EGERTON UNIVERSITY

TEGEMEO INSTITUTE OF AGRICULTURAL POLICY AND DEVELOPMENT

WPS 58/2016

A Review Paper on Large scale Irrigation in Kenya: A Case Study of Maize

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WP58/2016

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Published March, 2016

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Tegemeo Institute acknowledges support for its research programmes from key partners, especially the United States Agency for International Development (USAID). Others include Bill and Melinda Gates Foundation (BMGF), the Rockefeller Foundation, the World Bank, European Union, Ford Foundation and the Food and Agriculture Organization of the United Nations (FAO).

Acknowledgments

The authors gratefully acknowledge funding from the United States Agency for International Development (USAID) and DfID through Future Agricultures Consortium. We wish to thank Mary Mathenge, Lillian Kirimi, John Thomson, Hannington Odame, Dennis Otieno, Simon Kimenju and the staff at Tegemeo Institute of Agricultural Policy and Development, for their comments, suggestions, and assistance.

Abstract

Policy makers and development experts believe that irrigation is the panacea to frequent drought related crop failure and to meet the demand for cheap and stable food supply in Kenya. The country has experienced heavy crop losses associated with drought in the years 1980, 1984, 2000, 2008, 2009, and 2011(WFP, 2011). Since 2009, the government set out to reduce reliance on rain-fed production by investing KES12.5 billion into rehabilitation of irrigation schemes in the country. This report prepared in May 2014, reviews existing literature on irrigation in the World and provides views by experts on the potential for irrigation and its major challenges. The review considers policy on irrigation and the past investments to elicit lessons which could inform research for new policy on irrigation in Kenya. The findings show that local experience with irrigation development in most public irrigation schemes is bad. The UN advises caution on large-scale irrigation in pastoral areas which could cause significant environmental degradation and low economic returns despite heavy subsidies, while undermining the pastoral economy. Avery (2013) argues that irrigation in semi-arid areas will be challenged by high solar radiation and temperatures, and dry winds that desiccate soils and crops. Experts have raised many questions in literature reviewed which include; what is the nutritional quality of irrigated crops not have been bred in semi-arid areas? How are local markets (supply and demand) going to be affected by the increase in supply of maize? What criteria will the government use to allocate water? What will be the impact of irrigation on the river ecology (hydrology, onsite soils, water tables, water logging, salinization, sodication, nitration, wildlife, micro-organisms, pests and diseases, genetic diversity, etc)? What will be the social and political impact of an influx of workers from other ethnic groups into the regions being developed for irrigation? What is the ex-ante economic surplus of the project? What is the opportunity cost of maize irrigation compared to alternative livelihoods like pastoralism? What is the policy on land and water use rights for investors, stakeholders and minority ethnic groups especially the Watta, Orma and Giriama living in Galana/Kulalu? What will be the effect of large-scale irrigated maize production on the market considering its potential effect on maize producing regions in Western Kenya?

Key words: Irrigation, Arid Areas, Markets, Property rights, Environment, Policy

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Acronyms

ASAL	Arid and Semi-arid Areas
FAO	Food and Agriculture Organization
KES	Kenya Shilling
MTP II	Second Medium Term Plan
MoAL&F	Ministry of Agriculture, Livestock and Fisheries
NIB	National Irrigation Board
RoK	Republic of Kenya
WFP	World Food Programme

1. Introduction

Policy makers, development experts and farmers believe that irrigation is the panacea to improving food production in the Kenya. The country has experienced a series of heavy crop losses associated with drought in the years 1980, 1984, 2000, 2008, 2009, and 2011(WFP, 2011) this has affected its ability to meet the demand for cheap and stable food supply in Kenya. The trend shows an occurrence of two serious drought related crop failures and famine every decade. This has shifted government policy on agricultural production for food security towards large scale irrigation in ASAL areas (MTP II, 2013), although the Water Master of 1992 had prioritized expansion of irrigation in the Lake Victoria Water Basin which has enough water. Drought related crop losses are prevalent across the world due to climate change (Doeing, 2005) estimated an annual average loss of 20 million metric tons of maize, equivalent to around $US 7 billion per year due to drought. Similarly, maize losses in non-temperate areas were estimated to be about 19 million metric tons in the early 1990s or approximately $US 1.9 billion (Kostandini *et al.,* 2007). This has encouraged the thinking that investments into irrigated production would save the country from experiencing the high production losses associated with insufficient rainfall while improving the incomes of farmers and their livelihoods.

Avery (2013) reported that most people believed that the Kenya should move away from rain-fed production of staple foods and rely on irrigation. Irrigation provides an avenue for improving food security by increasing the area cultivated and land productivity as demonstrated in dry regions of Egypt, Asia, South Africa and Sudan. Kenya has huge areas of land in ASAL regions that are now being targeted for irrigation to emulate the example of Egypt, Asia and Israel. The Ministry of Agriculture policy supports development of irrigation in ASALs (RoK, 2009) which comprise 82% of Kenya's land and which has great potential for irrigated production instead of relying on rain-fed agriculture.

Since 2009, the Kenya government set out to reduce reliance on rain-fed production of food crops (which currently produce 38 million bags of maize) by investing part of the economic stimulus funds (KES12.5 billion) into rehabilitation of major irrigation schemes in the country (RoK, 2009). The government instituted in 2013, massive new investments in irrigation as spelt out in the Medium Term Plan (MTP-II 2013-2017), which set a target of one million acres (404,685 hectares), half of which is under maize to increase supply and hence improve peoples' livelihoods.

Previous focus under the vision 2030 programme was on small holder irrigation projects. The proposed Galana/Kulalu irrigation initiative is a large scale project in which 1.2 million hectares will be leased by private sector investors who are expected to invest in production of various crops including maize. It has been projected that the project could produce 40 million bags of maize (season lasts 3 months), which is above expected rain-fed production levels.

Efforts to improve food security in the country target staple foods but this tends to be synonymous with ensuring that there are adequate maize supplies. This has created consensus around heavy investment into irrigated maize production. Irrigation has the potential to increase crop output by 100 to 400 percent (Fernandez-Cirelli et al., 2009). By 2013, Kenya had an annual maize consumption of 42 million bags (KNBS, 2013) and this is projected to increase at the rate of 1 million bags per annum in tandem with population growth. It is also estimated that the government spends around US$40–65 million annually on famine relief; and the figure is even much higher when famine relief support by NGOs is taken into account (RoK, 2004).

This paper seeks to review research findings on irrigation in Kenya and highlight research gaps in existing evidence on irrigation in Kenya and particularly large scale maize irrigation to inform further enquiry and policy formulation on Kenya's budding interest in production of maize under irrigation.[2] The paper synthesizes concerns raised by different experts on irrigation and provides a case study on maize irrigation that could be relevant to policy on Galana/Kulalu project in coastal region. The specific objectives of the review are:

1. Establish the status of irrigation in Kenya.
2. Identify areas that need further investigation to inform investment policy on Galana/Kulalu project.
3. Identify policy gaps in large scale irrigation projects such as Galana/Kulalu.
4. Suggest some interventions that are required in Galana/Kulalu project based on existing evidence.

The rest of the paper is organized as follows: section two provides the historical review of irrigation in Kenya; section three gives an overview of the status of irrigation in Kenya; section three

[2] This scoping study was carried out in May 2014. At the time, a feasibility study of the Galana/Kulalu project was yet to be undertaken.

provides a description of literature on the suitability of Galana/Kulalu ranches for irrigation, its agro-ecology, evidence on the likely challenges of semi-arid land irrigation and the planned investment into the project; section four discusses research findings on the potential for maize irrigation and a case study on successful maize irrigation by a private sector investor in the USA and section five, summarizes the research questions on irrigation which are of concern to different experts.

2. Background

The history of early irrigation in Kenya shows that rice irrigation was practiced in around Ozi in lower Tana River some 500 years ago and later in Malindi and the Vanga area of Kwale by Arab slave traders Ngigi (2002). The British colonizers introduced irrigation around Kibwezi and Makindu in 1901-1905. Commercial farming under modern irrigation systems can be traced to the period after the introduction of cash crop such as coffee, pineapples, sisal and lucerne. During the Second World War (1939-1945), prisoners of war and conscripted labourers were used in the construction of irrigation schemes at Karatina, Naivasha, Njoro Kubwa in Taveta and on the shores of Lake Victoria. In 1946, the African Land Development Unit (ALDEV) embarked on a broad agricultural rehabilitation programme, which included development of irrigation. In the mid-1950s, the Unit initiated a number of irrigation schemes, including Mwea, Hola, Perkerra, Ishiara and Yatta furrow using detainee labour. In these schemes the land was owned by the state through the Ministry of Agriculture.

In 1966 the National Irrigation Board (NIB) was formed through irrigation Act cap 347 to manage tenant based national irrigation schemes. In 1978, the Netherlands provided funds to NIB which was then converted into a department of Irrigation and Drainage under the Ministry of Agriculture for development of smallholder irrigation schemes. From the late 1970s large scale commercial farmers producing mainly coffee expanded irrigation capacities using mechanical water abstraction and overhead sprinkler applications. In the period after the 1980s, farmers especially in the horticulture industry, adopted new and modern water saving irrigation technologies such as drip irrigation under green houses for production of high value crops and flowers.

2.1. Regional status of irrigation development

Kenya has a total land area of 58.26 million hectares out of which only 11.65 million hectares (20 %) receive medium to high rainfall while the rest is arid and semi-arid. Ngigi (2002) reported that the land surface potential for irrigation is estimated at 539,000 hectares but only 110,000 hectares of the total irrigation potential has been exploited. The country also has approximately 600,000 hectares suitable for land drainage including flood protection of which only 30,000 ha has been exploited. In 2003, irrigation accounted for only 1.5% of total land area under agriculture but directly contributed 3% to the GDP. It is therefore apparent that there is huge potential for irrigation to transform agriculture and enhance food security in the country. Kenya's irrigation sector falls under three organizational categories:

Smallholder schemes: These are owned, developed and managed by communities through irrigation water user groups or individual farmers. They produce for subsistence, domestic and export markets. There are 2,500 such irrigation schemes covering an area of 47,000 hectares, accounting for 46 percent of the total area under irrigation.

Public large scale schemes: The country has seven large-scale publicly funded irrigation schemes, namely Mwea, Bura, Hola, Perkerra, West Kano, Bunyala and Ahero covering a total area of 18,200 ha. These schemes are managed by the National Irrigation Board (NIB) and account for 18% of irrigated land area in Kenya. In these schemes each tenant farmer is allocated 1.6-2.0 ha for commercial production. The status of most water conveyance and infrastructure in large-scale public irrigation schemes is poor.

Private schemes: These are commercial firms using modern technology to irrigate high value crops for the export market. Such schemes cover more than 42,800 ha and employ a workforce of about 70,000 persons. They specialize in flowers, vegetables and fruits for both local and export markets.

The mapping of irrigation potential in Kenya has shown 5 irrigation basins. These are: Lake Victoria basin, Rift Valley basin, Uaso Ng'iro basin, Athi River Basin and Tana River basin, but this is subject to revision due to discovery of large aquifer such as the Turkana aquifer in 2013. Available data from NIB shows the size of the irrigation basins as given in table 1. Although policy on irrigation is still absent the government has emphasized its commitment to investing in irrigation. Under Vision 2030, the Jubilee government in Kenya planned to irrigate 1 million acres of land as part of the Vision 2030 flagship projects. It allocated an initial KES 2 billion towards the rehabilitation of existing irrigation schemes in Bunyala, Ahero, Perkerra, Mwea, Bura and Hola (NIB, 2013). The new policy has been to invest in about 627,287 acres of Galana/ Kulalu ranches and leased them out to private sector investors for production of food crops.

Table 1: Regional Irrigation Potential and Development

River Basin	Total Potential for Irrigation	Developed area	Balance
1. Tana	226,224	64,425	161, 799
2. Athi	91,006	44,898	46, 108
3. Lake Victoria Basin	297,213	15, 094	282, 119
4. Rift Valley	101, 753	9,587	92,166
5. Ewaso Ngi'ro	49,379	7, 896	41,483
Total	765,575	141, 900	623, 675

Source: NIB, 2013

The required infrastructure was to be put in place by NIB on behalf of the government in order to lower the investment costs and as an incentive for private investors to lease land and produce food. Essentially, the government heavily subsidized the investment in irrigation to entice private sector investors for large scale irrigation. Most smallholder irrigation schemes had performed dismally over the years except Mwea rice irrigation scheme which is performing well.

Civil society organizations have therefore been concerned about the economic, social and environmental rationale of shifting irrigation to ASAL regions. A breakfast meeting held at The Intercontinental hotel on December 3rd, 2013 by the Regional Learning and Advocacy Program (REGLAP) to discuss the new ASAL based irrigation schemes questioned whether the government had undertaken any comparative study on welfare for livelihoods based on irrigation compared to the dry land livelihood system of pastoralism to establish which one is more cost-effective. The argument by pastoralists seemed to be based on fears about loss of control over land resources, a lack of coherence in policy on ASALs and the dangers of projects with a leaning towards political expediency for investments in irrigation.

2.2 Policy on Investments in Irrigation in Kenya.

Rampa et al (2011) noted that the most striking feature of the water sector in Kenya is probably the huge increase in the overall resources invested in the sector in recent years with the expenditures by national government, private investors, and international donors increasing from KES 2 billion in 2002 to KES28 billion in 2009 to KES32 billion in 2010. This has resulted in a booming interest by a wide range of actors for water related issues, with a view to accessing the enlarging pot of financial and non-financial resources available for the sector. The water sector governance has yet to become harmonized even when there are many regional water boards which have been formed and which are supposed to coordinate the investments into water abstraction by public and private agencies. As the Galana/Kulalu project unfolds, it has generated diverse opinions on its viability and benefits to local communities at the coast. The policy on providing infrastructure and land to private sector investors as incentives for large scale irrigation in a public private partnership arrangement does not guarantee or safeguard the water and land rights of local communities.

2.3 Historical Lessons on Irrigation and the Agricultural Yield Gaps

The World Bank (1997) collected global evidence showing that irrigation has great potential in increasing agricultural productivity, in improving food security and in poverty reduction. Markwei et al (2008) have also reported that considerable potential exists to increase food production in those parts of sub-Saharan Africa where water availability is fundamentally not a problem by expanding irrigated farming systems. Irrigation is also seen as an important technology to ensure food security at local levels. According to FAO (1996), reliable sources of irrigation water in rural Africa, especially in arid and semi-arid areas are known to reduce risks and stabilise production levels for individual farmers. According to Fernandez-Cirelli et al. (2009), in arid and semi-arid regions, irrigation improves economic returns and can boost production by up to 400%. A Science in Development (Scidev.net, 2014) article argued that there is been a lot of focus on reducing the yield gap in crops using irrigation. Yield gap has been reported to be very high (76%) in SSA compared to other regions as shown below:

Table 2: Yield gaps for Maize

Region	Potential Yield (Ton/ha)	Actual Average Yield (Ton/ha)	Reported Yield Gap in 2014 (Ton/ha)
Kenya	6.0 – 10.0	1.8	7.0 - 8.0
East Africa	9.0 – 13.0	1.4	7.0 - 8.0
Sub-Sahara Africa	9.0 – 14.0	1.6	6.0 – 10.0
Southeast Asia	12	4.1	Still under evaluation
Northern America	13.4 -14.3	9.2	15%
Western Europe	18.0	9.7	8.0
Southern America	12.0 – 14.0	4.9	6.0 - 8.0

Source: FAO Statistics Division 2014 | 15 April 2014 and Global Yield Gap Atlas (2014)

According to Kalunde (2008), Donor agencies have been the major force spearheading development of irrigation through project schemes and programmes promoting different types of designs for water mobilisation (flood water cropping, stream diversion, water harvesting and lift irrigation), different forms of management and ownership of infrastructure (public or private, government or community or individual), and different levels of irrigation water control (from informal self-build to highly engineered structures). Kalunde (2008), in reference to the Tanzanian Moshi irrigation schemes found that many of the designs were developed using a top down approach, instead of a participatory, bottom-up approaches, to design and implementation. The large scale schemes depend on heavy donor funding as reported by NIB (2014) website; the Tana and Mwea irrigation schemes have been recipients of funding from IFAD, World Bank, OPEC fund, Government of Kuwait etc.

Moris et al (1990) found that the poor performance of irrigation projects has been common due to the ineffectiveness of large-scale irrigation projects unlike the traditional farmer-managed irrigation systems. They point out that large scale projects were often developed with major attention to hardware design and construction and paid much less attention to operation and maintenance. Experiences of irrigation development in Africa show that most public interventions in both small- and large-scale irrigation schemes have not produced intended results (Underhill 1984, 1990; Diemer and Vincent 1992; Rukuni 1995, 1997). Large-scale irrigation scheme developments will naturally favour permanent rivers and their more fertile adjoining alluvial flood plains. But there is agreement that water use is not efficient and problems of high silt load are a big challenge in both Tana and Athi Rivers.

Behnke, et al (2013) in a study of the Ethiopian Omo region irrigation states that the areas used to provide critical dry season grazing for livestock producers was converted into a farming area although it was already usefully integrated and complemented by small-scale agro-pastoralist irrigation. This scheme turned out to be an example of the conflicts that arise from large-scale irrigated crop incursions into ASAL areas. Pastoral communities in Ethiopia's Awash Basin were displaced from prime pastures by sugar irrigation projects. Similar displacement by commercial farmers has been resisted in Kenya's Lower Tana. The Lower Omo's Kuraz sugar plantation scheme near Kenya's northern international border involved major land areas excised from agro-pastoral communities and national parks, and has resulted in international accusations of human rights abuses. A study by Behnke et al (2013) also provides evidence that commercial crop products like sugar are less profitable than pastoralism.

The Integrated Regional Information Networks (IRIN) of the United Nations reported a 2013 study examining grazing lands along the Awash River in Ethiopia that revealed the shortcomings of large-scale irrigation. Beginning in the 1960s, these traditional pastoral grazing areas were converted into large-scale cotton and sugar plantations, which contributed to significant environmental degradation and very low economic returns despite heavy subsidies, while undermining the pastoral livestock economy. Irrigation projects have not improved the economic returns from agriculture in the Awash Valley, but they have transferred the control of valuable natural resources from Ethiopian pastoralists and farmers to government officials, said the study authors, noting that there is more community support for pastoralism than irrigation. Despite considerable investment by government, pastoralism is consistently more profitable than either cotton or sugarcane farming while avoiding many of the environmental costs associated with large-scale irrigation projects. As we enter an increasingly climate-constrained world, our findings suggest that pastoralism is a surer investment in the longer-term resilience and economic stability of Ethiopia's dry lowlands. Dr. Elmi Mohamed (former Minister Northern Arid Lands) was quoted in 2013 arguing that without better roads and markets for the farm produce investment in irrigation could be a wild-goose chase. He argued that there is no government presence to deal with conflicts affecting pastoralists and these regions produce fruits which rot before they access markets due to poor roads. Mangoes are a classic example in Tana River County.

2.4 Coast Lowland Irrigation

Ngigi (2002) reported that during the pre-independence days Bura irrigation scheme was set up using forced labour provided by Mau Mau detainees. Another scheme was set up at Hola after independence and later on Tana and Athi River development authority (TARDA) set up the Tana Delta irrigation scheme at Gamba. The Tana River flows from the Central Kenya highlands, for a distance of 800 kilometers to the Indian Ocean and supports around half of the hydropower generated in Kenya; irrigated agriculture, fisheries; livestock production and biodiversity conservation, supplying water to 17 million people. The coast region is poorly drained and very susceptible to flooding. Avery (2013) argues that the Bura and Hola schemes were challenged by marginal soils, the difficulties of ensuring reliable water supply, river channel mobility within its flood plain, and pumping problems. The water transmission distances for Bura resulted in large canal water losses. The canals also became choked with the invasive alien plant Prosopis juliflora. Both Bura and Gamba irrigation schemes collapsed due to mismanagement and floods caused by the el-nino rains in 1997.

The Hola and Bura irrigation projects faced many challenges including a local population which was pastoralist and therefore not familiar with crop production based livelihood. The general decline in irrigation development in the Tana Athi basin can be attributed to insecurity, salinity and sodicity problems, water scarcity and destruction of irrigation structures by the el-nino rains (Ngigi, 2002). The problems were exacerbated by the decline in financial support, inadequate marketing and infrastructure, inadequate technical knowhow, lack of credit facilities and lack of exposure of farmers to new irrigation technologies.

2.5 National Government Programmes on Irrigation in Kenya

Although there is no comprehensive policy on irrigation, the government has over time changed its strategy on investments in irrigation development. There is a shift from group based schemes to private individual farmers or corporations and also a shift in irrigation technology from gravity to motorized pumps. The new driver for large scale irrigation schemes is reported to be food security needs and the availability of large tracts of land in semi-arid regions (RoK MTP-II, 2013-2017). There are plans for massive investments in dams and water pans for water storage in different parts of Kenya. Some of these have faced controversy and have failed to take off as quickly as previously envisaged. The planned Nzoia river dam met stiff resistance from local communities who were supposed to be relocated. The Kuja river irrigation scheme in Migori has also faced a lot of challenges in the last 5 years and there is little progress in implementation although it had been allocated KES4.5 billion.

The Ministry of Water and Irrigation (2009) reports that past development of irrigation schemes mostly aimed to provide employment and settlement for the landless, especially in large publicly funded irrigation schemes where farmers participated as tenants. Services such as water conveyance, land preparation, inputs supply and produce marketing/processing were provided by the National Irrigation Board (NIB). In many of these schemes, some land is still idle, while crop yields are low, and Operation & Maintenance of the infrastructure was poorly done necessitating frequent rehabilitation. In addition, the benefits to the targeted people were low, with high occurrence of health hazards (malaria, bilharzia), while low sustainability and effective community participation have remained major constraints.

3. Challenges of Property Rights and Bio-diversity

3.1 Land and water ownership and access conflicts

Since independence in 1963, land in Tana River and parts of Kilifi counties has never been surveyed and registered for individual members of the local communities. Temper (2010) found that land ownership and boundary dispute cases have been in court since 1994 affecting Kulesa, Wema and Hewani villages in Tana River County. This has resulted in contested ownership and access to water and land. Over the last ten years, there have been tribal clashes arising from conflicts over crop farming areas and grazing areas. AFP (Aug 23, 2012) reported that at least 52 people mainly women and children were hacked or burnt to death in the worst ethnic massacre for several years between the Pokomo and Orma peoples. The dead included at least 31 women and 11 children. The Pokomo are a largely settled farming people, planting crops along the Tana River, while the Orma are mainly cattle-herding pastoralists. In 2001, at least 130 people were killed in a string of clashes in the same district and between the same two communities over access to land and the water.

Ensminger et al. (1991) argued that an examination of the causes behind a series of tribal conflicts in 2000-1 between the Pokomo and the Wardei-Orma allow us to understand the role of property rights and access rights to the resources underlying them. Property rights in the delta are often complex and overlapping, with concurrent systems of private, public, and common land and different rights to access, leasehold and freehold. Much of the land in the delta is trust land, whereby it is held in trust and administered by the county government for the community. This trust land may be set aside for purposes deemed to benefit the residents, or transferred to the government. Yet there are many instances where this "trust" is abused. Apart from property rights over land, are access rights to water. For example, among the Orma wells are owned by the person who first dug it and their patrilineal descendants. While the Pokomo lay claim to the land along the riverbanks to practice agriculture, the Orma stake their claim over the river waters. Violence erupts when the Orma try to gain access to the river for their cattle, often trampling and grazing in the Pokomo farms in the process.

The liberal land policy espoused by government in Kenya has contradicted communal land ownership which is widespread among pastoralist communities. Leah Temper (2010) report that the Orma/Wardei accused the Government of fueling ethnic conflict by imposing a liberal land tenure system on an area where land is communally owned without adequate consultation. Alphonce Gari in the star newspaper (May 4th, 2013) reported that Tana River leaders wanted the government to disband the multi-million Tana Athi River Development Authority (TARDA) project as it had contributed to the floods that affected thousands of families in the region. They argued that TARDA's rubber dams prevent water from flowing smoothly which increases the pressure and as a result have great impact when they burst during the floods.

In a report for an environmental impact assessment (EIA, 2008) done following plans by TARDA to lease land to Mumias Sugar Company (MSC) for sugarcane production, it is reported that there was a lot of concern and fear by livestock farmers (mainly the pastoralist community, i.e. Orma and Wardei) that implementation of project would displace them from their current grazing land in favour of cane growing. Pastoralists fear that the project will reduce livestock watering points along the river and interfere with livestock transit corridors. Earlier attempts by private companies to invest in sugarcane irrigation have been faced with conflicts as reported by Temper (2010) that there was competition between the proposal by TARDA/MSC and MAT International Ltd sugar project that was proposed upstream. MAT International Ltd intended to extract water from Tana River for its planned expansive cane farms of approximately 30,000ha North of Garsen town, 30,000 ha in Ijara District and a further 60,000ha in Lamu District. The rivalry was caused by the cancelling of the planned partnership between TARDA and MAT International Ltd in the current proposed project. This section is more objective the way it has been reported

Kalunde (2008) further discusses the problems with formal schemes citing the lack of institutional understanding over farmers' water rights and gender relations in irrigation management. She argues that irrigation schemes have often been centrally directed, or farmers have been made to adopt irrigation management reforms that increase the bureaucratic interests. This has been a main obstacle in the attempt to improve management performance of irrigation systems in many countries. Water rights normally are linked to rights to land, access to infrastructure and a right to participate in decision-making. Studies in some irrigation schemes such as in the Mahaweli in Sri Lanka (Schrijvers 1986), and in West Africa (Jones 1986; Carney 1988) have shown that land was the criterion for claiming a water right, such that water was only given to men who owned land. In some cases participation in construction of infrastructure gives rights to water. Water rights can also be expressed in terms of how much, when and for what crops, water may be used by a particular group of people. Even when water rights are awarded, poor women and men may encounter considerable problems in water delivery, such as not getting it in time or having to rely upon (inconvenient) night turns. Such problems of water allocation and delivery are usually contributed to by power differences reflecting socio-economic, gender and cultural factors (Beccar et al. 2002).

Many assumptions are made about the social and economic benefits of rural irrigation schemes particularly in feasibility studies commissioned as part of the project design. Irrigation schemes are often seen as a significant investment in the improvement of rural farmers' ability to increase agricultural production, reduce rural poverty and stimulate economic growth. Feasibility studies tend to focus on the economic benefits of the schemes in terms of per hectare returns on investment and seldom address the broader social issues regarding the impact of the scheme on gender relations, changes in nutritional status, and impacts on vulnerable groups such as children and PLWHIV and so on. It is not clear how investments in irrigation projects are likely to affect vulnerable groups in Kenya hence the need for policy assessment of the challenges of irrigation schemes, the efficiency of their design and maintenance and the wider social and economic implications.

3.2 Environmental and Bio-diversity concerns

The Coastal region earns Kenya a lot of revenue from tourism and fishing activities. There are unique ecological sites in Tana River County some of which have attracted international attention hence increasing the potential for tourism. Ensminger et al (1991) reported that Tana delta has very important small lakes like Lake Shakababo near Ngao village and Lake Kongolola on the right Bank of the Tana River, and Lake Harakisa, Lake Moa, Lake Dida Warede, Lake Kitumbuni in the eastern part of the left bank of the river. However, high sedimentation rate in the lakes is a major threat. Other smaller lakes have disappeared over time due to the same problem of sediment deposition. Un-expected floods displace people and destroy crops downstream. The floods are sometimes not a result of heavy rainfall in the area but arise from dam rehabilitation activities by

KENGEN. The power generation company (KENGEN) has been blamed for the floods since they released water from the dams upstream without notifying the locals downstream.
Temper (2010) found that the Tana River Delta is one of the important bird areas (IBAs) in Kenya. It is a stronghold of two threatened species, Malindi Pipit and Basra Reed Warbler. Internationally important bird populations have also been recorded in the Tana Delta for about 20 species. The delta houses one of the very few breeding sites for colonial waterbirds and other migratory birds in Kenya. This was identified to be near Idsowe, south of Garsen town, on Ziwa la Matomba, a seasonally-flooded lagoon where birds nest in the thicket. The floodplain supports a number of animals like the Topi, a few lions, elephants, Red Collobus, Crested Mangabey, etc. The river channels and lakes also support a large number of Hippopotamus and Nile Crocodiles, Dugong and marine turtles. Relevance of this section given that Galana Ranch is far removed from the lagoon areas and that the method of water extraction is pumping it to the centre pivot system.

Out of all the "promising irrigation projects" targeted under the Kenya Vision 2030, 84% were located in the ASALs. Avery (2013) argues that setting up schemes in semi-arid areas will be challenged by high solar radiation and temperatures, and dry winds that desiccate soils and crops. The water needs for crop irrigation in ASAL areas are frequently 4-times the amounts required in the cooler regions of the country. The soils in arid regions have an inherently low fertility index, lacking in clay content, and thus are highly vulnerable to erosion. Arid land soils tend to crust with salts as a consequence of solar heating and evaporation cycles. Without sufficient flushing rainfall, or irrigation water plus effective associated drainage, salts accumulate and soil fertility further diminishes. A high water table resulting from irrigation impedes the downward drainage and leaching of soluble salts. Hence, in arid climates, a rise in the water table combined with higher evaporation rates can cause salinization. Fernandez-Cirelli et al. (2009) reported that the introduction of irrigation in arid and semi-arid environments inevitably leads to water table variations, and often to problems of water logging and salinization. Nitrate resulting from nitrogen fertilizers used in agriculture is a widespread contaminant of groundwater and causes adverse effects on the health of humans, animals, and the ecosystem.

Experience elsewhere shows that the infamous Aral Sea in central Asia is disappearing because water from the Amu Darya and Syr Darya rivers that once sustained it has been diverted to irrigate cotton (Stockle, 2001). Twenty-four species of fish formerly found only in that sea are currently thought to be extinct. In the last 33 years, the Aral Sea has lost 50% of its surface area and 75% of its volume, with a concomitant tripling in its salinity, owing largely to diversion of water from its feeder rivers for irrigating cotton. The social, economic and ecological disaster that has occurred in the Aral Sea and its drainage basin since the 1960s is the world's largest modern example of how poorly planned and poorly executed agricultural practices have devastated a once productive region.

Rogers (2000) reported that in many nations, big dams and reservoirs were originally considered vital for national security, economic prosperity and agricultural survival. There is certainly no data to show what would be the effect of massive reduction of water flows into the Indian Ocean and Lake Victoria in Kenya due to heavy abstraction and damming of rivers upstream. Until the late 1970s and early 1980s, few people took into account the environmental consequences of these massive projects. Today, however, the results are clear: dams have destroyed the ecosystems in and around countless rivers, lakes and streams.

3.3 Politics of irrigation development in pastoral areas

As population levels rise and natural resources are perceived to decline, many governments believe that (large scale) irrigation is the answer. But this fails to recognize that investments in developing and then maintaining the highly capital intensive inputs required in irrigation is extremely expensive, especially for food production." Press reports in Kenya (The Star Oct. 2013) recorded political leaders urging the government to prioritize roads, security, agricultural output markets and also assure residents that irrigation investment is not just targeting crops but livestock production as well. Dr Mohammed Elmi, (Tarbaj MP) cautioned that government should tread carefully to avoid causing more conflicts by targeting large chunks of land with irrigation projects when the locals prefer them to remain as feeding grounds for their animals. Pastoralism is the economic mainstay of the residents and its development should be given priority. He argued that leasing large pieces of land would plunge the country into conflict since some communities are occupying territories of other counties, hence the need for wide consultations. IRIN (2013) quoted Ced Hesse, a senior researcher on dry lands at the UK-based International Institute for Environment and Development (IIED) arguing that semi-arid irrigation schemes are not only "economically, environmentally or socially unviable, but can also be destructive, adding that large scale irrigation schemes have the potential to undermine pastoralism.

Other perspectives which receive nominal interest are nutrition concerns on the quality of grain that is likely to be produced in the semi-arid regions. Although the main focus of consumers is the quantity of maize available to them, it has been reported that the protein value of maize produced under irrigation is low. A study carried out in Kansas State University in 2013 by Liu et al. (2013) to assess the effect of irrigation levels on the physical and chemical properties and ethanol fermentation performance of maize under a semi-arid climate showed that maize kernel weight, density, and breakage susceptibility decreased as irrigation level decreased. Starch contents of maize samples grown under a low irrigation level were approximately 3.0% lower than those under a high irrigation level. Protein contents ranged from 9.24 to 11.30% and increased as irrigation level decreased. Free amino nitrogen (FAN) was significantly affected by irrigation level: it increased as irrigation decreased. Apparently, the nutritional quality of maize reduces as irrigation level is increased. Therefore, there is need to evaluate the water requirement and the quality of maize that will be produced in ASAL areas.

4. The proposed Galana/Kulalu irrigation project

4.1 Background

There have been very high profile efforts to start off a new large-scale irrigation project in the coastal region of Kenya called Galana/Kulalu. Galana/Kulalu ranch was government land traversing the semi-arid central region of Coast Region which covers parts of both Kilifi and Tana River counties. According to NIB (2013) the two ranches have 627,287 ha (1.5 million acres) of land used for beef fattening, eco-tourism and honey production. The region receives on average 625mm of bi-modal rainfall per annum, with temperatures ranging from 24 - 32 degrees centigrade. The soils in the region are light sandy loams with some areas covered with red clay and black cotton soils. The soil depth is quite shallow with many areas having porous limestone basement rock. The water table is found at 30 – 40 feet deep with some areas having shallower water tables. The topography is flat and is covered with acacia shrubs. Throughout the year, the region experiences monsoon winds since it is very close to the Indian Ocean. Frequent floods occur during the long rain season whenever there are heavy rains in the Central highlands of Kenya. This is because two major rivers - Athi River and Tana River - pass through the region as they drain water from the highland regions of Mt Kenya, Abedares and Kiambu.

The government of Kenya (RoK, 2013) has identified specific crops to be grown under irrigation but managed by the private sector investors in the project area. These include: maize (500,000 acres), sugarcane (200,000 acres), beef and game (150,000 acres), horticulture including potatoes and groundnuts (50,000 acres), orchards including mangoes and guavas (50,000 acres) and dairy animals (50,000 acres) (NIB, 2014). The NIB (2013) website reported that the objective of the project is to enhance national food security through optimization of the productivity of the Galana and Kulalu Ranches through targeted investments on crop, livestock and fisheries production; optimization of eco-tourism activities and integration of sustainable utilization of other natural resources. The project will involve water storage and utilization of the available water and other natural resources to ensure economically, socially and environmentally viable crop, livestock and fisheries enterprises alongside eco-tourism activities.

The project components shall include:-

- Water Resources Development on the Tana and Sabaki (Athi) Rivers
- Water harvesting and storage infrastructure within the project area

- Water conveyance and distribution infrastructure from the two rivers and within the Galana and Kulalu Ranches for crop irrigation, livestock and fisheries production
- Land use planning and land development
- Establishment of production support and value chains structures
- Sensitization and capacity building of stakeholders involved in the enterprise value chains
- Operation, maintenance, administrative and processing infrastructure including offices and residential housing
- Improvement/development of transport and communication infrastructure
- Community livelihood investments for socio-economic benefits of the neighboring communities
- Protection facilities (prevention of destruction by wildlife)
- Seed money for stocking and operations (farm development)
- Environmental and social impact assessment

At the time of writing this review paper (2014), the project had already been launched by the President on January 14, 2014 and land clearance on the pilot farm had started. Unfortunately, by October 2014, major controversies around the project led to its suspension until further feasibility studies could be done. This review paper synthesizes some of the initial concerns before the project was started.

Engineer Odede (Engineers' Magazine, 2013) reported that the biggest challenge for the Galana/Kulalu project is water availability and the project was therefore carrying out an in depth study of the water resources available in the Tana and Athi River Basins to establish the existing water demand; the demand from equally high priority Vision 2030 Projects like Konza City, LAPSSET Project, Machakos City, etc. the assessment will consider the need for equity in water use along the basins and the demand from the Galana/Kulalu Food Security Project in order to determine the maximum area that can be put under irrigated agricultural production. This area will of course depend on crop choice, the on farm irrigation technology to be adopted, the water conveyance method to be used, the economic viability of each option considered and the possibility of water storage. Currently, NIB has engaged a consortium of consultants made up of Agri-green Consulting Ltd (Israel) (Lead Consultant), Environplan and Management Consultants Ltd (Kenya) and Amiran (K) Ltd, to carry out a pre-feasibility study of and plan the project. The pre-feasibility study involves semi-detailed soil surveys, detailed topographic survey and preliminary designs of the most viable option. The target date for achieving this project was set as 2017 and, therefore, its realization calls for innovation, precision and drive.

4.2 Potential Challenges to Galana/Kulalu Food Security Irrigation project

The consultants initially gave the green light for the project to proceed and NIB set up a trial farm of 10,000 acres to assess the performance of irrigation during 2014. However, this approach overlooked many challenges which have been reported by other experts such as Adams and Anderson (1988); Bernstein and Woodhouse (2001); they provide evidence to show that the history of irrigation intervention in Africa shows many problems and a complex dynamic of change. The abstraction of water for irrigation from rivers tends to have serious implications on stream flow, river ecology, water temperatures, underground water tables, local communities, wildlife, indigenous plants and the regions where they drain to such as lakes and Oceans. Although Athi and Tana rivers have periodic spates of high water flows due to heavy rains in the central highlands, the quantities of water needed are likely to be very huge considering the large hectare targeted. Engineer Odede, (Personal commun. August, 2014) was of the view that the maximum acreage that could be irrigated is 400,000 acres or less due to these challenges.

Figure 1: Floods in Tana River

A study by FAO 2013 on irrigation in Kenya's dry regions identified the following threats and challenges. The threats include:

- Changing river course will pause risks to investments in expensive infrastructure and this has been experienced on Tana River in the past
- Flooding resulting into recurrent damage to infrastructure and loss of crop. This has been experienced on Tana, Kerio, Daua rivers
- Siltation is common in major rivers which will result in high costs of operation & maintenance of infrastructure.
- Land degradation and salinization – this is already experienced in several schemes in Garissa and Turkana Counties
- Loss of dry season grazing where land close to the river is excised for irrigation and fenced off–conflicts as reported in Tana River
- Poor implementation - exacerbated negative social and environmental impacts e.g. Salinization
- The technical challenges expected in local rivers include: River morphology –e.g. River Tana has limited sites for gravity systems resulting in expensive intake infrastructure; Water quality is poor due to high silt load which limits the choice of irrigation method/technology; Saline borehole water eliminates ground water as an alternative source of irrigation water; Inadequate hydrological data resulting in poor planning for irrigation schemes (under or overestimation of irrigation potential and inaccurate/inconsistent data on potential irrigable land.
- Inadequate/poor communication infrastructure limits access to markets forcing farmers into subsistence irrigation since there are no incentives for commercialization
- Lack of County land use plans have led to chronic resource use conflicts

4.3 The Current state of maize irrigation in Kenya

In Kenya agricultural production is considered constrained by dependence on 'unstable' rain-fed agriculture, and strengthening the irrigation sector is now key in national policy. Bura irrigation scheme has been the major producer of maize under irrigation where the NIB supports tenants allocated land in the scheme to produce crops. In 2009/2010 under the Economic stimulus programme, a total of 5,200 acres were put under production in all the villages with maize crop.

This produced about 78,000 bags of 90 kgs each (7,020 tons). In the 2010/2011 cropping season, about 4,200 acres were planted with maize, Chilies and Cotton. Estimated yields were: maize 45,000 bags (4,050 tons), Cotton 360 tons and chilies about 100 tons. In the 2011/2012 cropping season about 7,950 acres were planted with commercial maize, seed maize, chilies and cotton.

According to NIB (2014) some of the challenges facing Bura Irrigation Scheme are:-

- Proliferation of Prosopis Juliflora bushes (Mathenge) in farming areas and in water conveyance and storage facilities.
- Wildlife menace – There is a lot destruction of crops by wildlife. KWS has not been able step up control.
- Livestock/crop conflicts-The farming community has for a long time been engaged in conflict with the pastoralist communities over damages to crops. This situation sometimes fuels tension between the two groups and especially in periods of extended drought.
- Susceptibility to flooding:-In cases where there is increased rainfall, most of the areas are affected by flooding leading to damages on crops and infrastructure.
- Lack of adequate storage facilities for farmers' produce.
- Lack of adequate credit facilities to enable farmers to obtain inputs on time, and at cheap competitive prices.

According to du Plessis (2003) maize can be regarded as an important grain crop under irrigation, as it produces very high yields. It can produce from 80 to 100 tons/ha green material and 16 to 21 tons/ha of dry material within a relatively short period (100 to 120 days). Payero et al (2006b) have noted that the questions that often arise are: 1) what is the minimum irrigation capacity for irrigated corn? And 2) what is the most suitable irrigation system for irrigating maize? These are very difficult questions to answer because they greatly depend on the weather, yield goal, soil type, area conditions and the economic conditions necessary for profitability. Maize yield is closely related to crop evapotranspiration (ET) and usually yields would be lowered if ET is lowered. Trooien et al. (1999) defined limited irrigation as 70% of evapotranspiration.

Fully irrigated maize typically receives 500 to 600 mm of irrigation water. Accurate estimate of ETc on a daily or seasonal basis can be valuable for best management of maize irrigation both in-season irrigation and for strategic irrigation planning and management (Payero et al., 2008).

Approximately 10 to 16 kg of grain are produced for every millimetre of water used. Jean du Plessis (2003) reported that a yield of 3,152 kg/ha requires between 350 and 450 mm of rain per annum. At maturity, each plant will have used 250 litres of water in the absence of moisture stress. Studies done in Zimbabwe (FAO, 2000b) have shown that grain maize irrigation is not profitable but green maize has been found to be profitable in 5 irrigation schemes. In Kenya farmers in Meru irrigate green maize (maindi ya maji) during the dry season of October – February using gravity flow.

Humphreys et al., (2004) evaluated the performance of maize under different irrigation systems. They reported that sprinkler, subsurface drip and furrow irrigated maize when compared side-by-side on a difficult, variable soil at the Coleambally Demo Farm in 2004–05 showed that sub-surface drip irrigated maize out-performed sprinkler and furrow irrigated maize in terms of yield, net irrigation water use and net irrigation water productivity. Crop performance and water use efficiency under all irrigation systems could be improved by better irrigation management, shallower furrows and smaller siphons to improve subbing, and increased nitrogen rates. Klocke et al (2007) studied yield and irrigation for maize in 1986–1998 in west central Nebraska and found that 90% of full irrigation grain yields could be gained by applying only 47% of full irrigation.

4.4 Case study Dee River Ranch in USA

The Dee River ranch is in Alabama and is owned by Annie Dee, Mike Dee and their 10 brothers and sisters. They are the sixth generation children on the farm of 10,000 acres (4,047 ha), that produces maize, soybeans, wheat, cotton, hay, pasture, and also raises cattle. The Dees, started by installing two pivots last growing season to verify the value of irrigation. After seeing the results, they added five more pivots this year and now estimate the entire project will pay for itself in less than four years. The pivots all range in length from 988 to 2,023 feet (304 to 617 m) covering about 1,500 acres (607 ha) of maize, soybeans and cotton. All seven machines are equipped with Zimmatic BOSS control panels, Growsmart® GPS satellite positioning for precise pivot position and end gun control, and chemigation and fertigation capabilities. The programmable controls increase efficiency and improve yields by allowing the right amount of irrigation, at precisely the right time of the crop growth cycle (precision farming). Using FIELDNET wireless technology the managers of the farm are able to control and monitor all pivots and get real time text message alerts to any of their cell phones. A user friendly Web portal provides a quick view of every pivot, including location, status and water usage. The pump control is used in a way that allows the pivots to be grouped with pump stations for information sharing to reduce energy costs. Water for the Dee River Ranch pivots comes from a 120 acre reservoir that was specially built for the project. The reservoir is fed by natural runoff and by water pumped from a nearby creek bed. The pump stations were custom engineered and pre-tested based on the specific needs, field conditions and irrigation network design at Dee River Ranch. The transfer pump station delivers water from a creek bed at the ranch up a gradient of 50 feet and over a course of 3,000 feet to the reservoir. Watertronics variable frequency drive (VFD) control technology is used to reduce energy consumption and cost by automatically adjusting water pressure and flow requirements of the system. At the farm, they depend on remote networking and broadband Internet from ezWireles that links all of the irrigation assets together—moving data across the entire project site and in an area with limited or no cell phone coverage. Antennas, including the 80 foot (24.4m) tall base station tower, links all of the Dee River Ranch pumps, pivots and ancillary devices, including FieldNET Wireless Irrigation Management, and provides on farm high speed Internet capability over an area of 20 square miles. The ezWireless system includes possibilities to add other high speed plug and play data devices, such as video surveillance cameras, soil moisture probes and weather stations.

RESULTS.

The Dees are now documenting the savings, efficiencies and higher yields from this cutting edge, integrated irrigation technology project. Five farms on the ranch had maize on them in 2012. The average dryland maize yield was 2.16 tons per acre while the average irrigated farm yielded 4.572 tons per acre, a difference of 2.006 tons. Dee added that the ezWireless broadband cloud over the ranch has simplified their operation and saved labor by allowing them to access, view and control the pumps and pivots from their computers and mobile devices. Mike Dee says the efficiency of the Watertronics pump stations is phenomenal, allowing the ranch to pump its irrigation water using electricity at a fraction of the cost of diesel.

5. Summary and Suggestions on Future Direction

There are challenges at various levels which require different forms of intervention. Currently, irrigation plays a crucial role in the horticulture sub-sector which is Kenya's second foreign exchange earner. Odede (NIB, 2013) has argued that irrigation would produce 3-4 times more than what can be realized through rain-fed agriculture. But insecurity in the arid areas would slow down the projects. The Galana/Kulalu project is full of promise for now, however many issues need urgent attention to tackle the challenges of viability, economic efficiency, water use efficiency and availability, river hydrology and flood control, property rights, subsidies, organizing markets and environmental impact assessment.

5.1 Questions raised by experts in literature reviewed

The targeted enterprises in Galana/Kulalu are maize, sorghum, sugarcane, beef, game animals, horticultural crops (potatoes, groundnuts, mangoes and guavas), and dairy animals. What is likely to be the nutritional quality of produce from irrigated crops in semi-arid areas especially for staple crops which may not have been bred for this region? What is the cost of production for selected enterprise compared to other alternatives? What is the potential yield of selected crops? Are maize and sugarcane for example going to perform better than they do in Eastern, Nyanza and Western Kenya? Who will gain and who will lose due to the implementation of the project and its outputs?

Who will be involved in market coordination? By leasing out land to the private sector, the government is assuming that the private sector will organize markets for the produce. How are local markets (supply and demand) going to be affected by the increase in supply of certain staple foods? How will producers, traders and consumers be affected by the outcome of large increases in maize supply in the local and regional markets? Who will lose and who will benefit? This calls for a study on the economic efficiency in maize irrigation and price transmission in the maize markets expected from the project and its implications on income distribution in the economy.

"Maximum production per drop of water" is the new mantra of investing in scarce water. Water use efficiency raises complex challenges (which crops, varieties, soil types, humidity, temperatures, and irrigation methods are most suitable for irrigation projects – no consensus on an accurate method for measuring water use efficiency exists). From past experience it is known that surface irrigation has low water use efficiency (40%). What is going to be the cost of investing in more efficient water abstraction, conveyance and application systems? How are the costs for infrastructure going to be recovered? Will investors be allowed to choose their irrigation technology? What criteria will the government use to allocate water?

Sustainability of the irrigation projects is a major concern given the poor performance of past irrigation schemes in Kenya. The impact of irrigation on the river ecology (water cycle - hydrology upstream, downstream, infrastructure, onsite soils, underground water tables, water logging, salinization, sodication, nitration, wildlife, micro-organisms, pests and diseases, air quality, genetic diversity, etc). Although society has for long time supported the development and improvement of irrigation, there is an increasing trend to make irrigated agriculture accountable for its impact on the environment. Depending on the nature of the projects, many questions regarding environmental impact may arise. A few examples follow.

- What is the social impact of relocating inhabitants of a given area to accommodate a new irrigation project (for example, relocating those living on the area to be inundated by a new reservoir)?
- What is the impact of the new project on wildlife, particularly endangered species, and on archeological patrimony?
- What is the impact of infrastructure associated with the construction and operation of the project (roads, power lines, canals, etc)?
- What will be the social and political impact of an influx or workers from other ethnic groups into the region being developed for irrigation?
- Does the construction plan provide for erosion and sediment control, does it minimize the disturbance of vegetation and soil, and does it include re-vegetation of disturbed areas?
- Will seepage be minimized or eliminated by selecting canal and ditch materials that prevent seepage?

5.2 Recommendations for Policy Research Areas

There is therefore need to study the following issues that have come out of various studies that were reviewed in this paper:

1. An ex-ante economic surplus assessment using cost-benefit analysis to find out the economic viability of the project.

2. There is a need to collect baseline data in the river basins and to update available hydrological data to aid in modeling Tana and Athi river basins hydrology, flood management and river course stability for long term planning and evaluation of the irrigation project.
3. There is need for assessing the opportunity cost of the maize project putting into consideration the economic value of alternative livelihoods like pastoralism (which could be integrated in the project).
4. An assessment of land and water use rights for investors, stakeholders and minority ethnic group is pertinent to the stability of the project.
5. There is need for analysis of the expected benefits from a public private partnership arrangement that favours private investors against indigenous communities and the policy measures that can improve coherence in related sector policies, laws and regulations implemented by different stakeholders, the roles of private investors and development of institutional capacity for supporting irrigation in Galana/Kulalu.
6. The effect of large-scale irrigated maize production on the market for maize in Kenya considering its effect on traditional maize producing regions in Western Kenya should be analyzed to provide a long term strategy or policy that will guide both public and private investments in Galana/Kulalu project

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