living. (FAO, 2008)
Malka	Passage for animals to access water
Sedentarization	staying in a particular place for a long time

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ABSTRACT

This study was based on Participatory Geographic Information System (PGIS) in communal land resource mapping in the River Tana Delta (RTD), Tana River County, Kenya. It explores facts about methods used in land mapping and their weaknesses. Inter communal conflicts which have existed for a long period of time has destabilized communal peace and sustainable development among communities in the developing countries. The PGIS as a tool enables local people make their maps and models helping them in solving conflicts over land resources.

This study also sought to establish the relationship between the community livelihoods and the use of communal land resources. The main objectives of the study were to map communal land Resources using PGIS for the benefit of the communities, to examine how the major livelihoods of the communities have impacted on communal land resources, to analyze the utilization and potential of communal land resources and finally, to assess the production in three major economic activities (Livestock, crop and fish farming) in various communal land resources in the River Tana Delta.

The research used descriptive research design with qualitative and quantitative approaches to explore the facts and characteristics of the population in context. The study targeted 35 villages in 11 sub Locations within two wards, that is, Garsen South and Garsen Central wards. A sample of 60 respondents was randomly picked from identified villages with homogeneous economic activities. Data analysis was done by use of descriptive statistics; frequencies and percentages, means and standard deviation while the relationship between the community livelihoods and use of resources was done by correlation analysis.

Earlier researches have shown that there has been mapping of the resources. However, unlike the earlier approaches used which did not cater for the use of the communal land resources, the PGIS places control over the mapped resources which gives solutions to existing conflicts. It also, provides trainings to the communities which help them gain knowledge on how to carry out their livelihoods in order to increase their productivity. Further studies have to be done on the implementation of the PGIS and the training so as to be extended to reach all communities.

The study deduced that there was significant relationship between the community livelihood and the communal land resources.

CHAPTER ONE

1.0 Introduction

1.1 Background of the study

Nothing has amazed our humanity more than the georeferencing of human socio-cultural, physical and biological environment making it accessible to the public. Contemporary methods of land planning have been marred with inter communal conflicts for a long time especially in developing countries where communities have fought for resources destabilizing their peace, stability and sustainable development (Chambers, 1997). Kenya is no exception and has seen majority of the areas experience clan or tribal clashes (Mbugua, 2013; Crafter *et al*, 1992; Maingi and Marsh, 2002).

Bandhari (2003) cites that addressing land and resource conflicts has been a major challenge that even the traditional approaches and modern government machineries have failed to find solutions. Dunn (2007) adds that to address such conflicts effectively, a paradigm shift from exogenous to endogenous has been evident. The top down Land Planning process is entirely dependent on politician and the local leaders while on the other hand, bottom up Land Planning process, paves way for elected leaders to provide help to the electorates (Hadi, 2000; McCall, 2003).

Today, the union of different players for common goal, generally referred to as participatory processes of Land use Planning and its' Management, endeavor to look for common answers where participants feel part and parcel of problem solving (Jankowski, 2008). Development Anthropologists argue that the participation bring people together in an accommodating manner focusing on the greater interest of each one of them. From a participatory perspective, development experts cite that having numerous proposals from the bottom is better than that super single proposal from the

top (Abbot *et al* 1998). However, many a times such suggestions may be hard to reconcile (Odhengo *et al* 2014).

Initially, participatory creation of maps was done through sketch maps as one of Participatory Rural Appraisal (PRA) methods. This was because development practitioners dreaded the more complex, demanding and time consuming scale mapping (Abbot *et al* 1998). PRA strategies put little importance on plotting course of action that would enable communities to interact resourcefully with policy makers. During this era, aerial photography, satellite imagery and topographical maps were under Government control with restricted access because of national security. (Weiner and Harris, 1999).

The advent of internet and information technology in the early 1990s saw the introduction of information technologies in spatial aspects such as Geographic Information System (GIS), Global Positioning Systems (GPS) and remote sensing analysis software (Bocco and Toledo, 1997). Bandhari (2003) adds that the era was also marked with free access to data via the Internet and a steady decrease in cost of computer hardware. Development practitioners as Hadi (2000) and Rambaldi (2010) argues, that a major milestone of technology was that the spatial data that was previously under government institutions, progressively became free to NGOs, CBOs and the society at large who had no chance in the processes of decision making by use of maps.

According to Dunn *et al*. 1997), during the 1990s, PRA and GIS combined to actualize Participatory Geographical Information Systems (PGIS). They add that the shift from GIS to PGIS came as a result of limitations associated with the former which was highly used for spatial analyses and spatial decision-making processes that strengthened only the top - down approach to development. The PGIS process is multidisciplinary in

nature and depends on local knowledge through participation, spatial analysis, decision making and implementation (Heywood, Cornelius & Carver, 2006). In addition, PGIS is considered as having superior effect in participation and use of local knowledge (McCall, 2004). Today PGIS has become an effective tool in solving resource conflicts and forming long lasting solutions to such conflicts (Jirka, 2013).

1.2 Statement of the problem

Participatory methods have been engaged in processes of budgeting, monitoring and evaluation, development projects, addressing gender related problems, human rights, health and resource management, among others (Goodchild, Steyaert and Parks, 2009). PGIS practice usually focuses on Geographic Information Technologies and Systems (GIT&S) on community empowerment through user-friendly and integrated applications, where maps become a major conduit in the process. Practitioners and researchers have adopted GIT&S to integrate manifold realities and various forms of information to foster social learning, two-way communication and expand public participation across socio-economic contexts, locations and sectors (Poole, 1995). Compared to GIS applications, PGIS has put mechanisms on access and utilization of culturally sensitive spatial data in the hands of those who authored them thereby safeguarding traditional understanding and knowledge from exploitation.

Despite the benefits from PGIS, it is yet to be appropriately utilized to bring out deep implications and inspire innovation and social change. Communities that co-exist with each other still fight over resources. Competition over access to power and resources has been at the core of most of the conflicts in the country. Human - wildlife conflict has become the order of the day in many communities. River Tana Delta (RTD) has had its own share of ethnic conflicts with the worst happening in August, 2012 between the Orma and Pokomo communities that left 100 people dead because of resource use

problem. This vast triangle of land provides for several communities and colossal numbers of livestock, wildlife and water birds. Farming and pastoralism play a big part as the major economic activities. The residents of Tana Delta have had constant challenges in addressing production in the various communal resources in the RTD such as crop farming, livestock farming, fish farming and other economic activities thus a long lasting solution is needed.

There has been an attempt to Adjudication process; Witu and Ngao adjudication sections. Unfortunately, Ngao adjudication area (section) ended up in court immediately after its completion, on the issuance of titles. Most of the land in the area has not been adjudicated and therefore remains community land. This means that there needs to be adequate consultation with the communities for any development to go on. Previous studies such as Tana Delta Land use plan (Odhengo *et al*. 2014), the Strategic Environmental Assessment (Odhengo *et al*. 2014) and Making peace under a mango tree (Cuppen, 2014) among others have focused on conservation of biodiversity, broad policy framework on private and public investments, enhancement of the Delta region as a Ramsar site and the role of institutions within the Delta. Specific focus on the community and their resource was lacking there by not solving the resource conflict in totality.

It's against this background that this study mapped communal land resources using Participatory Geographic Information System (PGIS) specific to the different communities that reside in the Delta addressing the problem by looking into the various local mechanisms of sharing the communal resources.

1.3 Research Questions

The study was guided by the following key research questions:

i. How communal land resource mapping is important to the communities in RTD of Tana River County?

ii. How major livelihoods amongst the communities in the RTD have affected communal land resources?

iii. How utilization of communal land resources in RTD has affected their potential?

iv. Are productions in Livestock, crop and fish farming viable?

1.4 Research Objectives

The objectives of the study were to:

i. Map communal land Resources using PGIS for the benefit of the communities in RTD of Tana River County.

ii. Examine how the major livelihoods of the communities in the RTD have impacted on the communal land resources.

iii. Establish the utilization and potential of communal land resources in RTD of Tana River County

iv. Assess the production in the major economic activities occurring in the communal land resources in the RTD.

1.5 Significance of the Study

This research purposed to map land resources in River Tana Delta (RTD) of Tana River County using PGIS. The study further outlined and discussed the use and benefits of land resource mapping, effectively letting the stakeholders and policy makers in this field have a grip on how economic activities affect resource use at the same time promoting compatibility among the ever competing economic activities. To the residents of RTD and entire Tana River County, the participatory exercise with the communities created awareness and acted as a tool to avert the ever unending conflict which has been a major problem between the communities in the region.

The residents of RTD also got a solution to productions in the various land resources in the Delta such as crop farming, livestock farming, fish farming and other economic activities. In addition, the study helped the communities achieve a long lasting peace as they exploit natural resources by looking at the alternative ways that the communities can use to get their livelihoods apart from the traditional practices which by now may not be tenure able with the effects of global warming, population increase and receding wetlands due to settlements. Finally, the research contributed to the existing literature on PGIS in communal land mapping and the literature gaps where researchers have focused mainly on conservation and biodiversity (Odhengo *et al* 2012, McCall, 2009 & Viles, 2007), development and management of water resources (MRC, 2011) and the role of institutions (Cuppen, 2014) in the Delta regions failing to identify the specific communal resources within rural set ups that contribute to the livelihoods of the communities.

1.6 The Scope of the Study

The study covered two wards in River Tana Delta region namely Garsen Central ward (Dumi, Danisa, Galili, Kipao and Ongonyo Sub–Locations) and Garsen South ward (Ngao, Tarasaa, Oda, Golbanti, Idsowe and Dalu Sub–Locations), (IEBC, 2017). The study explored how PGIS can be used in mapping of communal resources in the study area. In addition, the study endeavored to make a case whether the economic activities around the RTD region have interfered with the livelihoods. Christensen & Pozarny (2008) define livelihoods as consisting of inherent ability, resources and undertakings required to produce. The study took place between July and August, 2017.

CHAPTER TWO

2.0 Literature Review

2.1 Introduction

In this chapter, literature review, theoretical and conceptual frameworks are presented. The chapter begins with an overview of Participatory Geographic Information Systems (PGIS) and continues with an empirical review of the roles and benefits of PGIS to communities, land use and economic activities in Tana Delta then concludes with the theoretical and conceptual framework. This is in relation to the four main objectives which include mapping of communal land resources by use of PGIS, examination of how the major livelihoods in River Tana Delta have impacted on the communal land resources, establishing the utilization and potential of communal land resources in RTD and assessing the production in the major economic activities.

2.2 Overview of Participatory Geographic Information Systems (PGIS)

The new spatial information technologies which include GIS, GPS, remote sensing software and free access to spatial data and imagery have empowered those who command them. Disparities in access can lead to gains by powerful people at the expense of communities and local people, further marginalizing those already marginalized. PGIS is a broad approach which seeks to reverse this (Poole, 1995). Combining Participatory Rural Appraisal/ Participatory Learning and Action (PRA/PLA) and spatial information technologies has empowered smaller and marginalized groups in spatial decision-making processes (Weiner and Harris, 1999).

Local people have been trained to use the technologies to construct their own maps and 3-D models and use these for their own research (Goodchild, Steyaert and Parks, 2009). The maps and models do not correspond with the ground and PRA maps in accuracy, they have only been used for interactive purposes (Rambaldi, 2005).

According to Jirka (2013), applications made have been many and they include protecting ancestral lands and resource rights; management and resolution of conflicts over natural resources; collaborative resource use planning and management; intangible cultural heritage preservation and identity building among indigenous people and rural communities; equity promotion with reference to ethnicity, culture, gender and environmental justice; hazard mitigation for example, through community safety audits; and peri-urban planning and research (Weiner and Harris,1999).

2.2.1 Levels of Participation in PGIS

For a long time, many studies have been done to show and categorize the many ways and stages of participation, from simple data transfer to actual people empowerment. Arnstein (1969) became the first person to validate the eight levels, from non-participation to peoples' empowerment. Arnstein's levels of participation pass through six intermediary stages called symbolic cooperation (Weiner and Harris, 1999).

The first two levels popularly known as rungs in the ladder are non-participation that has been suggested by many authors in place of real participation (Jankowski, 2008). Their main aim is to empower the elected and local leaders to guide participants.

The third and fourth rungs are Informing and Consultation levels respectively and are popularly referred to as levels of 'tokenism' that allow the have-nots to hear and to have a voice (Chambers, 1997). When they are offered power holders as the total extent of participation, citizens may actually hear and be heard. But under these conditions they

may lack the power to ensure that their views are heeded by the powerful. When participation is restricted then there is no change (Craig and Elwood, 1998).

The fifth level is the Placation level which is a higher level tokenism. It allows the people to have their say but let the leaders to decide. Level six offers the people the opportunity for partnerships which involve negotiations and tradeoffs with the leaders. This is an added power in participation and decision making. At the top most are Delegated Power and Citizen Control levels seven and eight respectively. At these levels, the have-not citizens obtain the majority of decision-making seats, or full managerial power (Arnstein, 1969).

However, Craig (2002) came up with a six level ladder to define the levels of participation. In his ladder, the lower part differentiates the privileges that an expert gives to the people after retrieval of information. These privileges include rights to know, be informed, participate in a forum and right to disagree with.

Craig (2002) continues to state that the lower three levels refer to minimum participation and aims to sensitize people with no representation. The higher three rungs are referred to as strong participation and they endevour to empower the people in participation process. Proponents of Craig's model argue that the upper three levels may be achieved through public participation which outlines goals, players and action plan in the implementation of real participation to facilitate sound solutions (Weiner and Harris, 1999).

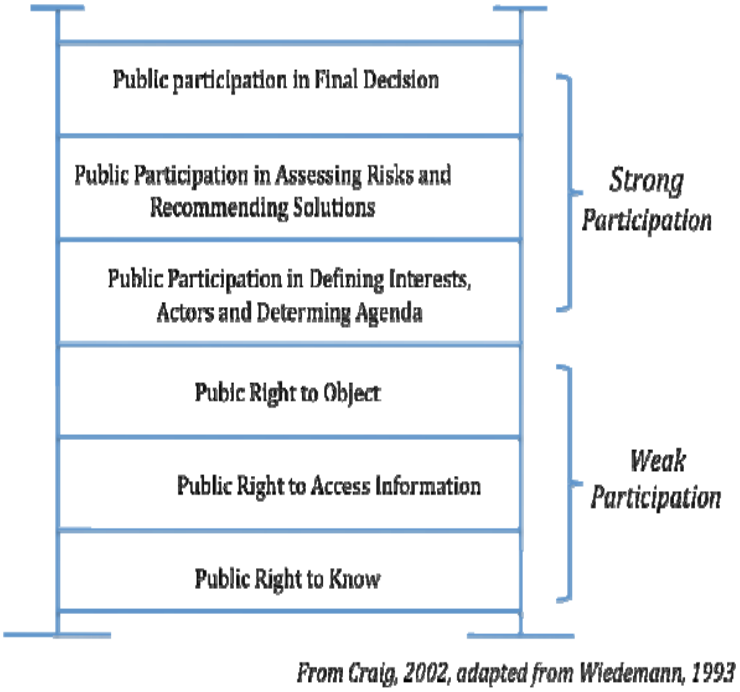


Figure 2.1 Craig's Ladder of Participation

2.2.2 Roles and Benefits of PGIS to Communities

PGIS applications have been documented for countries as diverse as Fiji, Indonesia, Canada, Brazil, Nepal, Nicaragua, Cameroon, Ethiopia, Ghana, Namibia, South Africa, Tanzania, Uganda and Kenya. PGIS has become popular in mapping which enables the local people to prepare their own maps for their own use. The uses are not limited to conflict resolution, declaration of rights, research and analysis (Weiner and Harris,1999).

In a review of local-level mapping and geometrics of local spatial knowledge, Poole (1995) categorized six types of applications, which he interprets the first five as inexorably progressing from one to the next in a development process. According to him, the applications are geared towards gaining recognition of land rights, demarcating traditional territories, protecting demarcated lands, gathering and guarding traditional

knowledge, managing traditional lands and resources, mobilizing community awareness and resolving conflicts.

PGIS has been extensively used in land demarcation in which majority of development practitioners have dubbed it *Claiming Our Land*. According to Weiner and Harris (1999), this PGIS role incorporates several different components of humanity. Of the components are the demarcation of traditional boundaries for both land and other natural resource claims. Dunn (2007) cites that PGIS has been used in recognition of customary land rights in law and identification of areas of use and occupancy. Studies by Engle (2000) and Chambers (1997) on use of PGIS revealed that PGIS has been essential in prioritizing claims between different communities especially those at war and in the evaluation of communities' scenarios of alternative land management systems. In addition, PGIS has proven to be effective in preparation for court procedures due to its rigor, accuracy, and appearance of the spatial information (Elwood, 2009).

Knowing and using resources means mapping resources and this defines the use of PGIS at several levels of intensity and complexity. For instance, PGIS identifies, locates and analyses specific natural resources. Alarcon, Orban-Ferauge and Pandan (2009) cite that the use of PGIS in natural resource systems include land use, land cover, landscape units, land use management, including watershed management, integrated farming systems, coastal zonation, conservation, bioregional mapping, ecosystem planning, hazards and risky landscapes, working with external management plans, tourism and eco-tourism.

Bandhari (2003) argue that PGIS has succeeded in managing both internal and external conflicts. He cites that community mapping, PGIS and Participatory 3D modeling has helped in identifying, understanding, predicting better, and ameliorating conflicts and

competition. This was echoed by Elwood (2009) when he noted that PGIS has been essential in both mediating and negotiating as well as in post conflict. However, Rambaldi (2010) argues that it is feasible that the mapping and recording of claims and counter-claims can also lead to the exacerbation of land and resource conflicts.

Empirical literature has also proven that PGIS strengthens the community. For instance, Mosse (1994) cites that PGIS strengthens the community by expanding the community awareness of their rights and entitlements to their lands and landscapes which in turn gives the community a sense of ownership. Chambers (1997) adds that PGIS promotes institutional strengthening of the community's institutions and organizations which leads to the empowerment of the community as a whole, or empowerment of certain groups and sections within the community such as women, pastoralists, landless, elders, children, property owners, lower castes, nomads.

Lastly, PGIS promotes cultural historical knowledge and local history such as cultural landscapes. According to Dunn (2007), cultural knowledge includes the sacred values of land and space for local, and especially for indigenous, peoples. Rambaldi (2010) adds that cultural historical knowledge goes on to include cultural landscapes, places of historic, cultural and religious significance. In addition, PGIS has been used to fix land related problems in marking land for the ancestors who in many communities refer to ancestral burial grounds, memorials such as battle sites or ancient settlements, and other culturally significant sites and areas (McCall, 2009).

Globally, PGIS has been applied in the planning for the lower Mekong River Basin. The Mekong River plan is one of the world's greatest Planning for a River Basin. Being one of the world's pronounced river systems, it traverses a huge floodplain as it enters the sea via a wide delta. Each landform is with its own opportunities and challenges. River Tana alike, rises in the Aberdare Mountains, traverses central, upper Eastern and

Coast provinces as it enters the sea via a wide delta in Tana River County. The River is greatly used for farming, fishery and tourism by different communities in Thailand, Viet Nam and Cambodia (Rambaldi, 2010).

To address resource conflicts among the communities, MRC prepared an Integrated Water Resource Management (IWRM) process that supports coordinated development and management of water and land resources (McCall, 2009). This was in order to exploit economic and social welfare in a way that does not compromise the sustainability of the ecosystems as it exists in the delta regions. It also acknowledged that IWRM is not an end in itself but a means of achieving three key strategic objectives of efficiency, equity and sustainability.

In Tana Delta, PGIS has not been fully utilized by the communities for their own benefit. Registration of land is still an emotive issue that has triggered violence in the past (Odhengo *et al* 2014). In relation to the different livelihoods in RTD, there is preference in land regulations. Nomadic pastoralists prefer access to large tracts of land while crop farmers desire to secure their private farms. It is important to note that they are all dependent on the River Tana for their sustainability. Presently, Nature Kenya together with other government agencies developed a Strategic Environmental Assessment (SEA) which concerns environmental, social, economic and cultural considerations. It investigates the impacts of Tana Delta Land Use Plan (LUP) on community's welfare and natural systems (Odhengo *et al* 2014). The Tana Delta Land Use Plan which was launched by Nature Kenya in July, 2015 aims at guiding decision making on developments and policy formulation for RTD.

In the RTD land use plan, broad mapping for settlement, agriculture, investments and livestock has been done. The LUP has significant influence on the way land is allocated to interest groups for various uses. However, communities have expressed their

discontent with Nature Kenya claiming that they are inclined to particular communities. Other concerns raised have been about Nature Kenya's priorities regarding nature conservation as opposed to economic development (Odhengo *et al* 2014).

Mekong River Basin has a lot of similarities to River Tana Delta and by extension River Tana basin because of the opportunities that a water resource can present which includes Agriculture, transport, tourism, fishing and accesses to safe water when treated. Above all, it has also been depicted that the highest percentage of the population is rural and are therefore considered poor as the case in Tana Delta. This strongly points out to the problem of food security and dependency in relief food as the case in Tana Delta (Odhengo *et al* 2014)

PGIS can effectively solve the Tana Delta challenges in competition over resources that have led to frequent conflicts. Mbugua (2013) cites that communal conflicts in RTD have been there since 1992 general elections in Kenya. First it was the Pokomos and Orma in 1991, then followed in 1992 and 1995 (Odhengo *et al* 2014). Today, the conflicts revolve around land and pasture. The nomadic pastoralists (Orma and Wardei) have accused the farmers (Pokomo) of blocking their access to water and pasture. On the other hand, the farmers have complained of destruction of their crops by the nomads. There has been objection to land adjudication processes by the Government especially pastoralists. They have complained of Land that was taken away by Government and political elites at their own peril. (GoK 2000).

2.3 Livelihoods

According to Food and Agriculture Organization (FAO, 2008), livelihoods consist of capabilities, Assets and activities required for means of living. Likewise to the study area, sustainable livelihoods refer to when the livelihoods can cope and recover from

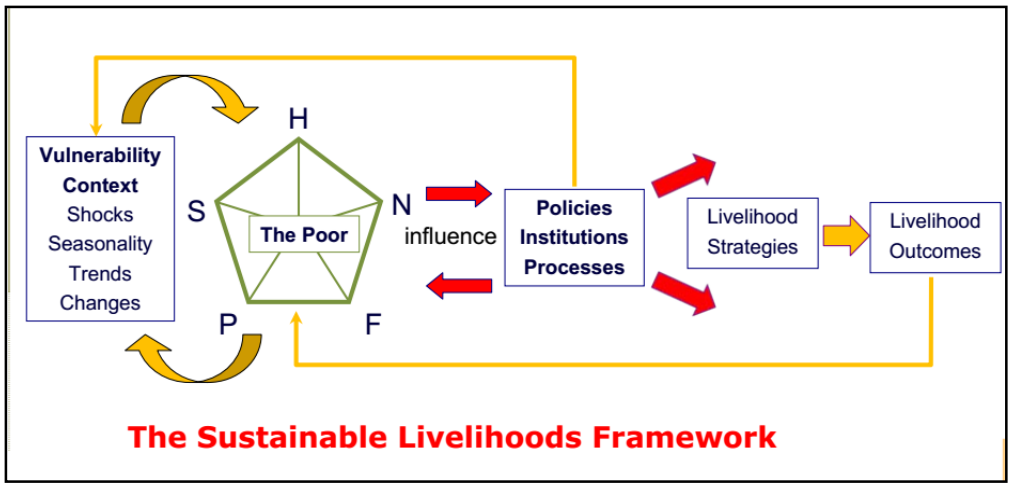
stress and shocks while maintaining or enhancing capabilities and assets without undermining the natural resource base. The FAO sustainable Livelihood framework (Figure 2.2) was developed with three main objectives

a) Alleviate rural poverty and vulnerability through agricultural and rural investments,

b) Assess vulnerability and livelihood strategies

c) Provide an enabling environment for improving sustainable rural livelihoods andeconomic growth.

In this framework, like in Tana Delta, the rural poor was/is envisaged to be surrounded by the livelihood assets composed of Human asset (H), Natural Asset (N), Financial asset (F), Physical Asset (P) and Social Asset (S). These Assets, FAO says have got their own vulnerability which affects their sustainability. However, through policies and institutional interventions, sustainable livelihood strategies can be employed to give good outcomes. Linked to this study, the researcher established how the utilization of these livelihood assets in the River Tana Delta have impacted on the communal land resources as highlighted in objective two which was to examine how the major livelihoods of the communities in the River Tana Delta have impacted on the communal land resources.



Source: FAO, 2008

Figure 2.2 Sustainable Livelihoods Framework

2.4 Tana Delta Livelihoods

The main livelihoods in the RTD are nomadic pastoralism, crop farming and fishing. It was however observed that majority of the residents practice a range of livelihoods to supplement their income.

2.4.1 Nomadic Pastoralism

This is one of the three main livelihoods in RTD. Nomadic pastoralism which is under strain in Kenya is still very important in Kenya's GDP. FAO estimates the contribution by livestock to be above 12%. With sedentarization becoming the current common practice, many of the nomadic pastoralists have sedentarized except for RTD pastoralists. Sedentarization may have numerous advantages including education, healthcare, increased access to public services and security. Due to less mobility by the herders, competition over natural resources has increased causing more erosion (Ensminger, 1992).

2.4.2 Subsistence farming

Besides nomadic pastoralism, subsistence farming is another key livelihood in RTD. Crops that are produced for local consumption include maize, vegetables, green grams

and beans. There are also cash crops being cultivated and that include mangoes, water melons, cashew nuts and bananas. More often than not, the crop farmers fail to harvest due to huge variability in rainfall (Schade, 2011).

Crop farmers have always used River Tana as their main source of water for irrigation. Seasonal flooding of the River Tana causes fertile residuals deposits in the flooded areas. It is however noted that upstream damming along River Tana has also caused major decrease in water volume particularly the annual floods. (Maingi and Marsh, 2002. Crop farming which is commonly practiced along the reparian because of its alluvial deposits, erosion of the river banks has been experienced with instances of the river changing its course. The law that protects the riparian is hardly in effect.

2.4.3 Large-scale farming

River Tana being the longest river in Kenya with a continuous discharge, has been subjected to large irrigation projects as from 1950 (Hirji and Ortolano, 1991). Hola and Bura irrigation schemes were set up in the 1980s, for rice and cotton large-scale production. However, these projects have never been fully operational due to several challenges. Currently, they operate only at a small scale.

The first significant irrigation scheme in RTD was done in 1980s. It covered an area of 16,800ha (16.8 square kilometres) (Hirji and Ortolano, 1991). Community land was allocated to the Tana and Athi River Development Authority (TARDA). Because of the enormous chunk of land, TARDA continued to source for donors who would utilise the land. The first donor objected due to social and environmental reasons in the assessment reports. TARDA engaged a new donor Japanese Overseas Economic Cooperation Fund (OECF) (Hirji and Ortolano, 1991) who helped in creation of the first polder in the year 1988 of approx. 2000ha (Hamerlynck *et al*, 2010). Production started in the year 1993,

although the infrastructure was completed in the year 1997. The yields were very low which eventually led to abandonment of the project after the floods destroyed the project in the year 1997. Recently on 14th September, 2016, the Malindi Land and Environment court revoked the lease by the Tana and Athi River Development Authority (TARDA) of 25,875 hectares of Tana Delta Irrigation Project. That means that the land reverts back to the community.

2.4.4 Other livelihoods

The other livelihoods include fishing, production of charcoal, trading and transportation. Fishing is currently done along the river and in oxbow lakes. The lakes rely on over flows from the river and little rainfall of which they occasionally dry up. As is in the case of nomadic pastoralism and crop farming, fishing is done by the Pokomo and the Luo (Mireri, 2010).

Charcoal production is also an important source of income for the residents; however its utilization has caused significant environmental degradation. Charcoal according to UNICEF (2009) still remains the main source of energy for cooking standing at 98%. In an attempt to safeguard the environment, FAO and other organizations introduced *Prosopis Juliflora* a plant locally known as Mathenge (FAO, 2006).

Mathenge has had fair share of criticism, from toxicity of its fruits to an enemy of natural vegetation. It is also extremely difficulty to eradicate (TDDC, 2008). The first plantations of mathenge were done around Hola and Bura irrigation schemes in early 1980s (FAO, 2006). Currently, considerable efforts are being put in place to produce charcoal out of mathenge.

2.5 Theoretical framework

This study sought to map land in a region that has been marred with frequent conflicts over resources. Hence the study was guided by the tragedy of the commons theory.

2.5.1 Hardins' theory tragedy of the commons

Tragedy of the commons theory, Hardin (1968) argues that the idea of the commons, "that our use of "breeding rights" is a common good, and that those who overuse their right to breed are driving us toward extinction". He continues to argue that "freedom in a commons brings ruins to all". The tragedy of the commons is often cited in connection with sustainable development, resource use and environmental protection. It has also been used in studying behavior in the fields of economics, evolutionary psychology, anthropology, game theory, politics, taxation and sociology. In comparison, Malthusian theory and Homer Dixons' environmental scarcity and violent conflicts have also been discussed.

2.5.2 Malthusian Theory

In this theory and in relation to natural resource management (NRM), Malthus idea that capacity of natural resources will not be enough for every user has gained considerable backing. His idea has been challenged in the development of technologies. According to Malthus (1803) there are two checks probably to avert the Malthusian catastrophe. Preventive check which appreciates the willingness to avoid population growth and the positive check which considers things that may shorten the average life span of a population (disease, warfare, famine and poor living and working environment). Compared with 'tragedy of the commons' by Hardin's (1968) some natural resources are 'common' as his example pasture.

2.5.3 Homer Dixon Theory – Environmental Scarcity and Violent conflicts

The natural resources e. g pasture a used by Hardin (1968), is in Homer-Dixon's dichotomy. Pasture according to Homer Dixon is rivalrous. If a user uses a portion, then others have less to utilize. Pasture is non-excludable. It implies that no one can prevent the other from using the same resource.

Other theorists for tragedy also reason that communal land ownership with individual ownership of livestock gives motivation for more herds thereby over utilizing the resource (Ensminger and Rutten, 1991). That the normal choice for users is to have large herds', which means higher chances of recovery after drought and in return leads to overgrazing. Dollard, J. *et al* (1939) argues that frustration causes aggression, that when the source of the frustration cannot be challenged, the aggression gets displaced onto an innocent target. In contrast, many other scholars such as McCayand Acheson, (1987), points out the many successful common property regimes. Contrary to this, antagonists have indicated that 'tragedy' is a generalization. It assumes or downplays the existence and functions of self-governing institutions (Dietz, Ostromand Stern, 2003). Ostrom (1990) argues that local institutional systems can be able to manage resources for collective gain while the beneficiaries learn to cooperate while experiencing resource problems.

2.6 Summary

Indeed in the literature review section, Elwood (2009) spells out the roles and benefits of PGIS to the communities. This includes land demarcation for each and every land use, prioritization of claims by different communities who are at war and also helping in arbitration processes particularly the law courts because of PGIS rigor, accuracy and appearance of spatial information.

Following Hardin's study, communal property systems were considered as a hindrance to development. This contributed to the change by developing countries to have statutory property right systems, whereby land is owned by an individual, company, co-operative or group.

According to Engle (2000), aggression sets in when community become frustrated in pursuit their livelihoods. Elwood (2009) links it to the start of clan or tribal conflicts especially when there is inadequate supply of essentials. In relation to this study, **Hardin's theory – *Tragedy of the commons*** can be applied to scale opinions of inequity and marginalization among communities in RTD. A number of authors relate competition for resources amongst communities as a primary cause of conflicts in Africa. (Weiner and Harris, 1999).

This theory has been criticized as inaccurate and fails to account for demographic transition, distinguished between common property and free access to resources. Likewise, Susan Jane Buck Cox (1985) argues that the communal land as an example used to argue this economic concept is on a weak historical ground, and misrepresents what she terms as actually the "triumph of the commons"; successful common usage of land for many centuries. She argues that social changes and agricultural innovation led to the demise of the commons; not the behavior of the commoners (Dietz, Ostromand Stern, 2003).

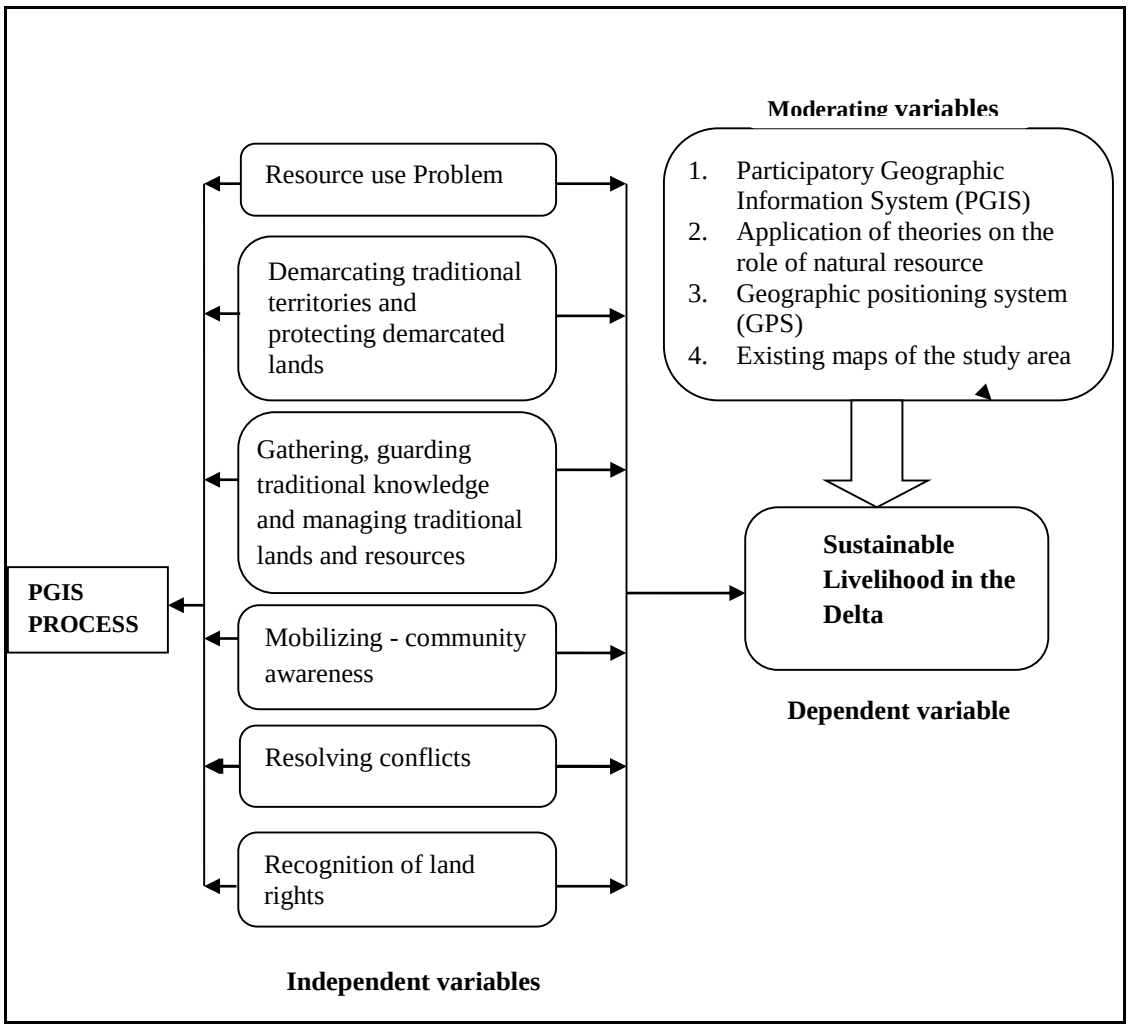
2.7 Research gaps

With the foregoing review, it is evident that participation is key to the effect that Craig (2002) gives the levels to gauge whether participation is weak or strong. But, participation has been limited to sensitizations and not much participation has been done to include GIS in mapping at least in Kenya. In this case therefore, there is need

to popularize PGIS as a tool that helps in managing both internal and external conflicts by expanding community's awareness. Bandhari (2003) and Mosse (1994). Previous studies such as Tana Delta Land use plan (Odhengo *et al*. 2014), the Strategic Environmental Assessment (Odhengo *et al*. 2014) and Making peace under a mango tree (Cuppen, 2014) among others have focused on conservation of biodiversity, broad policy framework on private and public investments, enhancement of the Delta region as a Ramsar site and the role of institutions within the Delta. Specific focus on the community and their resource was lacking there by not solving the resource conflict in totality.

2.8 Conceptual framework

The conceptual frame figure 2.3 is according to Hardins' Theory. It shows both the independent, depended as well as moderating variables. The independent variables are the roles and uses of PGIS which include resource use problems, demarcation of traditional territories, gathering traditional knowledge, community awareness, resolving conflicts and recognition of rights. Moderating variables are the tools that will be used in mapping of the commons (pasture land, agricultural land and fisheries) being utilised. They include PGIS, existing maps, GPS and application of theories on the role of natural resources. All the variables are intended to lead us into sustainable livelihood in the Delta.



Source: Researcher, 2017

Figure 2.3 Conceptual framework

2.9 Research hypothesis

This research tests the hypothesis;

H_0=There is no significant relationship between community livelihoods and the use of communal land resources in River Tana Delta.

H_1= There is a significant relationship between community livelihoods and the use of communal land resources in River Tana Delta.

CHAPTER THREE

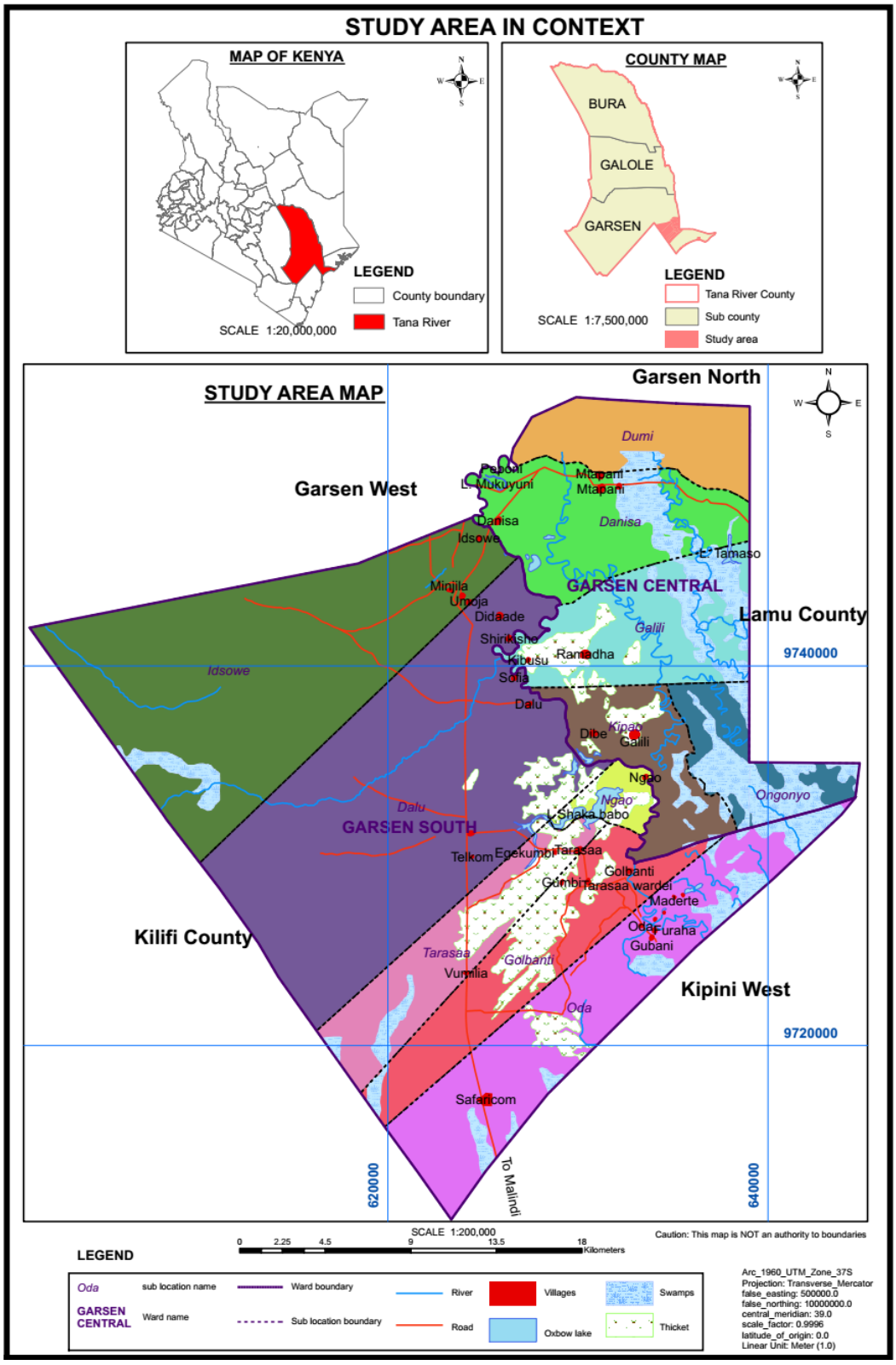
3.0 Research Methodology

3.1 Introduction

This chapter examines in detail the methodology adopted in carrying out the study. It covers the following aspects; research design, target population, sampling procedure, methods of data collection, validity and reliability and methods of data analysis.

3.2 Study Area

The study area was two wards Garsen Central and Garsen South in River Tana Delta popularly known as 'Tana Delta.' Administratively, it is located in Tana Delta Sub County of Tana River County. The most iconic feature is River Tana, the longest river in Kenya flows for approximately 1,000 Km (620 miles) and forms RTD between Lamu and Tana River Counties with an approximate area of 163,600Ha (404,092 acres). The RTD is one of the largest wetlands in Kenya, rich in biodiversity and home to nomadic pastoralists, crop farmers and fishermen. (Odhengo *et al.*, 2014). The study area is about half of the Delta with an area of 93,685Ha. It borders Garsen West and Garsen North wards to the North, Lamu County to the East, Kipini West ward to the South and South East and Kilifi County the South West. The area has a population of 30,871 people (GoK (2010). It also lies between latitudes 000'53'' and 200'41'' South and longitudes 38025'43'' and 40015' East. The land generally slopes South Eastwards towards the Indian Ocean with an altitude of between 2m and 90m above the sea level. Rainfall varies between 400mm and 750mm with rainy seasons in March–May and October–December. Mean annual temperature ranges between 30^{o}C and 33^{o}C. (CRA, 2011). Figure 3.1 shows the study area in relation to the country Kenya, the County Tana River and Tana Delta Sub County (Garsen constituency).



Source: Adopted from IEBC and Survey of Kenya

Figure 3.1 Study Area in Context

In addition, Tana River Delta was designated as a Ramsar on 30th January, 2014. It is the sixth Ramsar site in Kenya after Lake Naivasha, Lake Nakuru, Lake Elementaita, Lake Bogoria and Lake Baringo. It supports a rich diversity of wildlife and plants including coastal and marine prawns, shrimps, bivalves and fish, five species of threatened marine turtles and African elephant, Tana Mangabey, Tana River Red Colobus and White-collared Monkey. The fauna consists of over 600 plant species have been identified, including the endangered *Cynometralukei* and *Gonatopusmarattioides*. It is also home to tens of thousands of wetland birds and is internationally important for the survival of no less than twenty two (22) species of birds (Odhengo *et al*, 2012).

Apart from the River Tana there are also *lagas* which flow in a West East direction of the Tana Delta draining into River Tana and eventually into the Indian Ocean. The River beds are known to support livestock as well as wildlife during the dry season since they have high ability to retain water. They essentially form appropriate sites for shallow wells, sub surface dams as well as earth pans. (Tana River County website, 2017)

The major ethnic groups are the *Pokomo*, many of whom are farmers, the *Orma* and *Wardey* who are predominantly nomadic pastoralists and other small tribes which include *mijikenda, Watta, Monyoyaya* and the *luo* who practice fishing. Over time, conflicts have occurred between farmers and nomadic communities over access to water and other communal resources at the Delta. Flooding has also been a regular problem caused by heavy rainfall upstream of The River Tana destroying crops, properties and causing evictions (Maingi and Marsh, 2002).

Land resources in RTD include the land, the River Tana, ox bow lakes, rangeland, riverine forests, shrub land and the coastline. Cumulatively, these resources make the delta what it is.

3.3 Research Design

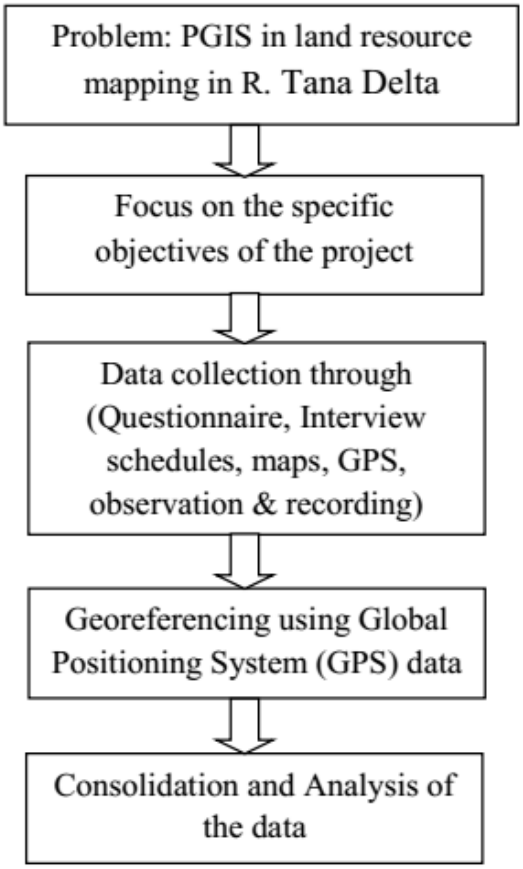
The study used both qualitative and quantitative approaches. The research design is descriptive. Descriptive research design describes methodically the truths and features of a specific population or study area (Richey and Klein, 2007). Descriptive studies include gathering information to test validity of a given hypothesis on a specific subject. A sample survey was used and probability sampling methods were used; multistage sampling, where a combination of cluster sampling and simple random sampling methods were used. For this study, PGIS as a tool was used in mapping; the other tools described in the conceptual framework were used in the preparation of georeferenced spatial illustrations (maps) using the existing maps as a base map on which information was either added or amended. Based on the information that was gotten, the research gives an account of how socio-economic factors and population increase has impacted on the communal land resources in the RTD.

3.4 Data Types and Sources

3.4.1 Primary data

The main source of data was through mapping of communal land resources using PGIS and community mapping. PGIS entailed understanding of the main problem which was to map land resources within the River Tana Delta and specifically in the study area. This was achieved by clearly addressing the specific objectives with their specific data collection tools to achieve the resource maps as will be shown. Georeferencing of maps was done using the Global Positioning System (GPS) and community maps. Finally the data so collected was consolidated and analyzed to come up with the true analysis. PGIS was done through consultations with the respondents, authorities from the County

Government, National Government and the field assistants for purposes of documentation. Figure 3.2 shows the step by step process of the PGIS



Source: Adopted from Forrester, J. M & Cinderby, S. 2011

Figure 3.2 PGIS Process

Apart from the interviews with field office and natural resource experts which the researcher used unstructured questionnaire, household questionnaire was semi structured to accommodate the salient issues of the respondents and without losing focus on the actual data to be collected based on the varied interpretation.

The interviews were to get both expert and community knowledge on the natural resources and its sustainable utilization. They also assisted in understanding the dynamics in resource utilization by a community or communities. Participant

observation was also used to compliment the information gotten from the key informants.

3.4.2 Secondary data

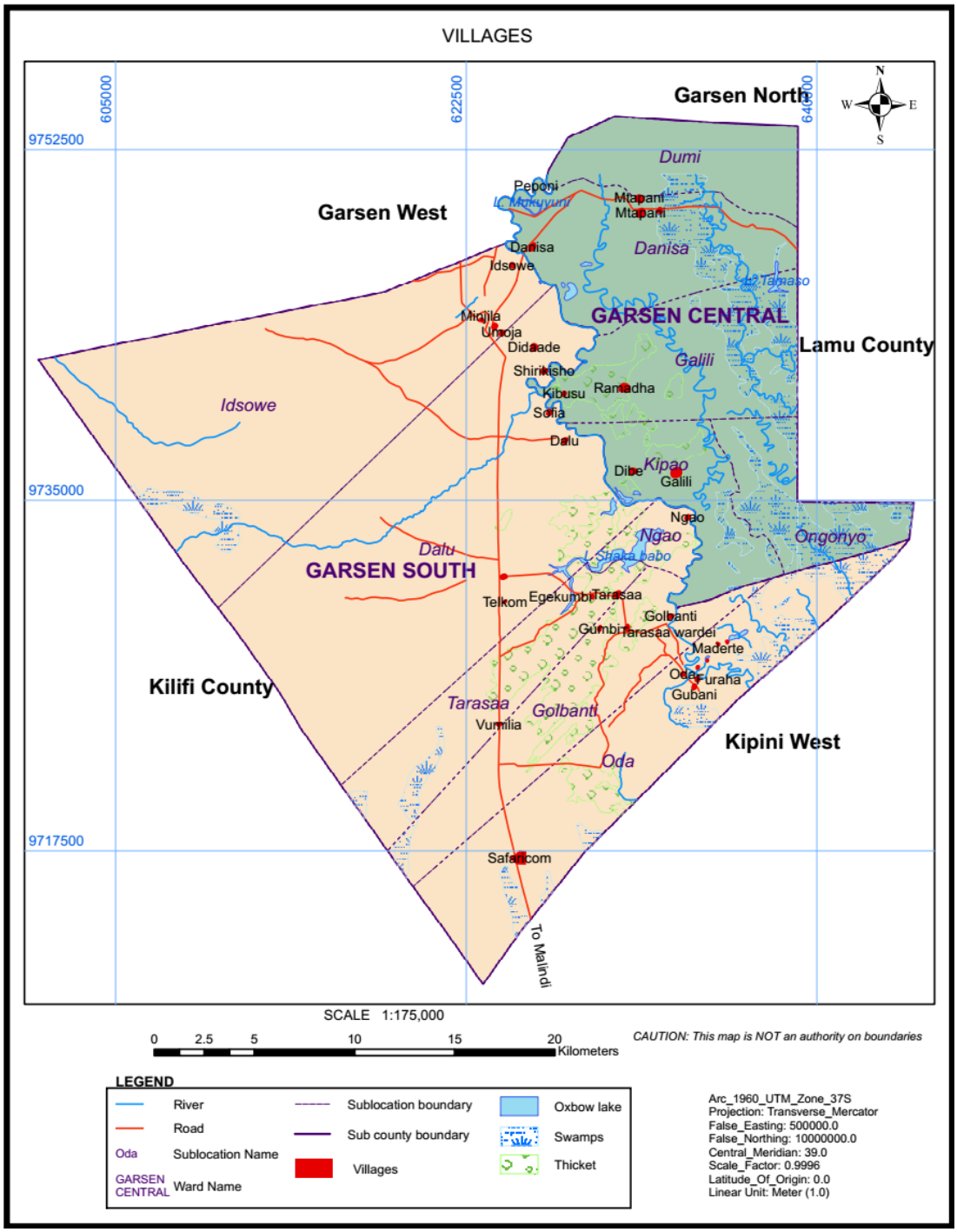
Secondary data was collected from maps, scientific publications, books, Government and International publications. They were reviewed to provide an insight into the study area. Maps used were obtained from the ministry of lands office, Independent Electoral and Boundaries Commission (IEBC) and Google Earth. The articles reviewed include those touching on natural resources in the Tana Delta which formed the basis of the study. The concept of sustainable resource use and alternative ways was also researched.

In terms of procedure, the controlled map that was prepared which had all the features that the respondents could identify with was used by the teams that were administering the household questionnaires for the respondents to map the location and extent of where they practice their economic activity. For each and every economic activity or representative of a cluster, this was done. The information was both captured in the questionnaire and the map.

3.5 Target Population

Stillwell and Clarke (2011) defined population as the total collection of elements which we wish to make some inferences. According to Engelhardt, Kohler, and Prskawetz (2009), a population element can be an individual in an organization, customer database, or sum of quantitative data for which measurement is taken. The target population was 30,871 people (according to housing and population census of 2009) who are residents in the study area and from the sampled villages. The sampling for respondents was through probability sampling method. Multistage sampling was used

which combined both cluster sampling of all the villages in each of the eleven (11) sub location and followed by simple random sampling to get a representative village and respondent. Thirty six (36) villages were randomly sampled from each of the sub locations. Questionnaires were administered to Sixty (60) respondents from the thirty six (36) villages randomly sampled for their response on the subject matter. Figure 3.3 below shows the villages that were visited for response during the data collection.



Source: Adopted from IEBC and Survey of Kenya

Figure 3.3 Villages

3.6 Data Needs and Analysis

The table below gives a summary of data requirement, collection and analysis methods used in the study.

Objective/ Research Question answered	**Collection method**	**Data analysis**	**presentation**
Types of communal Resources in River Tana Delta	Literature review(existing publications) Questionnaires Observation PGIS	Descriptive statistics	maps, photographs and tables
Types of livelihoods	Literature review(existing publications) key informant interviews(communities) Observation	Descriptive statistics	photographs and tables
Population and communities using the resource(s)	Literature review (Review of existing publication) key informant interviews(Communties)	Descriptive statistics	Charts and tables
Quantity of produce from the land resources	Literature review (Review of existing publication) key informant interviews(Communties)	Descriptive statistics	Tables
Sources of labour in the utilization of the land resources	Literature review(existing publications) key informant interviews(communities) Observation	Descriptive statistics	Charts and tables
Credit and loan facilities available in the utilisation of land resources	Literature review (Review of existing publication) key informant interviews(Communties)	Descriptive statistics	Charts and tables

Institutional services in terms of training and extension services	Literature review (Review of existing publication) key informant interviews(Communties)	Descriptive statistics	Graphs and tables
Nature of conflicts that arise from resource utilization	Review of existing publication, key informant interviews(communities)	Descriptive statistics	Charts
Level of coexistence between the communities at the Delta	Focus group discussion, key informant(field work officers)	Descriptive statistics	Table
Level of receptiveness to new ways of doing things	Literature review, key informant interview(communities)	Descriptive statistics	Charts

Source (Researcher, 2017)

Table 3.1 Data needs and analysis

3.7 Methods of Data Analysis

To ensure easy analysis, all the data collected from the respondents through community mapping of their economic activities and communal land resources was collated to eventually get the cumulative area of each of the three major economic activities in the delta, i.e livestock farming, crop farming and fishing. This was helpful in fulfilling objective i & iii on communal land resources. The maps are shown in the subsequent chapters.

In the case of the household questionnaires, they were correctly coded to ensure accuracy during the analysis process. Descriptive statistics such as the simple frequency distributions, percentages, mean and standard deviation were also used to analyze the tabulated data. The household questionnaires were particularly used to address objective ii & iv on livelihoods. The other information gotten from the key informants were also considered in drawing conclusion to the findings. To test the hypothesis of

the study, Spearman Rank correlation Analysis was used in testing the relationship between the community livelihoods and the use of communal resources

Presentations are done by use of percentages and frequency graphs, tables, charts and pie charts as will be seen in the next chapter. The coding, analysis and drawing of charts was done using Statistical Package for Social Scientists (SPSS) based on the respondents' responses. Topographical maps, aerial images and satellite maps were also used for the PGIS.

3.8 Ethical Considerations

During the study, key informants and respondents were assured of the integrity of the information that they give and the purpose of the research. On their consent the exercise was successfully done.

CHAPTER FOUR

4.0 Results and Discussions

4.1 Introduction

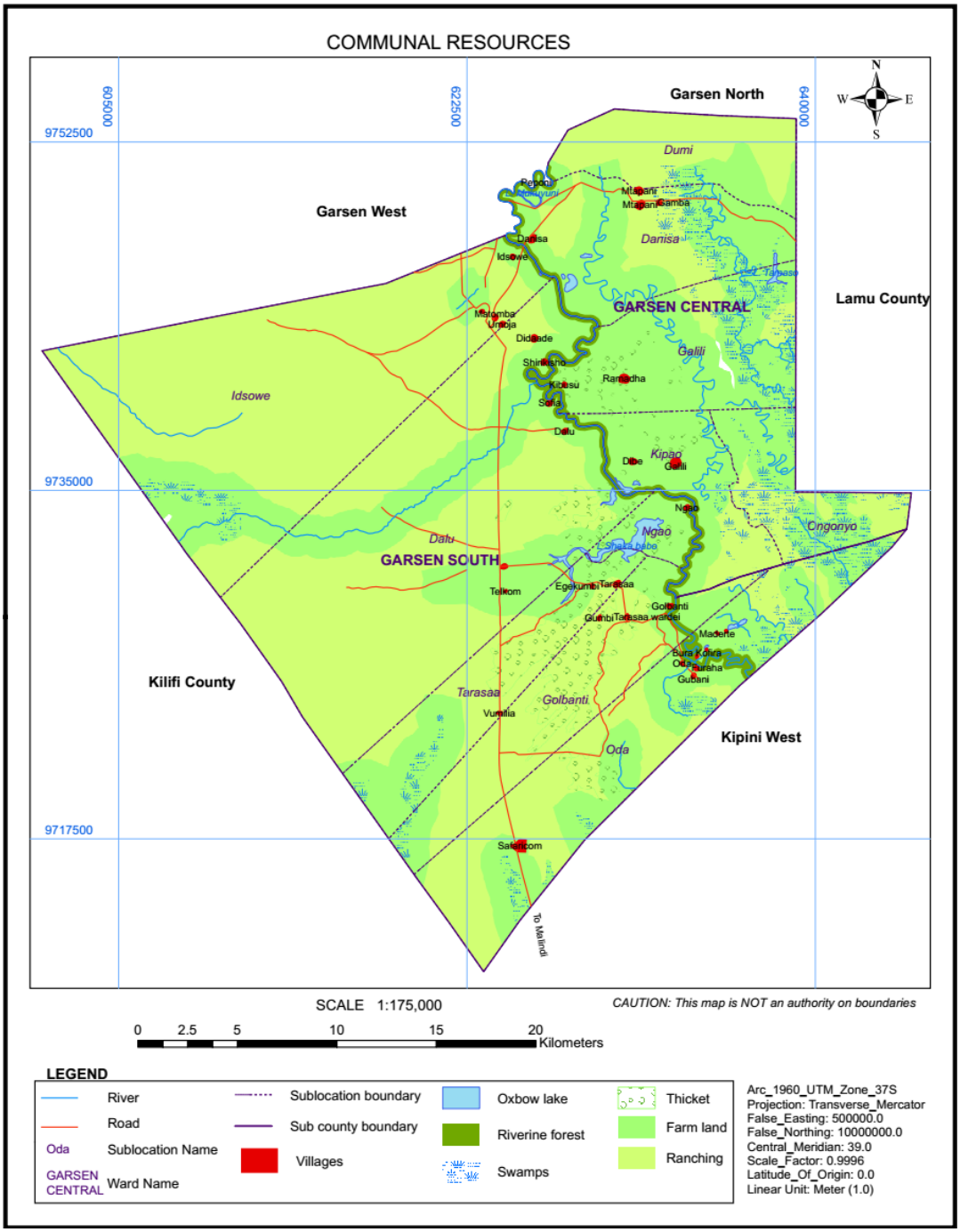
This chapter presents results and discussions of the case study based on the research objectives and the null hypothesis. The results are based on a response rate of 98% (n=60). The results are presented in graphs, charts and tables showing frequencies and percentages.

4.2 Mapping of communal land resources for the benefit of communities in River Tana delta

This objective was to help in obtaining information through the research questions that would aid in the mapping of the existing communal land resources in the Delta. The following questions related to the objective were asked and their responses were as follows

4.2.1 Location of farm lands

One of the major livelihoods in the Delta is crop farming, from the findings, it constituted of 32% of the responses. The farming activities occur along the main River Tana, around the swamps and along the streams joining the main river also known as *laga*. The farm lands are potentially from the banks of the river and the stream extending to a maximum of one kilometre. Figure 4.1 shows the exact locations in the study area as mapped through community participation.



Source: Adopted from IEBC and Survey of Kenya

Figure 4.1 Communal Resources

4.2.2 Location of pasture land

Livestock farming is also a major economic activity in the Delta constituting of 34% of the responses. The system used in livestock keeping in the study area is nomadic pastoralism where the people move from one place to another in search of pasture and water. The movement of the people with animals is not just arbitrary but organized with specific routes. For instance when the rains start the livestock farmers move their animals out of the Delta and vice versa. Potentially, the areas beyond the farm lands and fishing areas are locations for pasture. Figure 4.1 also shows the ranching areas within the study area.

4.2.3 Location of fishing sites

Fish farming is also an economic activity in the study area but not as popular as livestock and crop farming. It constitutes of 8.5% exclusive practice with others doing mixed farming. The potential sites for fish farming are located along the main river Tana and Lakes Mukuyuni and Tamaso which are oxbow lakes. Lake Shaka Babo shown in the figure 4.1 has since dried up and therefore has been converted to farm lands.

4.2.4 Other land resources

Apart from the economic activities which occur in communal land resources, the other resources include Riverine forest, land, scrubs and wells. Apart from the wells, the riverine forest, scrubs and the land has been mapped in figure 4.1. The scrubs generally occur in the rangeland and within the riverine forests.

4.3 Impact of major livelihoods on communal land resources

Examination of the impacts of livelihoods on the communal land resources was the second objective of this research. The research questions below gives the information from the respondents

4.3.1 Livelihood distribution in the Delta

There are three major livelihoods in the River Tana Delta namely livestock farming 34%, crop farming 32% and fish farming 9%. Others are a combination of two major economic activities which comprises of 25%. The chart illustrates the distribution in percentages.

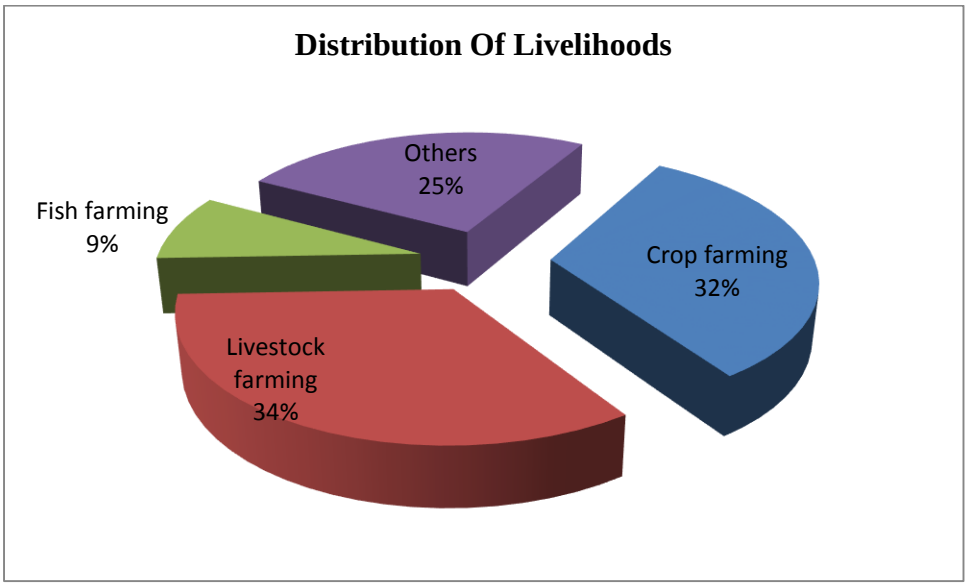


Figure 4.2 Distribution of livelihood

4.3.2 Average land size for crop farming

The average land size for cultivation is estimated to be 0.4Ha per household. This is so due to the logistical problems of irrigating the land under cultivation and the subsistence nature of farming by the communities. The plate 1 below shows the flood irrigation as used in crop farming

Source: Researcher, 2017

Plate 4.1 Flood Irrigation

4.3.3 Land Tenure

The land is communal and is not registered to a particular group or individual.

4.3.4 Average Land Size for livestock farming

The land that is used as pasture land is communal and therefore the research could not determine the average land size for livestock farming. However, considering the climatic conditions and the types of animals kept the only viable system is nomadic pastoralism. According to FAO (2005), a study on Agro ecological zones and densities of livestock in Kenya conducted in the year 2000 indicate that cattle and ruminants had a LU of <10 per square kilometer. This implies that the allowable cattle and ruminant size should be 530 as per the 53,161 Ha (53.161square kilometer) available land.

4.3.5 Viable use of Communal Land resources

From the survey, 43(73%) of the respondents indicated that they are using the communal land resources viably while 16(27%) did not agree to viable use of communal land resources. It is therefore implied that the residents of the Delta have used the communal resources viably except that new technologies need to be introduced to maximize on the produce and to make them move from subsistence to large scale production because of the potential.

4.3.6 Use of technologies and systems

Some of the technologies and systems used in the utilization and production in the communal land resources include

S/No.	Economic Activity	Technologies and systems used
1	Livestock Farming	Nomadic Pastoralism system
2	Crop Farming	Flood Irrigation system
3	Fish Farming	Hooks, lines, fishing net and fish traps technology

Source: Researcher, 2017

Table 4.1 Technologies in Tana Delta livelihoods

In terms of the respondents being receptive to new technologies, 57(97%) did agree on adoption of technologies while 2(3%) did not agree on adoption of technologies. This shows that a great number of respondents are okay with the adoption of technologies.

4.4 Utilization and potential of communal land resources in River Tana Delta

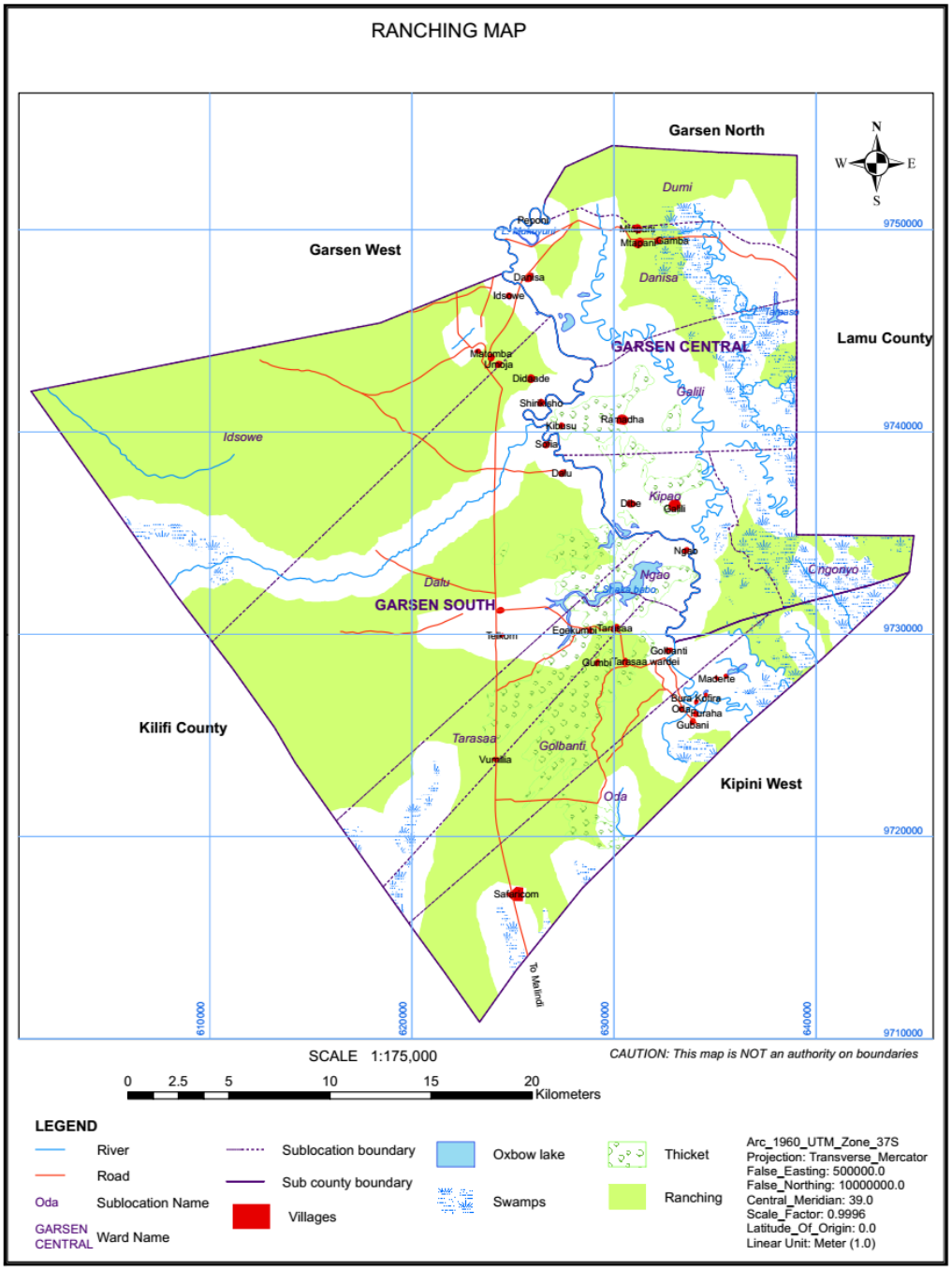
The third objective of this study is addressing the utilization and potentials of the communal land resources in the Delta. The following key economic activities were assessed

4.4.1 Livestock farming

The community that keep livestock largely practice nomadic pastoralism. This has been due to climatic conditions of the region of not receiving enough rainfall to sustain the supply of pasture and water for the herds of cattle, goats and sheep. The average numbers per household are estimated to be 72 for cattle, 55 for goats and 56 for sheep.

It was important to note that there is a pattern that the herders follow in moving animals from one location to the other. For instance when the rainy season begins, the herders would move westwards towards Kitui and Taita Taveta Counties and only start moving back during the dry spell.

Figure 4.3 below shows the mapped areas that are currently being used as pasture land and the extent which gives the potential. Due to the conditions stated above, the area(s) mapped for ranching will not be sufficient not unless the number of livestock reduce to allowable livestock unit (LU) of <10 for cattle and ruminants per square kilometer and introducing high quality breeds that can be sustained by the area available.

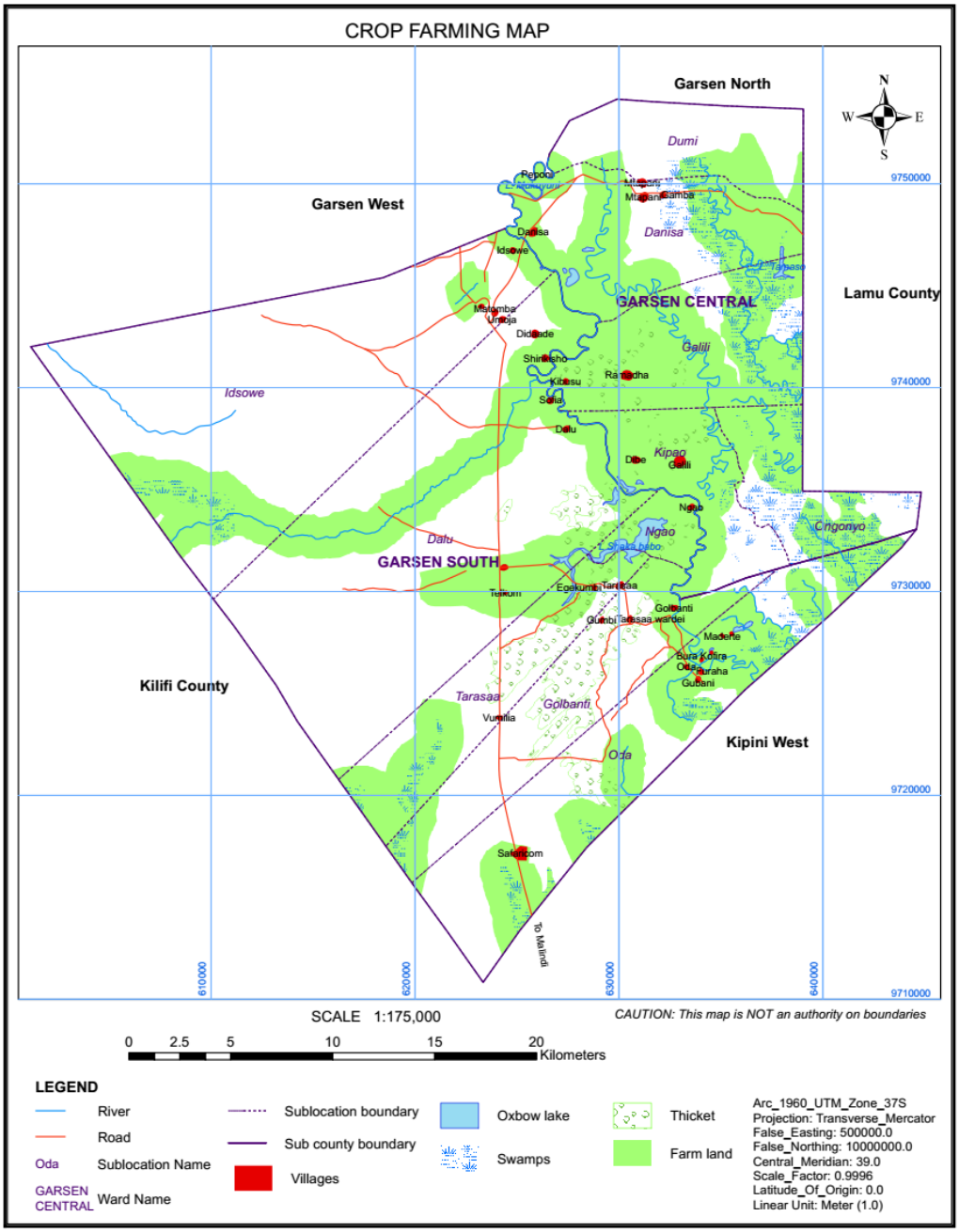


Source: Adopted from IEBC and Survey of Kenya

Figure 4.3 Livestock farming

4.4.2 Crop farming

It was established that farming occurs along the River Tana, *lagas* and around the lakes and swamps because of proximity to water for irrigation purposes. Currently the farming that is going on is more of subsistence for crops like maize, beans, watermelon, green grams, tomatoes, bananas, mangoes vegetables (kales cowpeas and tomatoes) and pineapples. There is need to mechanize the farming to expand it for large scale production apart from the maximum one kilometer stretch along the river, laga, lakes and swamps. The soils are well drained and fertile for crop production. This detail is well illustrated in figure 4.4

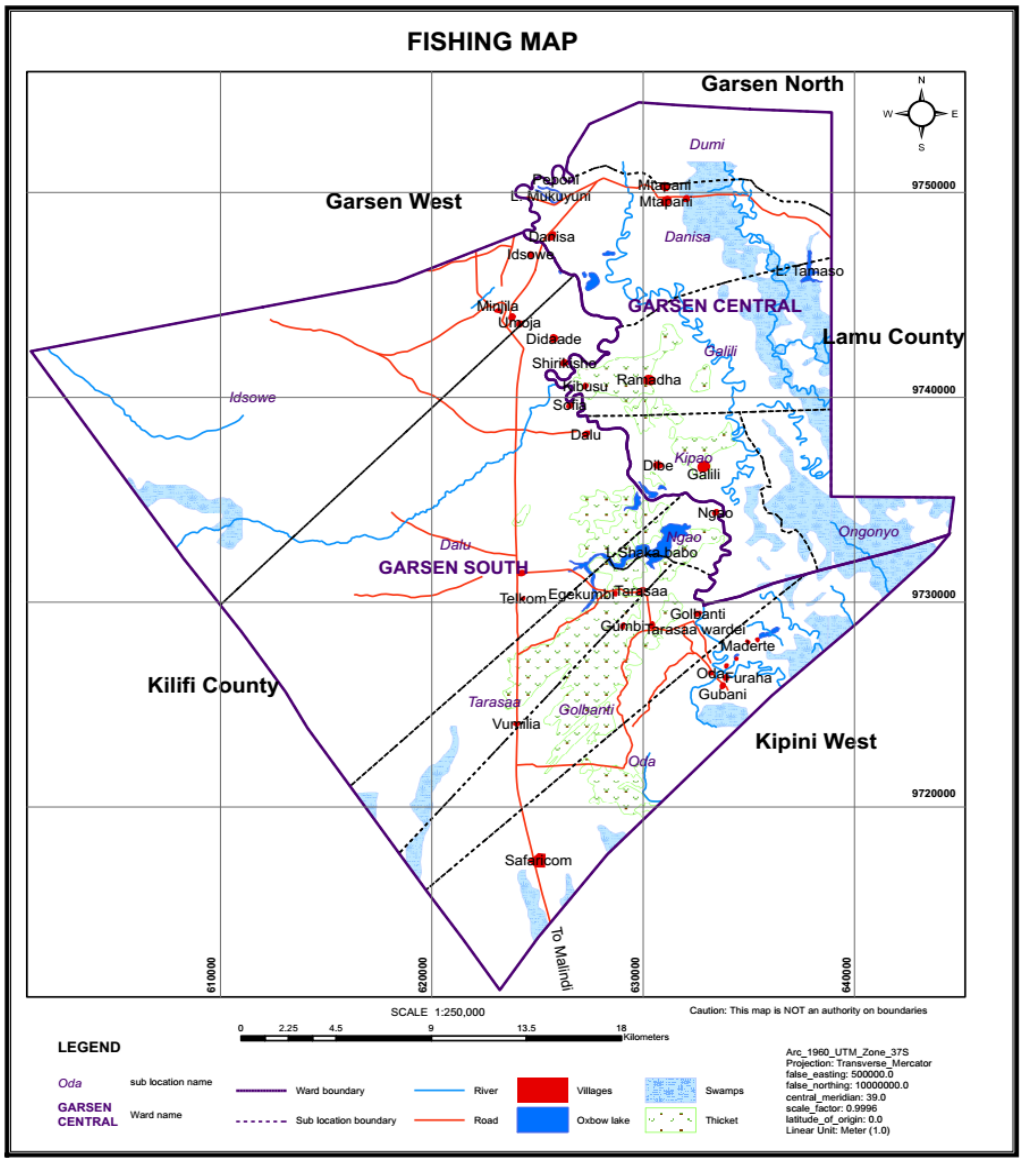


Source: Adopted from IEBC and Survey of Kenya

Figure 4.4 Crop farming

4.4.3 Fish farming

According to the study, fishing activities occurs in the river and the oxbow lakes. There has been initiatives by government to boost fish farming by introduction of fish ponds but this has not done well and the project seem to have stalled. However there is great potential for fish farming considering the production levels being experienced as will be discussed in the next objective of the research. Figure 4.5 shows the river, Lake Tamaso and Mukuyuni among the most resourceful.



Source: Adopted from IEBC and Survey of Kenya

Figure 4.5 Fishing

4.5 Productivity in major livelihoods of the River Tana Delta

The major livelihoods as has been discussed in the foregoing include livestock farming, crop farming and fish farming. This section will put to perspective the various issues responded to in addressing objective four of the research which deals with productions in the livelihoods of the Delta.

4.5.1 Livestock farming

4.5.1.1 Types of Livestock

The main livestock kept in River Tana Delta are cattle, goats, sheep and donkey. Other types of livestock include poultry. East African Zebu, black head Persian and East African were the main cattle, sheep and goat breeds raised in RTD (Plate 4.2 and 4.3)

Source: Researcher, 2017

Plate 4.2 Black head Persian sheep and the East African goat

Source: Researcher, 2017

Plate 4.3 The East African Zebu

4.5.1.2 Number of Animals Kept

The table 4.2 shows the number of animals kept in River Tana Delta, the means and standard deviations. They are as follows; totals are 1734 cattle, 1615 goats, 1359 sheep, 12 donkeys and 55 hens. It also shows the means of 72.3333, 55.6897, 56.6250, 6.0000, and 18.3333 and standard deviation of 101.02202, 85.98551, 65.39566, 0.00000, and 10.40833 for cattle, goats, sheep, donkeys and hens respectively. The numbers particularly for the cattle, sheep and goats is huge if that is per household and therefore the livestock unit needs to be checked if the animals are to be confined in the Delta and particularly the study area.

Animal kept	Total	Entries	Mean	Std. Deviation
Cattle	1734	24	72.3333	101.02202
Goats	1615	29	55.6897	85.98551
Sheep	1359	24	56.6250	65.39566
Donkeys	12	2	6.0000	0.00000
Poultry	55	3	18.3333	10.40833

Source: Researcher, 2017

Table 4.2 Number of animals kept

4.5.1.3 Production per Animal

The Table 4.3 below shows the number of animals produced their means and standard deviations. It shows that there are 757 cattle, 954 goats, 745 sheep, 6 donkeys and 170 hens produced in a season. There means are 31.5417, 32.8966, 29.8000, 3.0000, 56.6667 for cattle, goats, sheep, donkeys and poultry respectively. Their standard deviations are; 61.98876, 64.23247, 41.61730, 0.00000 and 30.55050 respectively. There exists standard error means for the entries as follows; 12.65340, 11.92767, 8.32346, 0.00000 and 17.63834 respectively.

Animal Production	Total	Entries	Mean	Std. Deviation
Cattle	757	24	31.5417	61.98876
Goats	954	29	32.8966	64.23247
Sheep	745	25	29.8000	41.61730
Donkeys	6	2	3.0000	0.00000
Poultry	170	3	56.6667	30.55050

Source: Researcher, 2017

Table 4.3 Production per season per type of animal

4.5.1.4 Challenges Experienced in Livestock Farming

The challenges experienced by livestock farmers among the most frequent are diseases, attack by wild animals, low market prices, drought, lack of pasture, low production and high operation costs. The diseases that attack the animals according to the veterinary officer are as classified below

a. Tripanosomiasis - most prevalent along the riverine and affects all livestock
b. Contagious caprine pre – pneumonia (CCPP) - only attacks goat
c. Elementhiasis (worm infestation) – affects all livestock
d. Foot rot disease – affects all livestock during the rainy season
e. Tick borne disease – (heart water and anaplusmosis) – attacks all livestock and occurs during drought

Apart from the challenges listed above there are also interventions being done in the livestock sector to better manage livestock production. They include

1. Livestock feed supplements by National Drought Management Authority (NDMA)
2. Livestock off take system by (NDMA & National Government)
3. Livestock insurance by (NDMA, Takafuru Insurance Co. & National Government)
4. Hay bailing by (NDMA) – done in Kibusu Garsen South
5. Breed improvement – NDMA had brought in 10 heifers and 2 bulls

4.5.2 Crop farming

4.5.2.1 Types of Crops Grown

The main crops grown in the Delta include maize, beans, watermelon, green grams, tomatoes, bananas, mangoes vegetables (kales cowpeas and tomatoes) and pineapples.

4.5.2.2 Crop produce per season

The Table 4.4 shows the cumulative production (in kilograms) per crop per season, the production per household (mean) and standard deviations. Maize is the highly produced crop with a produce of 10 bags per household per 0.4Ha (acre) followed by watermelon with 1398 Kgs. The others are as follows cowpeas 100 bags, tomatoes 1200 Kgs, beans 7 bags, green grams 6 bags, kales 570 Kgs and mangoes 825 Kgs per household per 0.4Ha (acre). The standard deviations for cowpeas could not be computed since the entry value is equal to one.

Crop	**Total production (KGS)**	**Entries**	**Mean**	**Std. Deviation**
Maize	26210	29	903.7931	714.76976
Beans	6100	10	610.0000	577.04227
Tomatoes	7200	5	1440.0000	1502.66430
Watermelon	16780	12	1398.3333	1376.17278
Green grams	3490	6	581.6667	669.63921
Cowpeas	9000	1	9000	0.00000
Kales	1710	3	570.0000	699.07081
Mangoes	1650	2	825.0000	247.48737

Source: Researcher, 2017

Table 4.4 Crop produce per season

Being that the average land size for cultivation is 0.4 Ha, and for the maize plant which is most produced in this case as per the table 4.4. It means that for the average mean of 904 kilograms will have ten (10) bags of maize. Compared to Kenya seed specifications and standards, an acre (0.4 Ha) should produce about 23 bags. The maize seed varieties grown in the Delta are Pwani Hybrid 1(PH 1) and Pwani Hybrid 4 (PH 4). See table 4.5 on produce as highlighted

SEED VARIETY	**ALTITUDE (METRES)**	**LENGTH RAINY SEASON**	**POTENTIAL AVERAGE YIELD - BAGS/HA**
H 614D	1500 - 2100	5 - 7 MONTHS	94
H 625	1500 - 2100	5 - 7 MONTHS	98
H 626	1500 - 2100	5 - 7 MONTHS	102
H 627	1500 - 2100	5 - 7 MONTHS	112
H 628	1500 - 2100	5 - 7 MONTHS	118
H 622	1000 - 1800	4 -6 MONTHS	67
H 623	1000 - 1800	4 - 6 MONTHS	71
H 511	800 - 1500	4 -5 MONTHS	50
H 513	800 - 1500	4- 5 MONTHS	65
DH 01	600 - 1300	2 -3 MONTHS	38
DH 02	600 - 1300	2 - 3 MONTHS	40
KATUMAINI	600 - 1300		
COMP.			
PH 1	0 - 1200	3 -5 MONTHS	58
PH 4	0 - 1200	3 - 5 MONTHS	60
COAST COMP.	0 - 1200	4 -5 MONTHS	

Source: Adopted from Kenya Seed Company

Table 4.5 Crop produce per Hectare

4.5.2.3 Challenges Experienced in Crop Farming

The challenges experienced by crop farmers in common are inadequate rainfall, destruction of crops by animals, pests and diseases, low yield, high cost of farm inputs, drought, insecurity and lack of capital. From observations in the field, the other problems include diversion of the river at will and the use of not effective systems in crop farming especially in irrigation. Refer to plate 1 on flood irrigation.

4.5.3 Fish farming

4.5.3.1 Types of Fish Caught

The most common type of fish in the Delta and particularly the study area include tilapia, catfish, proptopterus (*kamongo*) and clarias. The most common fish is tilapia and catfish according to the respondents. This is because the fishing areas are either the River Tana or the oxbow lakes. These habitats are good for both mudfish and Tilapia respectively. Plate 4.4 shows catfish and *kamongo* in the market.

Source: Researcher, 2017

Plate 4.4 Catfish and Kamongo

4.5.3.2 Fish Production

Table 4.6 below shows the mean production in the year 2016 for the four most common fish in the area. Tilapia has the most catch followed by catfish, *kamongo* and clarias respectively.

Source: Fisheries Department Tana Delta, 2017

Table 4.6 Mean fish catch year 2016

CATFISH			**CLARIAS**			**PROTOPTERUS** ***(Kamongo)***			**TILAPIA**		
Tot. (Kgs)	Local Cons. (Kgs)	Transp. (Kgs)	Tot.(Kgs)	Local Cons. (Kgs)	Transp. (Kgs)	Tot.(Kgs)	Local Cons. (Kgs)	Transp. (Kgs)	Tot. (Kgs)	Local Cons. (Kgs)	Transp. (Kgs)
637	265.4	371.6	517.4	205.2	312.2	598.7	244.4	354.3	649.8	269	380.9

4.5.3.3 Challenges Experienced in Fish Farming

The challenges experienced in fishing include and not limited to attacks by wild and aquatic animals, lack of proper fishing gear, drought, lack of ready market, unavailability of fingerlings, long distance to market places and insecurity. Other challenges cited by the fisheries department in the sub County include slow uptake of fishing as an activity, drying up of the potential lakes and swamps due to diversion of the river by a select group of communities living upstream (E.g lake Shaka Babo, ziwa la kongolola) and the issue of many tributaries with no sufficient water.

4.5.4 Other combination of livelihoods

It is worth noting that apart from the three major livelihoods mentioned; there also exists combinations of agro fishers (crop farming and fishing), agro pastoralist (crop and

livestock farming) and those that do mixed farming but rather in small scale. About a quarter of the sample population was found to be doing a combination of the livelihoods.

4.5.5 Marketing of the produce

The value chain for the products produced out of the livelihood activities needed to be established to find out the markets available for the products and the production in each economic activity. It was established that 93.2% sell their products in the local markets which include; Tarasaa, Garsen, Oda, Minjila among others. The remainder find markets regionally and nationally that includes Malindi, Mombasa and beyond. There is also a negligible fraction of about 2% that do not sell their produce.

4.5.5.1 Challenges in Accessing Market

The challenges residents experience in accessing markets for their produce include poor market infrastructure, unhealthy competition, unavailability of ready market, high transport cost, low market prices, long distances, insecurity, delayed payment, theft and poor roads.

4.5.6 Conflicts Arising on Utilization of Resources

The conflicts that were alluded to by the respondents were amongst them Animal crop conflict which constituted 22.0%, human wildlife conflict 37.3% and human human conflict (insecurity) 40.7%. The insecurity constitutes the highest percentage according to the respondents considering that the area has had effects on the war against *alshabaab* and the tribal clashes.

4.6 Test of Hypothesis by Correlation Analysis (Relationship between community livelihoods and use of communal resources

		Ward Name	Use of communal resources
Ward name	Spearman Rank correlation Analysis	1	0.315
	Sig. (2-tailed)		0.015
	N	59	59
Use of communal resources	Spearman Rank correlation Analysis	0.315	1
	Sig. (2-tailed)	0.015	
	N	59	59

Table 4.7 Correlation analysis of community livelihoods and use of communal land resources

The above table 4.7 shows the relationship between community livelihoods and use of communal resources at a significant level of $p<0.05$. It shows a value of 0.315 positive correlation. We can therefore deduce that the two variables have positive relationship with each other. This shows that there is significant relationship between the two variables hence we reject the null hypothesis and accept the alternative hypothesis. The relationship was investigated using Spearman Rank correlation coefficient where preliminary analyses were made to avoid the assumptions of normality, linearity and homoscedasticity. We therefore reject the null hypothesis and accept the alternative hypothesis since our test yields positive relationship

CHAPTER FIVE

5.0 Summary, Conclusion and Recommendations

5.1 Introduction

This chapter presents summary of findings, discusses them against the objectives, literature review presented and null hypothesis tested making conclusions, recommends, policy and gives suggestion for further study. The null hypothesis tested was whether there was significant relationship between the community livelihood and the communal land resources.

5.2 Mapping of communal land resources for the benefit of communities in River Tana Delta

5.2.1 Summary of findings

According to the first objective of this research project, the study observed that there is the River Tana, pasture land, arable land, oxbow lakes and riverine forest as the major communal land resources (Figure 4.1). Pasture land was found to be the land beyond the farm lands and fisheries which is one (1) kilometer from the river and the swamps.

There are two types of conflicts namely human – wildlife conflict and human – human conflict. Human - wildlife conflict occur where the people and their activities utilize resources that are shared with the wildlife in search of water and pasture. For example search for pasture and water in the forests (Witu and the other small forests) and the game park (Tsavo East National Park).

The human - human conflict occurs amongst the major competing economic activities, particularly along the River Tana where a lot of farming is taking place. This manifests itself where there are no proper *malka* for the animals to access water.

5.2.2 Recommendations

Since majority of the residents of RTD do not receive adequate training on the utilization of the communal resources. There is need to intensify the trainings by the agencies who are on the ground for example Red Cross, United Nations (UN), United Nation Environmental Program (UNEP) and the County Government of Tana River.

5.3 Impact of major livelihoods on communal land resources

5.3.1 Summary of findings

On the impact of livelihoods on the communal land resources, the study established that there were three main economic activities namely livestock farming, crop farming and fish farming. Apart from these main activities, there were others who practiced mixed farming in the form of agro pastoralists, agro fishers and all the three (Figure 4.2).

On crop farming, the average land size per household was 0.4Ha while the size of land for livestock per household could not be established because of the communal tenure. However, the average numbers of animals were established to be 72, 57, 56, 18 and 6 for cattle, sheep, goats, poultry and donkey. These numbers against the LU of <10 animals for cattle and ruminants per square kilometer, is too high considering the climatic conditions of the region. Due to this fact, the pastoralists employ nomadic pastoralism system of livestock production. Flood irrigation system and the use of hooks, lines and fish traps were used in crop farming and fish farming respectively.

5.4 Utilization and potential of communal land resources in River Tana Delta

5.4.1 Summary of findings

This study observed that there were three main sources of livelihoods in RTD mainly livestock farming, crop farming and fish farming (Figure 4.2). Figure 4.1 on communal

resources also maps out the various communal land resources that support the livelihoods.

Livestock farming was established to be happening in the areas beyond crop and fish farming except for the small passages to access water which the livestock also use as part of their grazing fields. The area was established to be 53.161square kilometers. This area according to the LU can only handle 530 animals as opposed to the current numbers in table 4.3. It is worth noting that the delta as a whole support more animals within and from without during the dry seasons.

Crop farming on the other hand was occurring up to one (1) kilometer from the river and the swamps. This was the potential area for the activity. Likewise, fish farming, mostly done in River Tana and two ox bow lakes within the study area namely Tamaso and Mukuyuni. However, there is also great potential in fish ponds since it has been tried before but did not pick very well.

5.5 Productivity in major livelihoods of River Tana Delta

5.5.1 Summary of findings

5.5.1.1 Livestock farming

The main types of livestock kept in the delta are cattle, sheep and goats. The average numbers kept per household are 72, 57 and 56 respectively. In terms of livestock production per season, the study found that the numbers increased by nearly half the as shown in table 4.3. It was also established that most of the livestock were being kept for meat, milk was only sold for subsistence purposes.

The main challenges in livestock production in the delta include diseases, attack by wild animals, low market prices, drought, lack of pasture, low production and high operation costs.

5.5.1.2 Crop farming

The main crops planted in the delta are maize, watermelon, tomatoes and beans. The total area for crop farming is approximated to be 40.477 square kilometers equivalent to 40,477 Ha. Since the average size of land for farming was found to be 0.4 Ha which is equivalent to an acre, the production per household were established to be 10 bags, 1398Kgs, 1200 Kgs and 7 bags respectively for the main crops. For the maize plant, which is taken to be the staple food for the Kenyan people, the produce was found to be below average compared to the potential average yield specified by Kenya Seed Company. This may be attributed to the climatic conditions, the systems of farming and the high poverty levels in the delta.

The main challenges recorded during the research are inadequate rainfall, destruction of crops by animals, pests and diseases, low yield, high cost of farm inputs, drought, insecurity and lack of capital. Others include diversion of the river at will and the use of not effective systems in crop farming especially in irrigation.

5.5.1.3 Fish farming

The most common types of fish in the delta are tilapia, catfish, proptopterus and clarias according to this study (Table 4.6). As recorded by the fisheries department in Tana Delta in the year 2016, the productions in fish type were as follows, 650Kgs, 637Kgs, 599Kgs and 517Kgs for tilapia, catfish, proptopterus and clarias fish. This indicates potential and if enhanced can yield high returns with the fisher community and improved technology in fish ponds to compliment the fish resources in the delta.

The main challenges were attacks by wild and aquatic animals, lack of proper fishing gear, drought, lack of ready market, unavailability of fingerlings, long distance to market places and insecurity. Other challenges include slow uptake of fishing as an

activity, drying up of the potential lakes and swamps and the issue of many tributaries with no sufficient water.

5.6 Recommendation

From the study, the following recommendations were made in line with the study objectives;

1. The first objective of the study which was to map the land resources in River Tana Delta was achieved. Therefore, the PGIS project should be implemented to help map the land resources in the locality of River Tana Delta. Thorough sensitization programs should be put in place to create awareness and to achieve long lasting solutions by the people for the people.
2. The second objective was to examine how major livelihoods have impacted on the use of communal land resources. It was noted that the communal land resources have provided the opportunity for the communities' livelihood. The major livelihoods are drawn from the key communal land resources as livelihood assets in the Delta (River Tana, Rangeland and the lakes). There has been utilization of the resources however, there is need to improve on technologies being used and extension services to advice on best practices that suite the environment.
3. The third objective, to establish the utilization and potential of communal land resources. The utilization of the resources is being realized except that the production for each particular livelihood is not viable. Particularly for livestock farming, the number of cattle being kept per household exceeds the LU considering the land left for pasture land. It is important to note that the Delta only offers refuge during the dry spell.

For the crops, the Delta is a fertile place with loam to black cotton soils full of alluvial deposits but the erratic rainfall patterns have pushed them to irrigation practices which are not effective to realize the potentials. For the communities to realize bumper harvests there is need to improve to efficient and sustainable modern irrigation systems.

Fishing as an activity has great potential because of the fisher community and the land resources. The intervention is to improve on the fish husbandry through diversification, awareness and use of better fishing equipment

4. The last objective to assess the production in various communal land resources was found to be low for crop farming and fish farming. As has been suggested in objective three above, there needs to be a lot of continuous extension services, awareness and introduction of modern technologies to maximize on the potential of the resources.

5.6.1 Suggestions for further studies

Land based resources are naturally available. However, there are challenges that hinder the sustainable exploitation of such resources. There is need for continued research on the challenges hindering full operationalization of the PGIS in the management of natural resources**.**

5.7 Conclusion

The study has highlighted the communal land resources as mapped by the PGIS and challenges involved during exploitation of such resources. The challenges include; attack of residents by wild animals, inadequate rainfall, displacement of residents and lack of enough land for pasture among others. For the success of the project, there is need to provide solutions for such challenges.

The mapped resources include pasture land, farmlands, River Tana, riverine forest, oxbow lakes, thicket and swamps. These areas are the most suitable for the corresponding specific economic activities of pastoralism, crop farming and fishing which are carried out in the Delta. For the crop farming, it can be done up to a kilometer away from the main water sources as mapped in the map. But this is only possible when other interventions are put in place including setting up dams as reservoirs, developing irrigation canals to reach the far but potential areas and authorities to offer extension services on the best crops to be cultivated for higher yields.

The livestock will have the already put interventions which are to provide Livestock feed supplements, Livestock off take system, Livestock insurance, Hay bailing and Breed improvement for sustainable livelihood.

The fisheries sector apart from utilizing the river and the lakes, it is possible also to encourage the construction of fish ponds as an alternative to the already existing fishery resources. This can be done particularly along the main water courses to access water.

There are conflicts such as disputes over land for crop farming and livestock rearing, blocked water points by farmers which arise during exploitation of the arable land. These conflicts can be solved by giving knowledge and trainings on alternative ways of carrying out economic activities.

Despite the challenges, there is clear recognition of PGIS, training and use of technology in exploitation of resources. However, there is a lot to be done for proper operationalization of the PGIS in terms of policy and controls.

The hypothesis test was done using Spearman Rank correlation coefficient where preliminary analyses were made to avoid the assumptions of normality, linearity and homoscedasticity. The positive correction value between the two variables leads to the

rejection of the null hypothesis and acceptance of the alternative hypothesis. From the test of hypothesis, we can conclude that the community livelihoods have a positive impact on the mapped communal land resources in River Tana Delta.

5.8 Policy

There is a lot to be done on policy and awareness of existence of communal land resources and governance. With the PGIS as a tool and the maps as a product, there is need for ratification and to make them authentic documents to guide decision making and resource use. This can be done through the respective county Government.

The policies also in place and many others to be formulated need to be enforced taking cognizance of the livelihoods and sustainability of the communal land resources. There is need to research on high quality breeds and seeds of high resistance and of good production. Of course this should go hand in hand with modern technologies.

REFERENCES

Abbot J., Chambers R., Dunn C., Harris T., Porter G., Townsend G &Weiner D 1998, Participatory GIS: opportunity or oxymoron? Participatory Learning & Action PLA Notes 33, 27-34.

Alarcon E., Orban-Ferauge F & Pandan M 2009, Participatory Geographic Information System (PGIS) for Sustainable Solid Waste Planning in Barangay Punta-taytay, Bacolod City, Philippines,70th Philippine Institute of Chemical Engineers National Convention, February 25-27, Davao City, Philippines.

Bandhari B 2003, Participatory Rural Appraisal, IGES, Institute for Global Environmental

Bocco, G &Toledo, V. 1997, Integrating peasant knowledge and geographic information systems: a spatial approach to sustainable agriculture. Indigenous knowledge and development monitor 5(2): 10-13.

Chambers, R 1990, Rapid and Participatory Rural Appraisal, Appropriate Technology, Vol. 16, n°4.

Chambers, R 1997, Whose reality counts? Putting the first last. London: Intermediate Technology Publication.

Christensen, I & Pozarny, P 2008, Socio – Economic & livelihood Analysis in Investment Planning, FAO

Crafter, S., Njuguna, G &Howard, W 1992, wetlands of Kenya, proceedings of a seminar on wetlands of Kenya, IUCNArticles

Craig, W &Elwood, A 1998, how and why community groups usemaps and geographic information. Cartography and Geographic Information Systems 25(2): 95-104.

Commission of Revenue Allocation, 2011. Kenya Inter Agency Rapid Assessment

Cuppen, J 2014, Making peace under a mango tree' A study on the role of local institutions in conflicts over natural resources in Tana Delta, Kenya. Unpublished

Dennis; and Stephen Daniels (eds.) (1988) The Iconography of Landscape: Essays on the Symbolic Representation, Design and Use of Past Environment. Cambridge: Cambridge U.P.

Dollard, J., Doob, Leonard W., Miller, Neal, E., Mowrer, Orval Hobert, Sears,

Duerden F &Kuhn R 1996, The application of geographical information systems by First Nations and Governments in northern Canada. Cartographica 22 (2) 49-62.

Dunn C 2007, Participatory GIS — a people's GIS? Progress in Human Geography 31 (5) 616-637.

Dunn, C., Atkins, J & Townsend, G 1997, GIS for development: a contradiction in terms? Area 29 (2) 151-159.

Elwood S 2009, Geographic Information Science: new geovisualization technologies emerging questions and linkages with GIScience research. Progress in Human Geography 33, 256-263.

Engle, S 2000, Participatory GIS: A new framework for planning more sustainable forms of tourism development. Unpublished Masters of Development Studies, Victoria University, Wellington, New Zealand.

FAO, 2008. Socio- Economic and livelihood Analysis in investment planning.

Forrester, J.M & Cinderby, S. 2011, A Guide to using community mapping and participatory - GIS

GoK 2000, Interim Poverty Strategy Paper, Government printers, Nairobi

GoK 2000, The Environmental Management and Coordination Act, No. 8 of 1999, Government printers, Nairobi

GoK 2010, 2009 Kenya Population and Housing Census, Vol 1A.Kenya National Bureau of Statistics, Nairobi.

Goodchild, M., Steyaert, L & Parks, B 2009, Environmental Modeling with Geographic Information Systems.Oxford University Press, London.

Hackeloeer, A.; Klasing, K.; Krisp, J.M.; Meng, L. (2014). "Georeferencing: a review of methods and applications". Annals of GIS. 20 (1): 61–69.

Hadi A 2000, A participatory approach to sanitation: experience of Bangladeshi NGOs. Health, Policy and-Planning 15(3) 332-337.

Hardin G 1968, Tragedy of the commons, Science, New Series, Vol. 162, No. 3859. (Dec. 13, 1968), pp. 1243-1248

Harley, B 1988, Maps, knowledge and power. pp. 277-312 IN: Cosgrove,

Heywood D.I., Cornelius S & Carver S 2006, An introduction to Geographical Information Systems.3rd Edition. Essex, UK: Pearson Prentice Hall.

Jankowski, P 2008, Towards Participatory Geographic Information Systems For Community Based Environmental Decision Making. Journal of environmental management, vol. 90, No. 2009, pp. 1966 – 1971

Jirka P 2013, Geographic Information Systems in Developing Countries – What are the Ethical Issues we need to be aware of? Vol LIX (2) P. 40-48, ISSN 1802-5420.

Maingi, K., Marsh, E 2002, Quantifying hydrologic impacts following dam construction along the Tana River, Kenya. Journal of Arid Environments vol. 50, pp. 53-79.

Malthus Thomas. 1803 (14th edition: 1826). An Essay on the Principle of Population. London: J.M. Dent, pp. 1-24 passim

Mbugua, K 2013, Inter-communal conflicts in Kenya: The real issues at stake in Tana Delta. International Peace Support Training Centre (IPSTC). ISS 1

McCall M 2003, Seeking good governance in participatory-GIS: a review of processes and governance dimensions in applying GIS to participatory spatial planning. Habitat International 27 (4) 549-573.

McCall, M 2009, Applying Participatory-GIS and Participatory Mapping to Participatory Spatial Planning (in particular to Local–level Land & Resources Management) utilising Local & Indigenous Spatial Knowledge. A Bibliography. Morelia: UNAM, CIGA (149p.)

Mekong River Commission, 2011, Basin Development Plan Programme, Planning Atlas of the lower Mekong River Basin

Mosse, D 1994, Authority, gender and knowledge: theoretical reflections on the practice of Participatory Rural Appraisal. Development and Change 25: 497-526.

Nyerges T. 1993, Understanding the scope of GIS: its relationship to environmental modeling, Oxford University Press, London

Odhengo P., Matiku P., Nyangena J., Wahome K., Opaa B., Munguti S., Koyier G., Nelson P., Mnyamwezi E &Misati P 2012, Tana River Delta Strategic Environmental Assessment Scoping Report. Unpublished

Odhengo P., Matiku P., Waweru P., Guda D., Kinara T., Kathike S., Mmyamwezi E., Munguti S., Nelson P & Koyier G 2014, Tana River Delta Land Use Plan, unpublished

Poole, P. 1995 Geomatics: who needs it? *Cultural Survival Quarterly* (Special Issue) vol. 18, no. 4.

Rambaldi G 2010, Practical ethics for facilitation participatory community mapping. IAF Europe Newsletter, February 2010, pp.6-15. Strategies, Japan.

Robert R. (1939). Frustration and Aggression, New Haven, CT, US; Yale University press, OCLC 256003.

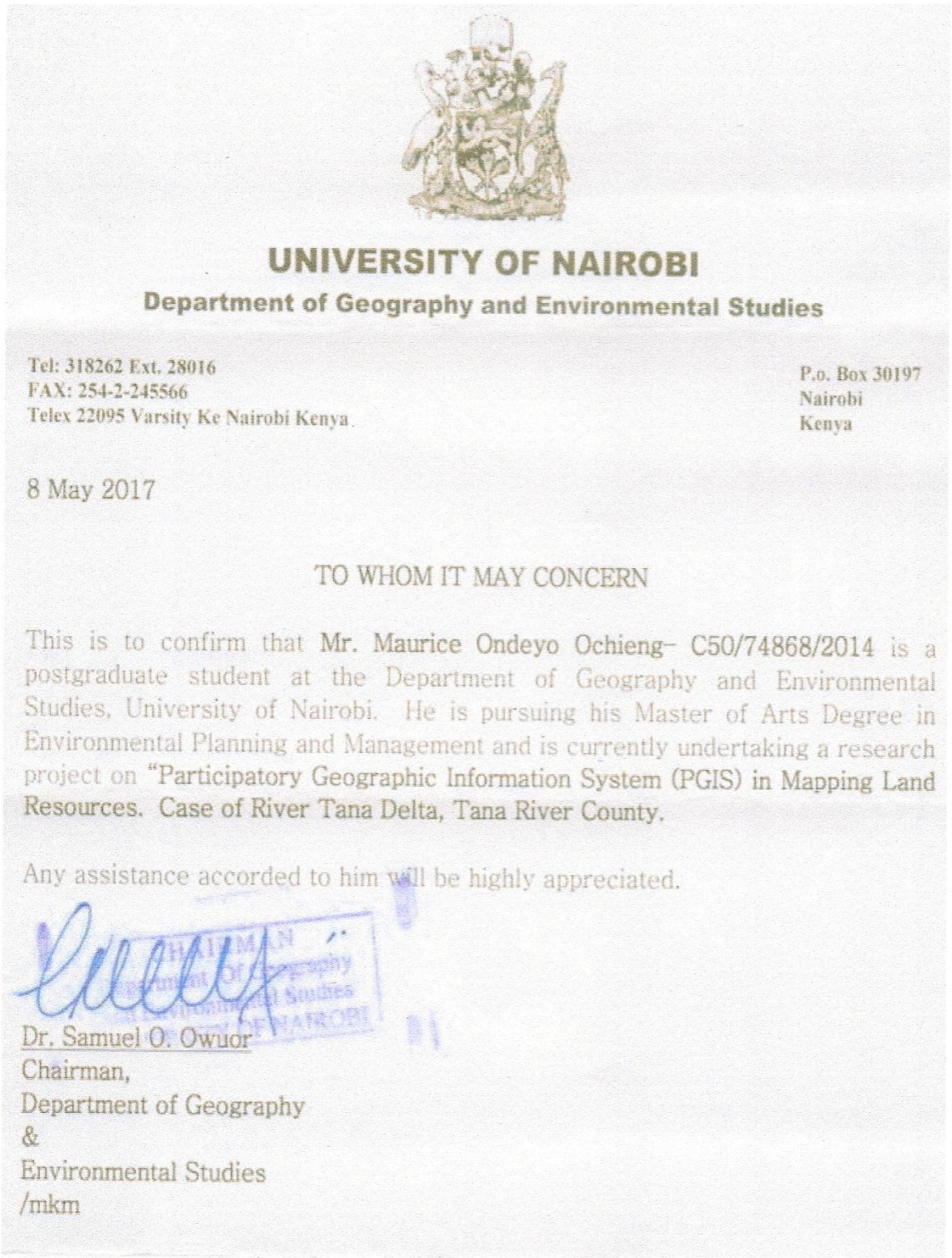
Susan Jane Buck Cox 1985, No tragedy of the commons. Environmental ethics 7(1): 49-61

Viles, A. 2007, Review of Ground water resources in the Orange River catchment

Weiner, D & Harris, T 1999, Community-integrated GIS for land reform in South Africa. International conference on geographic information and society, University of Minnesota, June 1999.

APPENDICES

Appendix I: Introduction Letter



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8 May 2017

TO WHOM IT MAY CONCERN

This is to confirm that Mr. Maurice Ondeyo Ochieng– C50/74868/2014 is a postgraduate student at the Department of Geography and Environmental Studies, University of Nairobi. He is pursuing his Master of Arts Degree in Environmental Planning and Management and is currently undertaking a research project on "Participatory Geographic Information System (PGIS) in Mapping Land Resources. Case of River Tana Delta, Tana River County.

Any assistance accorded to him will be highly appreciated.

Dr. Samuel O. Owuor
Chairman,
Department of Geography
&
Environmental Studies
/mkm

Appendix II: Household Questionnaire

QUESTIONNAIRE CONFIDENTIAL

QUESTIONNAIRE FOR PARTICIPATORY GEOGRAPHIC INFORMATION SYSTEM (PGIS) IN LAND RESOURCE MAPPING. CASE OF RIVER TANA DELTA (GARSEN CENTRAL & GARSEN SOUTH WARDS), Tana River COUNTY.

Ward Name: _____ **Date:** _____

Sub Location: _____ **Village** _____

1. PERSONAL DATA

Name of the respondent: …….

Age: (18 – 35) ☐ (36 – 50) ☐ Above 50 ☐

Gender: Male ☐ Female ☐

Marital status: Married ☐ Single ☐ Divorced ☐ Widow/Widower ☐

Level of Education: Primary ☐ Secondary ☐ Tertiary Not Gone to sch.

How long have you stayed in this area since birth ☐ less than 5 years ☐ 5 – 10 years above 10 ☐ years

2. HOUSEHOLD INFORMATION

a. Household size …….

b. Number of males …….

c. Number of females ……..

3. LAND ALLOCATION FOR ECONOMIC ACTIVITIES

a. Are you a

Crop farmer (Answer Q3b – 3h) ☐ Livestock farmer (Answer Q3i – p) ☐ Fish farmer (AnswerQ3q – 3t) ☐ Others specify

……

……

b. If you are a crop farmer, where do you carry out your farming activities

……

……

c. Which crops do you grow

……

……

……

d. What is the acreage of land for crop farming

……

e. What is the produce per crop per acre

……

……

……

f. What challenges do you experience in crop farming?

……

……

……

……

……

g. Do you own the land Yes ☐ No ☐

h. If yes is the land titled Ancestral ☐ leased ☐

i. If you are a livestock farmer, where do you carry out your activity

……

……

……

j. Which animals do you keep

……

……

……

k. What is the number of the animals kept

……

……

……

l. What is production per season per type of animal

……

……

……

m. What is the acreage of land for pasture

……..

n. Do you own any land for grazing? Yes ☐ No ☐

o. If yes, is the land titled Ancestral ☐ leased ☐

p. What challenges do you experience in livestock farming?

……

……

……

……

q. Where do you do your fish farming?

……

……

r. Which kind of fish do you catch or farm?

……

……

s. What quantity do you catch per day/month?

……

t. What challenges do you experience in fish farming?

……

……

……

……

4. SOURCES OF LABOUR

a. Do you use any hired labour? Yes ☐ No ☐

b. If Yes, for what purpose

……

……

……

c. If No what is your source of labour

……

……

……

d. How many hours do you spent per day in crop farming…….

e. How many hours do you spent per day in livestock farming ……..

f. How many hours do you spent per day in fish farming ……..

g. How many hours do you spent per day in other activities …….

5. SOURCES OF CAPITAL

a. Where do you get the money for investment?

……

……

b. Do you have access to credit facilities? Yes ☐ No ☐

c. If yes, which sources

……

……

……....

d. For what purpose do you access the credit facilities

……

……

……

e. When is the last time you obtained a credit?

……

f. From which facility?

……

g. For how much?

……..

h. What are the challenges encountered during the process?

……

……

……

……

6. MARKETING

a. Where do you sell your products?

……

……..

b. What is the distance to the market where you sell you products

……..

c. Do you have any challenges in accessing market for your produce? Yes ☐ No ☐

d. If Yes, kindly list them

……

……

……

7. LAND RESOURCES

a. What are some of the communal resources and their location in your sub Location?

……

……

……

……

……

b. Have you been able to use the resources optimally? Yes ☐ No ☐

c. If No, what are the challenges in utilizing the resources

……

……

……

……

……

d. What kind of conflicts arises in resource utilization?

……

……

……

……

……

……

8. TECHNOLOGY

a. Do you receive any trainings or extension services on the utilization of the resources?

Yes ☐ No ☐

b. If yes from which institutions

……

……

……

c. What technologies do you use in utilization of the resource

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d. Would you agree to adoption of new technologies in utilization of the resources?

Yes ☐ No ☐

Thanks You for your Cooperation