Determinants of Performance of Public Irrigation Schemes in Kenya

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Abstract

Ensuring adequate and nutritional access to food for a growing population is a major concern globally. In Kenya, the national development blueprint Vision 2030 and the Agriculture Sector Development Support Programme (ASDSP) stress the need to eradicate poverty and ensure food security by increasing productivity of agricultural activities and value addition of agricultural products, as well as commercialization of the agricultural sector. In recognition of the economic importance of agriculture, there have been several studies on production where focus has mainly been on the impact of structural adjustment policies, prices, standards and regulations, and market liberalization. However, assessment of the performance of public irrigation schemes in Kenya is not evident. To sustain food production, the government has invested on rehabilitation and expansion of irrigation with the aim of bridging the gap of 1.085 million (between irrigation potential of the country and the already irrigated land) hectares by the year 2030. Despite these efforts, food insecurity in Kenya is a challenge and the performance of public irrigation scheme is way off the mark, realizing only 40 per cent of the target production levels compared to private operated irrigation schemes. This study aims to establish the determinants of performance of public irrigation scheme in Kenya and give policy direction on how production can be enhanced so as to develop a vibrant irrigated agriculture. The study uses a panel fixed effect regression model to determine the factors that influence the performance of public irrigation schemes in Kenya. The results indicate that the size of land cropped in irrigation schemes, amount of donor funding to the scheme, and the per acre rate at which operations and maintenance cost was collected were significant at 1 per cent, 10 per cent, and 10 per cent with positive, negative, and positive effects on public irrigation scheme, respectively. Therefore, this study recommends the enhancement of policies and institutional changes at the scheme level, along with increase in government investments on irrigation and infrastructure, since they have an influence in production and productivity of the irrigation schemes. In addition, farmers should be treated as clients, shareholders or as co-managers of irrigation schemes rather than just beneficiaries so as to enhance their roles in performance improvement.

Abbreviations and Acronyms

ASAL	Arid and Semi-Arid Lands
ASDS	Agriculture Sector Development Strategy
ASDSP	Agriculture Sector Development Support Programme
ESP	Economic Stimulus Programme
FAO	Food and Agriculture Organization
FEM	Fixed Effects Model
GDP	Gross Domestic Product
GoK	Government of Kenya
IV	Instrumental Variables
KNBS	Kenya National Bureau of Statistics
NIB	National Irrigation Board
O&M	Operations and Maintenance
PMU	Project Management Unit
REM	Random Effects Model
SRA	Strategy for Revitalizing Agriculture
TC	Total Cost
TR	Total Revenue
WUA	Water Users Association

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1. Introduction

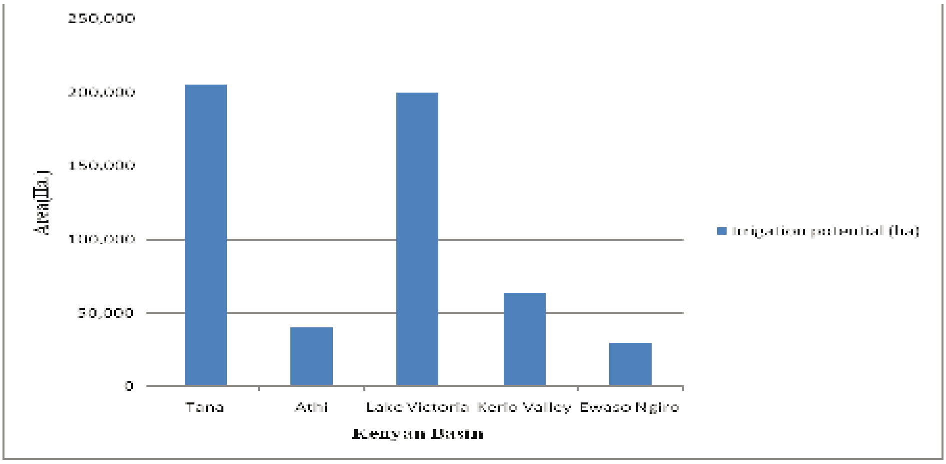
1.1 Background Information

Ensuring adequate and nutritional access to food for a growing population is a major concern globally. This has occasioned the design of strategies to boost agricultural production for different agro-ecological environments. Irrigation is one option for increasing agricultural productivity, especially under different schemes that produce food products for consumption as well as trading. The rising need for irrigation is as a result of inadequacy of soil moisture to support a wide range of crops, especially due to global warming. Global warming has manifested itself through various climatic change effects, which have led to changes in crop yields, reduced soil fertility, and increased soil erosion on farm land. Over the years, empirical evidence has shown that irrigation increases yield of most crops by between 100 and 400 per cent and it is expected that, in the next 30 years, 70 per cent of the grain production in the world will be from irrigated land (FAO, 2009). In addition, irrigated crop land in Sub-Saharan Africa (SSA) is currently estimated at 4 per cent, and it is expected that irrigated land in developing countries will be 27 per cent in the next 20 years (World Bank, 2008).

Kenya's population has been growing exponentially over the past 10 years, reaching 38.6 million in 2009, up from 28.7 million in 1999. Therefore, the country is facing an uphill task of securing adequate food supply through various strategies of increasing agricultural production capacity to match the population growth. The Kenya Vision 2030 has recognized development of the irrigation sector among the long term initiatives towards the achievement of a 10 per cent annual growth. This requires expansion of irrigated land to 1.2 million hectares in the potential areas, so as to enhance the country's food security and equity by improving the productivity of Arid and Semi arid Areas (ASALs).

Although agriculture is the backbone of the economy, accounting for about 25 per cent of the country's GDP, the scope for increasing production through expansion of arable agricultural land is severely constrained by over-reliance on rain-fed agriculture. Kenya has an overall estimated irrigation potential of 1.3 million hectares and a drainage potential of 600,000 hectares (Government of Kenya, 2010). According to the National Irrigation Board-NIB (2012), only 540,000 hectares of the available irrigation potential can be irrigated given the available water resources, while the rest require water harvesting and storage. Figure 1.1 shows the irrigation potential in different basins.

Figure 1.1: Irrigation potential in the Kenyan basins



Source: National Irrigation Board-NIB (2012)

1.1.1 Development of public irrigation schemes in Kenya

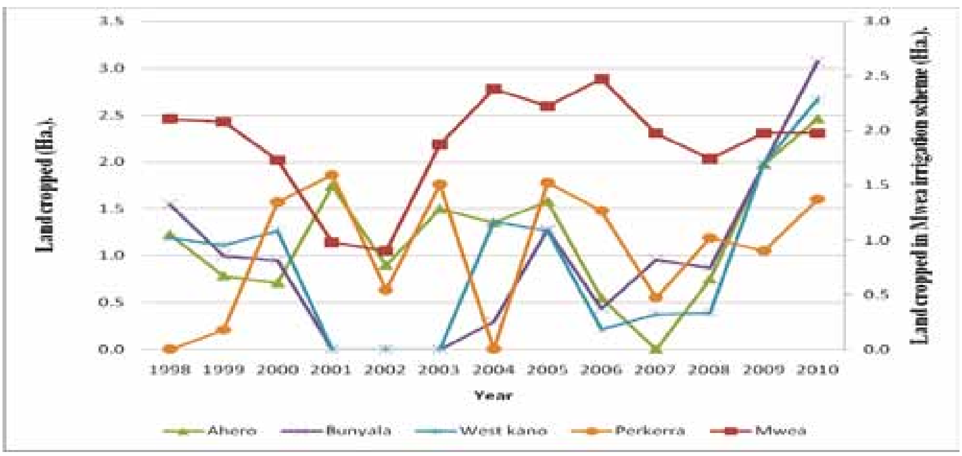
Historically, irrigation development across the country has predominantly been spearheaded by the government. The first schemes were established in 1954 and 1956 at Perkerra in Baringo and Mwea in Kirinyaga counties, respectively. Later, Ahero, West Kano, Bunyala and Bura irrigation schemes were constructed. In recent years, focus has shifted to the development of smallholder irrigation schemes and the rehabilitation of existing public schemes. The development of smallholder schemes targeted smallholder farmers, with more emphasis on irrigation of food crops such as maize, rice, wheat and horticulture. In addition, promotion of the production of horticultural food crops was the major aim of Economic Stimulus Programme (ESP) that was implemented in 2009/2010.

The operation and maintenance of the large-scale irrigation schemes is largely under the responsibility of the NIB. In 1998, Mwea irrigation scheme farmers took over the running of the scheme through transfer of irrigation management to Water Users Association (WUA). In this regard, the irrigable area of the scheme was expanded by about 4,000 acres resulting in serious water shortages. This was attributed to the weaknesses in the management of the WUA in terms of lacking skilled personnel, finance and machinery to maintain and manage the scheme, leading to neglect and an almost total collapse.

Currently, only 114,600 hectares (20% of total irrigation potential) have been put under irrigation in the whole country, where the development of irrigation potential has been categorized into three types: large private commercial farms (40%), government-managed schemes (18%), and smallholder individual and group schemes (42%) (Government of Kenya, 2010). Irrigated agriculture has made positive contributions through higher production, higher yields, low risk of crop failure, higher and year round farm and non-farm employment for rural livelihoods, food security, and poverty reduction (Molden, 2007). However, the country has remained dependent on rain-fed irrigation and less productive agricultural systems, which has resulted in food insecurity and an expose to severe poverty to millions of the population.

In general, irrigation in Kenya accounts for only 1.8 per cent of total land area under agricultural production, but it is approximated to be directly providing 18 per cent of the value of all the country's agricultural produce, while contributing 3 per cent to Kenya's GDP (Government of Kenya, 2010). Kenya's main irrigated crops are rice, maize, sugarcane, vegetables, bananas, citrus, coffee, tea, cotton and flowers, some of which require large scale production for economies of scale to be realized. Therefore, land productivity and consistent water availability is an inevitable agricultural phenomenon towards self-sufficiency in food production and food security. The strong demographic and increased income push to food demand is expected to increase in the future, hence necessitating the use of irrigation. However, the scope for expanding agricultural production through expansion of arable agricultural land is severely constrained in spite of the estimated potential. Irrigation infrastructure has been funded in targeted areas in a bid to improve food production and rural economies. Currently, there are a number of public irrigation schemes in different parts of the country (Figure 1.2).

Figure 1.2: Land cropped status in public irrigation schemes

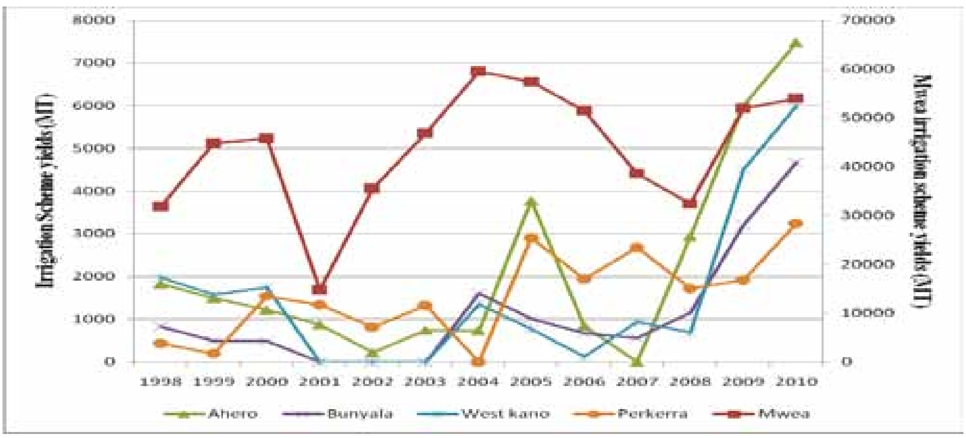


Source: National Irrigation Board-NIB (2012); KNBS (Various), Statistical Abstracts

1.1.2 Operations and management of public irrigation schemes in Kenya

Empirical evidence indicates that if Kenya's current irrigation potential of 540,000 hectares is fully exploited, poverty headcount would fall by 11 per cent by 2015, while rural poverty incidence would reduce by 13.5 per cent (Government of Kenya, 2012). Despite heavy initial investments, huge costs relating to land preparation, and the different kinds of machinery, irrigation in Kenya has not realized its full potential. In addition, irrigation activities demand costly continuous operations in terms of supply of water and adequate maintenance of the water distribution and drainage channels. Most of the irrigation structures have been funded by the government, the private sector and development partners since it is difficult for smallholders themselves to build such structures (PMU-Kenya, 2004). World Bank (2007) indicated that irrigation projects consume a lot of scarce resources through both recurrent and development expenditure and adversely affect developing countries whose capacity to set up irrigation infrastructure is limited. In Kenya, like in many other African countries, irrigation expansion has been hindered by poor performance of irrigation schemes (Thairu, 2010). Paradoxically, there are successful irrigation undertakings, especially among the private commercial large scale agricultural irrigated farms such as Dalamere, Delmonte and Kakuzi. Given the intensive investment, the already existing public irrigation schemes in the country should be operating efficiently and effectively to meet the expectations. In addition, FAO (2003) and de Fraiture et al. (2007) indicated that global food demand is expected to increase by 70-90 per cent by 2050, and half of this additional food demand could be met by decreasing 80 per

Figure 1.3: Public irrigation schemes performance in Kenya



Source: National Irrigation Board, 2012; Kenya National Bureau of Statistics, Various cent of the gap between actual and potential productivity. Therefore, enhancing the performance of the existing public irrigation schemes has a huge potential in curbing Kenya's increasing food insecurity as well as improving farm incomes. The trend in yields from public irrigation schemes in Kenya are summarized in Figure 1.3.

1.2 Research Problem

In Kenya, 25 per cent of the population experiences food insecurity, with approximately 10 per cent being severely food insecure and, at any one time, about 2 million people require assistance to access food (World Bank, 2007). Some argue that the food problem in Kenya is due to frequent drought and low agricultural productivity that have created a regular demand for food imports and shift of financial resources from development activities. As reported in the agriculture sector development strategy (ASDS) of 2009 to 2020, irrigation holds the promise for the Kenyan future, given the unexploited 9.2 million hectares in Arid and Semi-Arid Lands (ASALs). Less than one per cent of the land in medium and high rainfall areas is under irrigation. To sustain food production, the government has invested on rehabilitation and expansion of irrigation, with the aim of bridging the gap of 1.085 million hectares by the year 2030 (Government of Kenya, 2012).

Despite these efforts, the performance of public irrigation schemes is way off the mark, realizing only 40 per cent of the target production levels and 28 per cent of the expected revenues (Karina and Mwaniki, 2011) compared to private operated irrigation schemes. However, it is not clear what factors impact on the performance of public irrigation schemes in Kenya. Against this backdrop, this study seeks to establish the factors that influence performance of public irrigation schemes in order to shed some light on the areas requiring policy interventions.

1.3 Objectives of the Study

The overall objective of the study is to establish the determinants of public irrigation schemes performance in Kenya. The specific objectives are to:

(i) Examine the productivity of public irrigation schemes in Kenya during the period 1998 to 2010.

(ii) Determine the factors that influences the performance of public irrigation schemes in Kenya.

(iii) Suggest policy recommendations on public irrigation scheme performance.

1.4 Research Questions

(i) What has been the productivity trend of public irrigation schemes in Kenya?

(ii) What are the factors that influence the performance of public irrigation schemes in Kenya?

(iii) What policies are needed to promote sustainable public irrigation scheme performance?

1.5 Justification

Irrigation development is a critical factor for increasing productivity and promoting economic growth. Furthermore, it enables smallholder farmers to adopt more diversified cropping patterns, and to switch from low value subsistence production to high-value market-oriented production (Hagos et al., 2007). Recently, emphasis has been on the importance of sustaining and improving the performance of existing irrigation schemes, in parallel with area expansion and development of new irrigation (World Bank, 2006). Kenya's Vision 2030 has placed a high emphasis on investments in irrigation, and envisages a development rate of 32,000 hectares per annum. Despite this effort, the country is still faced with a huge deficit in food production, hence importing to bridge this shortfall.

In Kenya, several studies have been conducted to estimate the determinants of agricultural production (Kibe et al., 2007; Owuor, 2006; Nyangito et al., 2003; and Ngigi, 2002). However, the determinants of public irrigation schemes performance in food production are not evident. One main challenge in Kenya though is on how to properly advise and inform policy decisions, if there is little or no knowledge on how the existing public irrigation schemes perform. It is therefore against this background that this study seeks to establish the performance trends, as well as determine how different factors influence the performance of public irrigation schemes in Kenya and draw policy implications. This would be valuable to the agricultural sector, since it would complement the debate on public irrigation scheme performance, and provide a basis for reformulation of strategies that are geared towards the country's self-sufficiency in food production and food security.

2. Literature Review

2.1 Theoretical Literature

Historically, the neo-classical theory of the farm was developed to explain the behaviour of markets, rather than to prescribe optimum management strategies for individual farms. The neo-classical theory of the farm is essentially outward looking towards the market, in that it emphasizes the response of the farm to market forces. The elements of performance analysis were first set out more than a century ago by Walras in relation to general equilibrium theory. Dorfan (1953) effectively defines performance analysis as nothing but a reformulation of the standard economic problem, with the objective of determining the optimal levels of productive resources in given circumstances. Unfortunately, the tendency has been to obscure the methodological concepts of performance analysis by always associating the theoretical framework with the solution procedure, such as linear programming, thereby distracting attention from the power and generality of the performance analysis approach. On the other hand, the production economic theory approach represents the production choices faced by individual farms, hence it is inward looking. This is because physical and financial ratios, including land and/or water productivity, has continued to be the basis of most management decisions made by farmers.

A dichotomy has been developed between the actual performance and a conventional production theory (Musgrave, 1976; and Williams, 1969). Therefore, this dichotomy largely breaks down when both actual farm performance and the conventional economic theory of production are seen as outgrowths of the performance analysis framework. The simple physical performance description is the basic building block for practical farm management procedure and for production economic theory. Within the framework of performance analysis, the production theory becomes more relevant for practice, and the practical procedures can be seen to be deeply rooted in theory. Theory and practice come together. This is not entirely so, because conventional theory abstracts from an important problem in production of technical efficiency. By explicitly considering technical efficiency and all the conventional production economic concepts, performance represents not only a more practical approach to theory, but also a more powerful one.

In economic terms, production holds a particular meaning. It is the process of combining and coordinating inputs to transform them into outputs (Zerbe and Dively, 1994; Boardman *et al.*, 2006). Since the outputs will have a market value, several basic conditions or assumptions must be taken into account by the farm during the initial planning phase. Two commonly assumed goals are the minimization of cost(s) for a given level of outputs and the maximization of revenue for a given level of inputs. These conditions are sometimes referred to as the dual problem, where a production farm that minimizes its costs for a given output also maximizes its revenue for the given inputs (Boardman et al., 2006). Profit is generally given as total revenue (TR) minus total cost (TC), hence different farms determine their level of production based on the greatest expected profitability under the given set of available resources (Kay *et al*., 2004).

Production economic cost is the total cost of production including monetary, opportunity, external and social costs (Boardman *et al*., 2006; Zerbe and Dively, 1994). Included in production is: economic cost or opportunity cost which is the value forgone on the best alternative option, for example the opportunity cost of producing maize might be the income forgone by not renting the land to another grower; external cost, which is the production "side effects" such as the cost of environmental degradation, water-borne diseases, malaria among others; and lastly, social cost which is the non-monetary cost borne by society, such as unpleasant sights and smells from farming operations. Farm management must also consider production with respect to a time frame (short run or long run), which is a relative period of time with respect to production options. Short run is the period of time during which the available quantities of all necessary resources are fixed and cannot be changed, while long run is the period of time during which the quantity of all necessary productive resources can be changed (Boardman *et al*., 2006). As the amount of resources and the size of the scale of production changes, the long run average cost for the firm will be affected in one of the following ways: increasing returns to scale, when additional production leads to decreased cost per unit output; constant returns to scale, when increased or decreased production has no effect on average cost; and decreasing returns to scale, when additional production leads to increased average cost (Inoncencio *et al*., 2007; Gulati *et al*., 2005 and Kibaara, 2005).

2.2 Empirical Literature Review

2.2.1 Overall effects of irrigation on food security

Christiaensen et al. (2006) argue that although majority of poor people in developing countries, especially in Sub-Saharan Africa (SSA), depend directly on agriculture for their livelihood, there is no common view about the role of agriculture in economic development and food production. Further, investment in agriculture and its contribution to economic growth and poverty reduction is more than an equal amount of investment in non-agriculture. Therefore, in spite of the high optimism and the amount of resources committed to develop irrigation systems in the country, it has contributed to intensification of land use and to change in crop choice, but has been associated with less adoption of fertilizer and improved seeds and less improvement in yields than expected. As a result, it appears that the returns to investment in modern irrigation so far have been relatively low (Kibe *et al*., 2006). Empirical evidence shows that in areas where irrigation is widely used, overall agricultural yields and household income are higher, and less poverty and undernourishment have been observed (FAO, 2003).

Kibe (2007) and Ngigi (2002) revealed that the development of irrigation despite the high costs involved is one of the possible ways of addressing the challenge of declining agricultural productivity, in the wake of a growing population in Kenya. In addition, availability of water also plays a vital role on the performance of an irrigation scheme, and indirectly influences the cost of the project. Furthermore, Inocencio *et al*. (2007), Hussain *et al*. (2006), Hussain and Wijerathna (2004) and Saleth *et al*. (2003) sought to find out the impact of irrigation on food security in Sub-Saharan Africa, and concluded that those irrigation schemes located in areas with more water available have a tendency of being smaller in size and hence directly and indirectly reduces poverty. Direct impacts are realized through labour and land augmentation effect, which ultimately translates to improved performance, employment, income and consumption, while the indirect impact is realized through enhanced local economy and improved welfare at macro level. Huang *et al*. (2005) used logistic regression model to analyze cross sectional data. They show a strong positive correlation between access to irrigation and food security, leading to poverty reduction and equitable income distribution.

Contrary to the above mentioned literature, Jin *et al*. (2002) and Fan et al. (2000) revealed a negative and/or weak relationship between irrigation and agricultural productivity, which implies a negative or no impact on food security, household income, and poverty reduction at large. Most of the studies that use aggregate data could not identify a positive contribution of irrigation to poverty reduction, implying that the direct effect of irrigation could be undermined by other factors that could have been observed at household and/or plot level. Furthermore, Mosley *et al*. (2004), Gomanee *et al*. (2003) and Fan *et al*. (2002) found that higher government expenditure on agriculture, housing and amenities (water, sanitation and social security) had a negative and statistically significant impact on poverty, presumably by shifting the distribution of income in a pro-poor direction, since the level of aggregate income were held constant in their regressions. In a similar fashion, Datt and Ravallion (2002) estimated the determinants of differences in the rate of reduction of the poverty headcount across Indian public irrigation schemes over the period 1960 to 1994. They found that state government development spending has a large and statistically significant effect on food production and consequently poverty reduction, even when controlling for changes in agricultural and non-agricultural performance and a time trend. Thirtle and Xavier (2001) found that for a sample of 40 countries, the elasticity of incidence of poverty to agricultural productivity growth was about 1 per cent, that is the percentage of those living below the dollar a day poverty line fell by close to 1 per cent for every percentage increase in agricultural productivity. This empirical analysis helps to establish an inverse relationship between poverty and agricultural productivity growth.

2.2.2 Irrigation performance and management

Gomo (2012) and Bos et al. (2005) noted that irrigation performance can be defined as the level at which resources such as water, land and labour are being effectively utilized for the production of food, whereas irrigation performance assessment can be described as the regular observation of irrigation performance parameters with the objective of acquiring important information pertaining to resource-use within an irrigation scheme, and allows irrigation managers to make well informed decisions in terms of resource management. This process provides feedback information to scheme management at all levels, thus allowing a review of operations and evaluation of the efficiency with which resources are used at system, scheme, catchment and national levels. Murray-Rust and Snellen (1993) stated that the performance evaluation must provide sufficient information to irrigators and irrigation managers on the best ways to enhance performance. However, there has been a sharp decline in the World Bank lending for new public irrigation schemes in most of the developing countries, hence the emphasis on the sustainability and efficiency of existing irrigation schemes (Jones, 1995).

Low performance of many existing public irrigation schemes has prompted a change in public investment policy away from new infrastructure and towards programmes that improve the performance of existing schemes (NIB, 2008). On the other hand, Thompson (2001) states that irrigation is still one of the core investment activities of the World Bank's Rural Portfolio, though the number of irrigation schemes is expected to decrease. This, according to Thompson (2001), was attributed to the fact that investments in irrigation systems are perceived to have failed to address the changing needs of irrigation services. Rehabilitation of existing schemes was mostly carried out to restore original project objectives as this did not take into account or ignored the desirable changes in cropping patterns and irrigation techniques, thus leading to low performance. It has been cited that related issues of financial and physical sustainability tend to be naturally linked to government operations. This is because irrigation supply comes largely from public sector investments, hence the institutional options have significant implication for the efficiency of irrigation operations (Meizen-Dick and Rosegrant 2005; Raju and Gulati, 2005; and Gulati *et al.*, 2005). Furthermore, Denison and Manona (2007) state that despite the South African government putting millions of money into smallholder irrigation schemes, many of them have collapsed or remain under-performing. They further conclude that infrastructural development alone is unlikely to succeed. For success, there is need for comprehensive strategies that consider all the activities that make up an irrigation enterprise, such as markets, finance, inputs, institution-building and crop production information.

A report by FAO (2007) identified constraints that have led to the decline in irrigation performance to include relatively inadequate physical infrastructure and markets, poor investments in irrigation, lack of access to improved irrigation technologies, and lack of cheap and readily available water supplies. Gyasi *et al.* (2006) noted that there is limited knowledge on the determinants of the success of public irrigation schemes. This is because many schemes severely deteriorated or broke down completely in the past due to insufficient maintenance. Similarly, higher wages outside the schemes increase the opportunity cost of labour, and reduce the incentive for households to participate in the maintenance of the irrigation schemes. Furthermore, they indicated that transparent and accountable leadership is an important concern that affects the incentives for farming households to contribute to the maintenance of the irrigation schemes. Lack of transparency and accountability, and incidences of rent-seeking reduce trust and confidence in leadership, and undermine management efficiency. Leaders perceived to be corrupt lose their moral authority to enforce rules and regulations (Kikuchi *et al.*, 2003).

2.2.3 Factors affecting irrigation scheme performance

Bos et al. (2005) indicated that irrigation performance assessment can be used to satisfy different set objectives on different irrigation schemes, but the procedure will vary depending on the system and purpose of assessment. According to Merriam and Keller (1978), irrigation evaluations are conducted to quantify the gap between potential and actual performance of irrigation systems. Despite there being no standard way of measuring irrigation performance, most analysts suggest at least two basic domains for the purpose of irrigation or water delivery and agricultural productivity. While the former is associated with the immediate service output and determined most frequently through the performance criteria of adequacy, equity and reliability of water supplied, the latter is considered more outcome-based and judged against parameters such as farmers' crop yields, cropping intensities and, most recently, water productivity. Other studies suggest that such a limited set of indicators should also include measures determining the maintenance status of irrigation infrastructure, as well as more user-based socio-economic impact measures (Bos *et al.*, 2005; Molden and Gates, 1990; Murray-Rust and Snellen, 1993). With regard to particular perspectives from which irrigation performance assessment can be carried out, irrigation systems commonly feature a number of competing objectives and interest groups with differing values within the surrounding areas. Trends in performance of specific irrigation schemes over time can be assessed for the purpose of optimizing the resource use, and for benchmarking with other schemes exhibiting good performance. Molden *et al.* (2010) pointed out that for an increase in irrigation scheme performance, strategies based on existing biophysical and socio-economic factors are required. Frequent evaluation of irrigated areas have become more important in diagnosing and improving the performance of irrigation schemes in order to achieve optimal productivity in the context of increasing food demand, open global markets and competition for limited freshwater resources (Clemmens, 2006; Molden *et al.*, 1998 and Burt *et al.*, 1997). Such assessments should analyze the productive and hydrological impacts of internal irrigation processes so as to assist agents involved in crop production, water management and agricultural policy to improve the performance of irrigated schemes (Molden et al., 2010 and Perry et al., 2009). Water management is linked to crop production and farmers' profits, and therefore an assessment of irrigation performance is required in order to improve water management on irrigation schemes (Clemmens et al., 2008).

The categories of the determinants of irrigation performance has been described by Malano and Burton (2001); and Molden *et al.* (1998) in Molden et al. (2010) and it includes factors such as land, labour, water, cost of scheme operation and maintenance as well as the value of production that analyze the inputs into and outputs from irrigation schemes. They further developed a set of irrigation performance indicators for describing the performance at scheme level, which includes output per cropped area, output per unit command area, output per unit irrigation supply, output per unit water consumed, achieved production factor, and potential production factor, among others. However, these indicators do not provide specific information on what needs to be done to improve performance, but they are important for comparison of performance between different irrigation schemes or for study of impacts of management interventions.

Irrigation performance indicators have been sub-divided into four different categories, including agricultural performance, water supply and delivery, economic and environmental indicators (Greaves, 2007). The agricultural performance indicators have generally been used to analyze the output from an agricultural system in relation to the inputs used; that is agricultural productivity (Gomo, 2012; Thairu, 2010; Ntsonto, 2005). Molden *et al.* (1998), however, pointed out that agricultural indicators must be viewed in context to the region in which they are used. This is in regard to what is constraining in the region.

For instance, where water is a more constraining factor compared to land, then output per unit water may be more important than output per unit land. The reverse is true for a region where land is a constraining factor (Greaves, 2007). This has been used by Svendsen *et al.* (2009) and Ntsonto (2005) in determining the difference in performance of 16 irrigation projects following adaptation of new water management practices from developing countries. They found that the performance indicators are insufficient for decision making, planning and control operations in a dynamic irrigation environment. This is because they do not reflect all dimensions of organizational performance in a balanced and integrative framework (Gomo, 2012; and PMU-Kenya, 2004). In addition, Jusoh et al. (2008) concluded that there is need to include financial and environmental indicators, since they concentrate on the costs and returns, in monetary value, and they include cost recovery ratio; maintenance cost to revenue ratio, total cost of management, operation and maintenance per irrigation scheme and revenue collection performance. Finally, Yokwe (2009) and Greaves (2007) revealed that environmental indicators concentrate on sustainability of irrigation scheme performance, pollution of both land and water, as well as the effects of irrigation on the surrounding area.

2.2.4 Summary of Literature Review

Production economics theory forms the basis of assessing the determinants of the performance of public irrigation schemes in Kenya. Agricultural productivity is preferred in the current study as the best indicator of performance, as well as scheme size, number of plots in the scheme, farmers contribution to investment cost, new constructions, mode of O&M for systems, irrigated crops and regional effects (Thairu, 2010; Inocencio *et al.*, 2007; and Bos *et al.*, 2005). It is therefore out of the above reviewed literature that this study will analyze the determinants of performance of public irrigation schemes in Kenya in line with the recommendations of Thairu (2010) and Bos *et al.* (2005). The performance indicator will be on the basis of crop yields or scheme productivity being determined by land size, irrigation scheme management, O&M collection rate, investment cost and number of plots in the scheme. The irrigation scheme recurrent expenditure will be used as a proxy of the irrigation scheme management due to the limitation of data for the entire analysis.

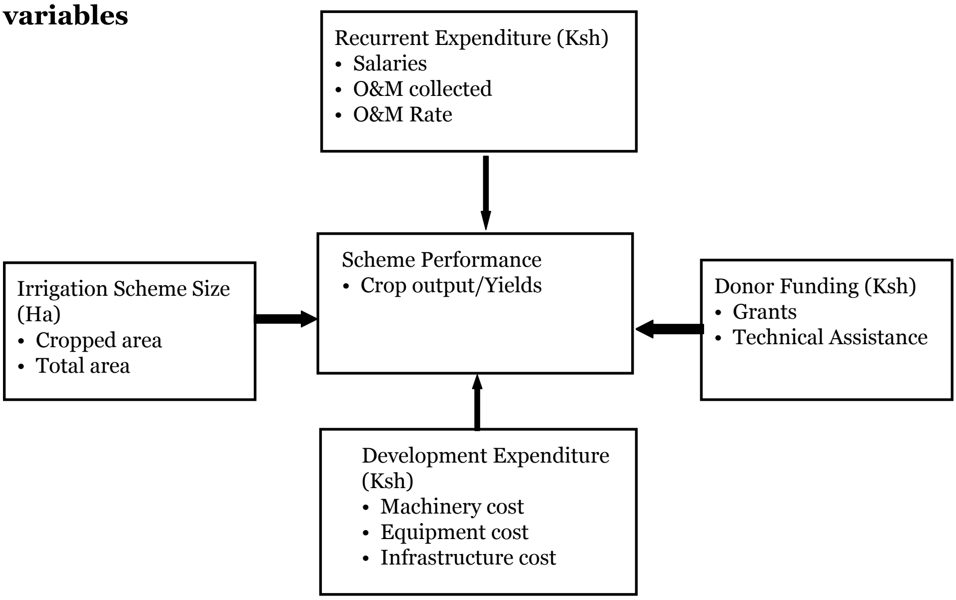
Since this study uses panel data, panel fixed effect regression model is preferred. Further, the panel fixed effect regression model is highly acclaimed for its simplicity and empirical robustness, and its ability to provide a solution to the problem of bias caused by unobserved heterogeneity, a common problem in the fitting of models with cross sectional data sets. Empirical literature has revealed that panel fixed effect regression model approach is a popular tool that has been used widely by researchers in analyzing the indicators of irrigation scheme performance. There is lack of empirical evidence on the determinants of irrigation scheme performance in Kenya.

3. Methodology

3.1 Conceptual Framework

The conceptual framework depicts the assumption that public irrigation schemes have a difficulty in attaining the expected performance. It is conceptualized that public irrigation performance is influenced both directly and indirectly by the size of the scheme, operations and management (recurrent expenditure), infrastructure and equipment (development expenditure), and the amount of donor funding in form of grants and technical assistance as well as scheme attributes. The factors that are considered to determine the performance of public irrigation schemes from previous studies are summarized in Figure 3.1. The concept of performance can be defined at different levels and in various contexts. In the context of the study, it includes the ability of the irrigation scheme to generate sufficient output level in order to satisfy the income expectation of the irrigators, and cover basic operational and maintenance costs of the irrigation infrastructure, while not mining the natural resources (Kamara *et al.*, 2001). The income expectation may also differ widely across different crops and among individual schemes (Shah et al., 2001). Furthermore, it includes the ability of the scheme to maintain cash flow and consistency of income generation over time, and management of risk associated with irrigation scheme operations.

Figure 3.1: Relationship between scheme performance and other variables



Source: Inocencio et al. (2007)

This study focuses on funding and output generation levels, where the government and other development partners' annual expenditure levels will be considered for individual public irrigation schemes. On the other hand, income generation through O&M cost collections at scheme level will also be considered as it affects the performance of the schemes. The management of a scheme involves three types of stakeholders: individual farmers, management entity (NIB) and the external role players. Public sector, contractors and service providers, banks and marketing or food-processing sector are various stakeholders who can provide financial or technical support to NIB and/or to the farmers.

Farmers manage production at farm level, and possibly market the products which in turn generates income. The natural environment and institutional context influences the production process and consequently impacts onto production, especially the rules on accessing resources such as land and water. Farm income influences production, since it defines the level of intensification and diversification. The income is used to pay operation and maintenance costs to the NIB, who technically manage, operate and maintain the scheme as a whole. NIB provides irrigation water and related-services to the farmers for them to produce. Finally, the net impact of irrigation management and development is sensitive to differences in agricultural productivity, where good irrigation scheme performance will improve wages and profits, hence increasing consumption and lower malnutrition and poverty in the country.

3.2 Data Types and Sources

The study uses panel data for the period 1998 to 2010 that were obtained from the Kenya National Bureau of Statistics (KNBS) and the National Irrigation Board (NIB) under the Ministry of Water and Irrigation. Data was obtained for five public irrigation schemes (Mwea, Perkerra, West Kano, Bunyala and Ahero) that are being managed by NIB in the country. The data types included total size of scheme (area), cropped area, total output (yields), gross value of output, operation and maintenance costs collected, rate of collection of operation and maintenance fees, the amount of donor/private funding and the government recurrent and development expenditure on each public irrigation scheme.

3.3 Analytical Methods

3.3.1 Descriptive statistics

Trend analysis was done using Microsoft Excel computer software to examine the public irrigation scheme productivity from 1998 to 2010. This analysis helped to inform the panel regression analysis later carried out to investigate the determinants of public irrigation scheme performance measured by annual actual yields per scheme. This study used charts and graphs to understand the trends in productivity of the individual schemes.

3.3.2 Model specification

Panel data analysis has been used widely in recent empirical studies that seek to address various challenges on economic development and policy analysis (Biwott, 2011; Githuku, 2010; Thairu, 2010; Hsiao, 2007; Inocencio *et al.*, 2007 and Bos *et al.*, 2005). This is because it provides a rich environment for the development of estimation techniques and theoretical results. Furthermore, panel data has the strength of accommodating more observations, hence increasing the degrees of freedom. In addition, it reduces the problem of collinearity of regressors and modelling flexibility of behaviour differences within and between countries and/ or groups or institutions (Biwott, 2011 and Hsiao, 2007). However, it has a setback of having a cumbersome collection of long term primary data, particularly on the selected variables. Panel data has fixed effect model (FEM), random effects model (REM) and instrumental variables (IV). Nevertheless, REM and IV were not used in the study due to the fact that there were no dummy variables and selection biasness in the data that were used, hence ruling out the problem of heterogeneity. A standard panel FEM specification is written as:

$$Y_{it} = \beta_1 + \sum_{j=2}^{k} \beta_j X_{jit} + \sum_{p=1}^{s} Y_p Z_{pi} + \delta t + \varepsilon_{it} \quad \text{......} 3.1$$

where Y_{it} is the dependent variable, X_j the observed explanatory variables, and Z_p are unobserved explanatory variables. The index *i* refers to the unit of observation, *t* refers to the time period, and *j* and *p* differentiate between different observed and unobserved explanatory variables, respectively. ε_{it} is a disturbance term assumed to satisfy the usual regression model conditions. A trend term *t* has been introduced to allow for a shift of the intercept over time. The X_j variables are the explanatory variables of interest, while the Z_p variables are responsible for unobserved heterogeneity and, as such, constitute a nuisance component of the model. Since the Z_p variables are unobserved and FEM takes care of that, there is no means of obtaining information about the component $\sum_{p}^{s} = {}_1\gamma_{pZpi}$ of the model and it is convenient to rewrite equation 1 as:

$$Y_{it} = \beta_1 + \sum_{j=2}^{k} \beta_j X_{jit} + \alpha_i + \delta t + \varepsilon_{it} \quad \text{...3.2}$$

where $\alpha_i = \sum_{p}^{s} = 1\gamma_{pZpi}$ and it represents the joint impact of the Zp_i on Y_i. Therefore, it was convenient in this study to refer to the unit of observation as an irrigation scheme, and to the α_i as the irrigation scheme-specific unobserved effects. In addition, the model assumes that the disturbance is the sum of three terms: a "scheme fixed effect" that is different for each irrigation scheme but does not vary over time; a "time fixed effect" that is different each year but does not vary across schemes; and a random effect.

Based on the reviewed literature, this study assumed that five variables affect the performance of public irrigation schemes in Kenya. These includesdevelopment and recurrent expenditure, donor funding, rate at which O&M is collected at scheme level, and the size of the irrigation scheme. Empirically, taking the above factors into consideration, the panel fixed effect regression model in this study follows the woks of Thairu (2010), Hsiao (2007), Inocencio *et al*. (2007), and Bos et al. (2005) where the model assume sa lagged form and is specified as:

$$I_{it}^{p} = \beta_1 + \beta_2 R_{it-1} + \beta_3 D_{it-1} + \beta_4 DF_{it-1} + \beta_5 IS_{it-1} + \beta_6 OMR_{it-1} + \varepsilon_{it-1} \quad \text{......................3.3}$$

Where: I_{it}^{p} = Irrigation scheme performance level in yields per area cropped

R_{it-1} = Management of the scheme proxied by recurrent expenditure to the scheme

D_{it-1} = Irrigation equipment and infrastructure proxied by development expenditure

DF_{it-1} = Grants and technical assistance costs proxied by donor funding/ investment

IS_{it-1} = Irrigation scheme total land size in operation in acres

OMR_{it-1} = Rate of O&M collection in the scheme in Kenya shillings

ε_{it-1} = Regression disturbance term

4. Results and Discussion

This section deals with the results and discussion of the study. It is divided into two sections: the first deals with the profile of the level of public irrigation schemes performance in Kenya; while the second is an in-depth assessment of various factors that affect the performance of public irrigation schemes.

4.1 Assessment of Productivity Trends of Public Irrigation Schemes in Kenya

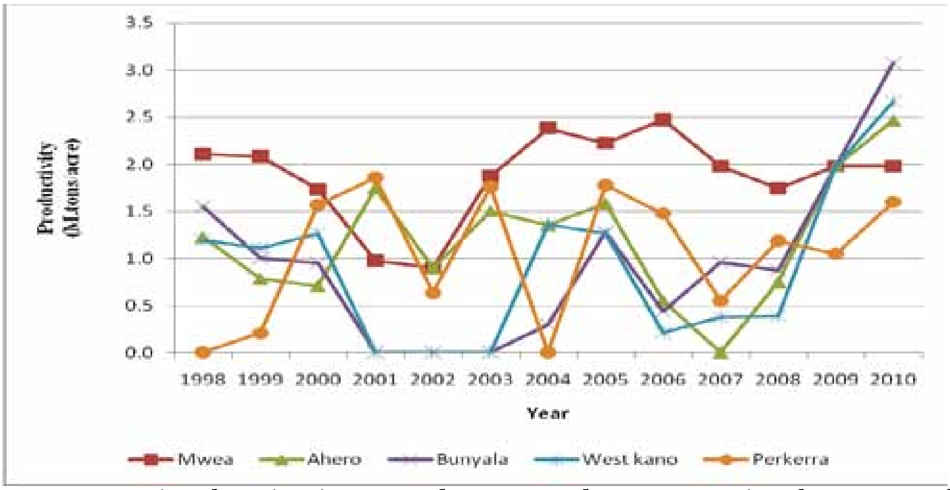
Productivity of irrigation schemes can be seen as a ratio of actual yields per land cropped in every scheme for each year. Conventionally, yields or outputs of an irrigation scheme have been a measure of performance in most of the studies. Productivity of irrigation schemes is also a good measure of performance, which shows the actual benefit on a per unit basis. As Figure 4.1 shows, the general productivity of irrigation schemes in Kenya has been fluctuating in various schemes in the period 1998 to 2010.

Between 1998 and 2002, there was a decline in productivity in most of the irrigation schemes. This was mainly due to low resource allocations from the government. However, most of them started showing a positive trend in productivity from 2002 when the NARC government came into power. This was also the time when the Strategy for Revitalizing Agriculture (SRA) 2004-2014 was being implemented in the country. Moreover, during the period , Mwea irrigation scheme benefited from counterpart funding between the Government of Japan which invested Ksh 2 billion while the Government of Kenya contributed Ksh 1 billion. Recurrent expenditure allocations to Mwea and Ahero irrigation schemes between 1998 and 2003 were among the largest in the irrigation sector.

The introduction of the Economic Stimulus Programmes (ESP) boosted the productivity of most public irrigation schemes in Kenya in 2008/2009, leading to an increase in their productivity.

Both Bunyala and West Kano irrigation schemes had a decline in their productivity between the period 2001 and 2003 due to the conflicts of political interest with other actors, such as the Dominion rice farms in the area. However, between 2007 and 2010, there was an improvement in the productivity of most of the public irrigation schemes in Kenya, and this is attributed to the stable and growing economy during the period. The Economic Stimulus Programme (ESP) also boosted the productivity of most irrigation schemes in Kenya in 2008/2009. Finally, the implementation of the Agriculture Sector Development Strategy (ASDS, 2009-2020) and the first medium term plan for Vision 2030, which saw

Figure 4.1: Trends in public irrigation schemes productivity in Kenya



Source: National Irrigation Board, 2013 and Kenya National Bureau of Statistics (KNBS), Various

Mwea receive development funds to a tune of Ksh 270 million in 2011 contributed to the noted productivity improvement.

This was aimed at increasing agricultural productivity, expanding irrigated agriculture, commercializing agriculture, and improving governance in the agriculture sector. The result of the study affirms that policy and institutional changes at the scheme level, along with increased government investments in irrigation and infrastructure, have an influence in production and productivity of the irrigation schemes. This result concurs with the findings of Meizen-Dick and Rosegrant (2005) and Gulati *et al.* (2005), who concluded that poor irrigation performance is directly related with the decline in irrigation investments and low rates of economic return on the irrigation projects.

4.2 Assessment of Factors Influencing Public Irrigation Schemes Performance in Kenya

The second objective of this study was to assess the effects of different factors on the performance of public irrigation schemes. Since panel data was used, a Durbin-Wu-Hausman (DWH) test was conducted to determine whether the estimates of the coefficients, taken as a group, are significantly different in the two regressions (fixed or random) and thereafter select the one to be adopted using the two methods. In the first case, the data was balanced (Appendix I) and the results of the DWH test suggest that fixed effect exists between the schemes of the data, hence the panel Fixed Effect Model (FEM) was adopted. The factors that were perceived in section three to affect the performance of public irrigation schemes in Kenya were estimated using a panel fixed effects regression model (Table 4.1).

The results indicate that the total size of irrigation scheme, amount of donor funding to scheme, and the per acre rate at which O&M were collected were significant at 1 per cent, 10 per cent, and 10 per cent, respectively. This, therefore, conforms to prior expectations. The results further indicate that total irrigation scheme size was significant, with positive effects on the performance of the irrigation scheme. This implies that increase in the scheme land size increases the probability of the scheme performing better in its activities. The findings of this study concur with those of Kibe *et al*. (2007), Clemmens (2006) and Huang *et al*. (2005) who concluded that as the scale of operation increases, farmers tend to benefit from the economies of scale of operations. In addition, those farmers who own large tracks of land tend to easily access credit facilities in financial institutions, which in turn helps them meet other farm inputs and hence better performance in their operations. Furthermore, the larger the public irrigation scheme size, the higher the economic returns as confirmed by the finding of Jones (1995) that "big projects just do better than small projects."

According to Inocencio *et al*. (2007), irrigation scheme size is a critical determinant of cost, and impacts on economic returns from irrigation through economies of scale. Larger irrigation schemes are supposed to attract better managers, and managing and implementing agencies such as the NIB may have more incentive to be cost-efficient given the relatively higher profile and greater public attention (Clemmens, 2006). The strong economies of scale in public irrigation schemes, therefore, suggest the importance of the scarce inputs such as land. On the other hand, poor performance has been observed for both large and small irrigation projects (Meizen-Dick and Rosegrant 2005; Brown and Nooter, 1992). They argued that scale of operation appears to be less important in determining the performance of the irrigation scheme than how it is managed. The result of this study indicates that, as far as the scale of public irrigation scheme is concerned, it is definitely the case that "large is good."

The rate at which farmers are being charged by NIB for the O&M services cost is significant at 10 per cent level. The positive effects on irrigation performance implies that it increases the probability of achieving more output or yields for public irrigation scheme. Majority of the schemes have been varying there O&M cost rate depending on the type of crop grown and the region of production. The result further shows that increasing this rate by one unit will lead to an increase in the performance of public irrigation scheme by 11.5 per cent as shown by the coefficient. This implies that O&M cost collection rate have a direct effect on the performance since when increased farmers tend to improve on their efficiency in order to maintain and/or increase their profits, which would otherwise be indirectly negatively affected. This result concurs with the findings of Inocencio et al. (2007) who concluded that where farmers contribute to irrigation development, irrigation schemes perform better than those without farmer contribution.

The government has been encouraging farmers' contribution to irrigation schemes as a part of a strategy to encourage a more participatory approach. This is aimed at achieving a greater sense of ownership among the beneficiaries of irrigation schemes, and results in more sustainable scheme operations, while reducing the financial burden of the NIB. The result in this study confirms the earlier findings, and supports a policy that encourages farmers to contribute to the O&M cost, on the grounds that it serves as an incentive to using the funds more effectively for farmers' needs and priorities. On the other hand, poor performance in most of the public irrigation schemes can be attributed to poor irrigation management by the NIB due to lack of accountability and incentives to deliver quality service and water supply. This is confirmed by Gulati and Narayanan (2003); and Gulati, *et al.* (2005) who concluded that poor irrigation performance is exacerbated by the absence of a link between irrigation quality, revenue generated from irrigation service fees, and staff incentives. The existence of well established and operational WUAs has also been associated with better maintenance of systems and more efficient water deliveries, which in turn led to higher yields and better economic performance of irrigation schemes (Gulati *et al.*, 2005; Raju and Gulati, 2005; and Shah *et al.*, 2002).

The amount of donor funding to an irrigation scheme is significant at 10 per cent level, with negative effects on the performance of public irrigation schemes. It implies that as the amount of donor finding increases in the scheme, the probability of farmers meeting the target of their operations decreases within the irrigation scheme. This implies that farmers tend to relax their effort in terms of effectiveness and efficiency, since most of the donor funds are not refundable, and they always target specific purpose in a particular scheme which has no effect on their profits. In addition, donor funds comes in form of grants and technical assistance, which are always aimed at capital investment and/or irrigation development that takes longer to be in operation. The results concur with the findings of World Bank (2008) that donors are providing relatively limited resources to the Kenyan agriculture sector, based on its comparative advantage, specialization and track record. Furthermore, most of the development partners have recently diverted their attention to smallholder irrigated agriculture, hence leaving the public irrigation schemes to be run entirely by the government.

Table 4.1: Summary of the determinants of public irrigation scheme performance

Variables	Coefficient	Standard error	P-value
Scheme land cropped size	0.4353651	0.1035223	0.000*
Management cost	0.0272844	0.1824122	0.882
Development cost	-0.0082568	0.1881861	0.965
Donor funds	-0.0629516	0.0328501	0.061**
Rate of O&M collection	0.1156603	0.0671855	0.091**
Constant term	-0.525307	1.000779	0.602
Diagnostic statistics			
Corr (u_i, xb)	0.0808		
Sigma_u	0.36588		
Sigma_e	1.54394		
rho	0.05317		
Number of Observations	65		
Number of groups	5		
F(5,55)	5.58		
Prob > chi^2	0.0003		

** ($p<0.01$) ** ($p<0.10$), Summarized from computer output (STATA), Appendix 1*

5. Conclusion and Policy Recommendations

5.1 Conclusion

This study aims to assess the determinants of performance of public irrigation schemes in Kenya. It examines trends in public irrigation schemes productivity between 1998 and 2010, and also the factors that affect the performance of public irrigation schemes. Among other findings, the results of the study indicate that policy and institutional changes, along with increased government investments in irrigation and infrastructure, have markedly influenced growth in production and productivity of the irrigation schemes. The results also indicate that total size of irrigation scheme, amount of donor funding to the scheme, and the per acre rate at which O&M were collected were significant at 1 per cent, 10 per cent and 10 per cent, respectively, and conforms to prior expectations. The results further indicate that total irrigation scheme size, amount of donor funding to the scheme, and O&M rate per unit of irrigated land was significant with positive, negative and positive effects, respectively, on the performance of the irrigation scheme in Kenya.

5.2 Policy Recommendations

The study results show that for intervention in public irrigations schemes, the total size of the scheme is an important factor since it leads to better performance, but the availability of water supplies is a serious constrain in many Kenyan rivers. Also, while some of these irrigation schemes perform poorly, many perform reasonably well, and therefore could be a positive component of particular links proposed under the ASDS of 2009-2020. However, the additional interventions of such links are likely to detract from the performance of specific public irrigation schemes, and therefore require careful scrutiny.

More studies have reported the problems and why programmes such as irrigation management transfers cannot or do not work. The results are in line with more recent evidence of promising positive impacts of greater farmer participation in public irrigation O&M in terms of enhancing irrigation performance in Kenya. Therefore, this study recommends for a policy that encourages farmers to contribute to the O&M cost, through formation of a well established and operational WUAs. In addition, its success would require NIB to treat farmers as clients, shareholders or as co-managers of irrigation schemes rather than just beneficiaries so as to enhance their roles in irrigation schemes O&M fee collection and management. However, while the results of the study provide support for such a policy, the inherent difficulties and challenges in making participatory initiatives should not be underestimated. Building capacities and stronger farmers' groups in form of WUAs, require a lot of time and resources which the Government and donors should invest in for public irrigations to be sustainable.

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Appendix

Appendix I:

```
edit
(17 vars, 65 obs pasted into editor)
. xtset id year
      panel variable:  id (strongly balanced)
       time variable:  year, 1998 to 2010
               delta:  1 unit
. xtreg prdvtymtha lnschmszacres lnrrctexp lnrdevexp lndnfnd lnomrt , fe
Fixed-effects (within) regression            Number of obs      =       65
Group variable: id                           Number of groups   =        5
R-sq:  within  = 0.3367                      Obs per group: min =       13
       between = 0.8680                                     avg =     13.0
       overall = 0.4468                                     max =       13
                                                     F(5,55)    =     5.58
corr(u_i, Xb)  = 0.0808                              Prob > F   =   0.0003
------------------------------------------------------------------------------
  prdvtymtha |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
lnschmszac~s |   .4353651   .1035223     4.21   0.000     .2279017    .6428285
   lnrrctexp |   .0272844   .1824122     0.15   0.882    -.3382778    .3928467
   lnrdevexp |  -.0082568   .1881861    -0.04   0.965    -.3853901    .3688766
     lndnfnd |  -.0629516   .0328501    -1.92   0.061    -.1287848    .0028815
      lnomrt |   .1156603   .0671855     1.72   0.091    -.0189823     .250303
       _cons |  -.5253073   1.000779    -0.52   0.602    -2.530913    1.480298
-------------+----------------------------------------------------------------
     sigma_u |  .36588097
     sigma_e |  1.5439462
         rho |  .05317239   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(4, 55) =     0.55              Prob > F = 0.6973
. estimates store fixed
. xtreg prdvtymtha lnschmszacres lnrrctexp lnrdevexp lndnfnd lnomrt , re
Random-effects GLS regression                Number of obs      =       65
Group variable: id                           Number of groups   =        5
R-sq:  within  = 0.3307                      Obs per group: min =       13
```

```
     between = 0.9231                               avg   =    13.0
       overall = 0.4533                              max  =    13
Random effects u_i ~ Gaussian              Wald chi²(5)     =    48.92
corr(u_i, X)      = 0 (assumed)          Prob > chi²       =    0.0000
------------------------------------------------------------------------------
 prdvtymtha |     Coef.          Std. Err.     z          P>|z|       [95% Conf. Interval]
-------------+----------------------------------------------------------------
lnschmszac~s |  .4717574    .0813519     5.80       0.000      .3123105      .6312042
     lnrrctexp |  .0173301     .1752879     0.10       0.921      -.3262279    .3608882
    lnrdevexp |  .0117812     .1806275     0.07       0.948      -.3422422    .3658045
      lndnfnd |  -.057653     .0316189    -1.82       0.068      -.1196249     .004319
        lnomrt |  .0715577     .0583487      1.23      0.220      -.0428036     .185919
        _cons |  -.7491193     .8516005     -0.88      0.379      -2.418226     .919987
-------------+----------------------------------------------------------------
    sigma_u |         0
    sigma_e |  1.5439462
           rho |         0   (fraction of variance due to u_i)
------------------------------------------------------------------------------
. estimates store random
. hausman fixed random
              ---- Coefficients ----
          |     (b)         (B)                (b-B)                sqrt(diag(V_b-V_B))
          |    fixed       random       Difference                         S.E.
-------------+----------------------------------------------------------------
lnschmszac~s |     .4353651      .4717574      -.0363923       .0640214
     lnrrctexp |     .0272844      .0173301        .0099543       .0504813
    lnrdevexp |    -.0082568       .0117812       -.0200379       .0527988
      lndnfnd |     -.0629516      -.057653       -.0052987       .0089092
        lnomrt |      .1156603       .0715577        .0441026       .0333064
------------------------------------------------------------------------------
                     b = consistent under Ho and Ha; obtained from xtreg
         B = inconsistent under Ha, efficient under Ho; obtained from xtreg
   Test:  Ho:  difference in coefficients not systematic
             chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                       =       1.94
         Prob>chi² =      0.0077
```