Efficiency of Fish Farming under Economic Stimulus Programme in Kenya

Tabitha Nduku

Productive Sector Division

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Bishops Garden Towers, Bishops Road
PO Box 56445-00200 Nairobi, Kenya
tel: +254 20 2719933/4; fax: +254 20 2719951
email: admin@kippra.or.ke
website: http://www.kippra.org

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Abstract

Fish is very important for food and nutrition security throughout the world. However, fish stocks from the natural sources in Kenya have been declining, making fish farming the only viable option to supplement fish supply. This paper examines the efficiency of the Government intervention in fish farming through the Economic Stimulus Programme. It assesses the efficiency with which the constituencies (grouped into counties) used the allocated resources for fish production. Results show a mean average efficiency of 65 per cent in 38 counties. Counties near large water bodies were relatively less efficient, contrary to the major water source criteria used for the fish farming intervention. Further, only 89 per cent of the fish ponds were observed, an indication that there could have been ponds that were constructed and abandoned or were never constructed at all. Only 49 per cent of the targeted fish production level was achieved. The optimal fish production expected from the 48,000 fish ponds that were to be constructed under the programme was 31,680 tonnes annually. However, in 2014, the total quantity produced from fish farming was 24,096 tonnes. Based on the findings, fingerling production hatcheries need to be implemented in the counties without any public or private hatcheries. Kenya can further borrow from Egypt and Nigeria, the leading fish farming producers in Africa, an approach which is both an intervention by the Government and a market-led approach to increase fish production and provide an incentive for fish farmers to produce for the market.

Abbreviations and Acronyms

AfDB	African Development Bank
AGRA	Alliance for a Green Revolution in Africa
ASALs	Arid and Semi-Arid Lands
CDP	County Development Profile
CIDP	County Integrated Development Plan
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
ESP	Economic Stimulus Programme
FAO	Food and Agriculture Organization
FFEPP	Fish Farming Enterprise and Productivity Programme
FNSP	Food and Nutrition Security Policy
GoK	Government of Kenya
Ha	Hectare
KER	Kenya Economic Report
Kg	Kilogramme
KMC	Kenya Meat Commission
KNBS	Kenya National Bureau of Statistics
KSh	Kenya Shilling
SFA	Stochastic Frontier Analysis
SSA	Sub-Saharan Africa
UN-CWFS	United Nations Committee on World Food Security

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1. Introduction

1.1 Overview

The primary role of the agriculture sector, which mainly includes crops, livestock and fisheries sub-sectors, is to produce diverse, safe and nutritious foods. The food basket in Kenya comprises cereals, pulses, milk, meat, starchy roots, fruits, fish and sea food (KNBS, 2014), which supply calories, proteins, fats, vitamins and micro-nutrients. The agriculture sector also provides the main impetus for poverty and hunger reduction, ensures food and nutrition security for all (Halwart et al., 2003), provides high nutritional value food, generates income, creates employment, and increases farm sustainability (Prein and Ahmed, 2000). Food and agriculture policies and interventions can have better impact on nutrition if the incentives for producing foods that are relatively unavailable and expensive but nutrient-rich and under-utilized as sources of food and income are increased (FAO, 2014). Such foods include fruits and vegetables, legumes, small-scale livestock and fish. Among these foods, fish, which is the focus of this study, accounts for 17-20 per cent of the global population's intake of animal protein, minerals and vitamins (FAO, 2014) and supplies 25 per cent of the total protein source in developing countries (Kareem and Williams, 2009).

A brief history of fish farming in Kenya by Ngugi et al. (2007) indicates that fish farming was introduced by colonialists in Kenya in the 1920s and in the 1960s. The Government popularized fish farming through "Eat More Fish" campaigns. Small ponds were constructed in Central and Western provinces, but the number reduced in the 1970s mainly due to inadequate extension services and lack of quality fingerlings. Production remained very low in small ponds and for mainly subsistence until in 2009 when the Government intervened in fish farming. Following the peak of the global financial and economic crisis in 2009, most governments in Sub-Saharan Africa (SSA) region mitigated the financial and economic crisis through Economic Stimulus Programmes (ESP). Kenya, Uganda and Tanzania increased government expenditure in 2009/2010 by 25 per cent, 19 per cent and 31 per cent, respectively, compared to the previous year (AfDB and World Bank, 2010; Kasekende et al., 2010). The budget increments were meant to jump-start the economies. For example, interventions through the subsidy programme in Malawi, and distribution of inputs in Sierra Leone (Brixova et al, 2010) stimulated agricultural growth. The ESP in Kenya was a highly intensive, high impact programme whose aim was to invest resources in projects with both short-term and long-term benefits. One of the ESP targets was to invest in long-term solutions to food security challenges, and expand economic opportunities in rural areas through employment creation.

The objectives of the ESP intervention in fisheries development were to create income and employment opportunities, improve nutritional status of the constituents, as well as contribute to regional development in the rural areas. It was envisioned as a short-term intensive programme to be implemented within six months from July 2009. However, the then Ministry of Fisheries Development designed a three year programme dubbed Fish Farming Enterprise and Productivity Programme (FFEPP) that was upscaled in subsequent years. In Phase I (2009/2010), the Government allocated Ksh 1.12 billion, translating to Ksh 8 million per constituency, to construct 200 fish ponds in 140 constituencies for fish farming. Each pond was also allocated 15 kilogrammes of fertilizer and 1,000 fingerlings (Mwamuye et al., 2012). The then Ministry of Fisheries Development took a lead role in implementing this project. The support to farmers was in form of pond construction labour by youth from the benefiting constituencies, supply of fingerlings and stocking of ponds, acquisition and supply of fish farming inputs, and specialized supplies and equipment. Harvesting, post-harvest handling and marketing of fish was to be done by farmers under the guidance of a competent aquaculture extension officer as stipulated in the ESP 2009 manual. Phase II was implemented under the Kenya Economic Recovery, Poverty Alleviation and Regional Development Programme, where the Government allocated a further Ksh 2.866 billion in 2010/2011 (Maina et al., 2014). Part of the funds were to be used for the construction of 300 fish ponds in an additional 20 constituencies, and construction of 100 other fish ponds in 140 constituencies that were under Phase 1. This means that Ksh 12 million was allocated to each constituency for construction of 48,000 fish ponds in 160 constituencies. The criteria used for a constituency to qualify for fish farming was based on the Aquaculture Inventory Survey of 2006, water availability, aquaculture suitability parameters, a riparian or near the Indian Ocean and a rural area.

Following the fish farming intervention, a milestone was achieved in national fish farming production, which increased each year from 2010 to 2014 albeit at a slowing rate by 7,258 tonnes, 7,112 tonnes, 2,222 tonnes, 2,014 tonnes and 595 tonnes, respectively (Table 1.1). This was attributed to an increase in area of farmed fish in the high aquaculture potential areas (KNBS, 2014). While the increase in national fish production as from 2010 is attributable to the ESP support, there is a sharp decline of 4,890 tonnes in fish production in 2012 and a further decline in 2013 and 2014.

Table 1.1: Quantity of fresh water fish production trends, 2009-2013 in tonnes

Freshwater fish	2009	2010	2011	2012	2013	2014
Lake Victoria	108,934	111,868	111,619	118,992	124,643	128,708
Lake Turkana	9,445	6430	7250	3001	4338	4165
Lake Naivasha	688	209	217	143	231	331
Lake Baringo	191	53	158	251	263	201
Lake Jipe	109	103	106	112	116	115
Tana River dams	584	583	943	967	705	1 024
Fish farming	4,895	12,153	19,265	21,487	23,501	24,096
Other areas	828	946	916	197	456	231
Total	**125,674**	**132,345**	**140,474**	**145,150**	**154,253**	**158,871**
Value of freshwater fish (Ksh million)	**10718**	**12274**	**15831**	**16866.8**	**19984.3**	**20543.7**

Source: KNBS (2014; 2015), Economic Surveys

There are a few studies undertaken in the fisheries sub-sector in some regions and constituencies that show cases of abandoned fish ponds. However, there is a dearth in knowledge on the overall performance of the fisheries intervention across the constituencies (which are grouped into counties in this study). Therefore, the extent to which ESP met its objectives remains ambiguous. There is need to evaluate the efficiency with which counties used the allocated resources for fish production in order to address regional disparities and targeting for current and future fish production and other related interventions. In 2014/2015, the Government allocated Ksh 0.1 billion for aquaculture development, which includes construction of 20 fish ponds in every sub-county in learning institutions, stocking the fish ponds with fingerlings and for provision of extension services (Government of Kenya, 2014), and it is important to monitor how these resources are utilized to achieve the desired objectives.

1.2 Problem Statement

Agriculture is the mainstay of Kenya's 80 per cent of the population living in rural areas. However, food and nutrition insecurity remains a real challenge among this group. The per caput protein supply in Kenya has been declining due to a reduction in the number of cattle slaughtered (KNBS, 2014;2015) and also due to declining natural fish stocks. Fish farming is a viable alternative source of a steady supply of protein for the country to feed the growing population and meet the demand for fish (UN-CWFS, 2014). The World Fish Centre (2008) notes that diversification of fish sources enables rural households to cope better with natural disasters and climate change. Frequent and intensive climate events have a major impact on the future of both inland and marine fisheries production. Low water levels reduces the recycling of nutrients, which affects the growth of natural fish stocks.

Food and nutrition insecurity is an ongoing policy concern for the Kenyan government. As a result, various policy interventions, both short and long term, have in the last few years been implemented to deal with food and nutrition challenges in the country. Fish farming is one such intervention that was initiated through the ESP, with specific objectives to create income and employment opportunities, improve nutritional status of the constituents, and contribute to regional development in the rural areas.

Fish farming in rural Kenya had been slow until 2007 when production increased from 1,000 to 4,000 tonnes per year (de San, 2013). A further improvement in fish farming was in 2009 (4,895 tonnes/year), when the Government introduced the ESP under which fish farming was identified as a key pillar in the production sector. The ESP was a short-term Government intervention to jump-start fish farming in Kenya with the objective to improve nutrition and create employment and income opportunities. Despite the massive investment, fish farming in Kenya lags behind compared to other countries in Africa. The fisheries sub-sector growth rate has been declining in the 2010-2015 period from 8.8 per cent to 2.9 per cent (KNBS, 2015).

It is not clear whether fish farming in Kenya achieved its goals in all the areas where it was implemented. Studies from different constituencies show that fisheries development under the ESP faced many challenges, and in some regions it stalled (Mwamuye et al., 2012). The major challenges were that some sites were unsuitable for fish farming, there was staff shortage, inadequate resources especially transport, political interference, shortage of fingerlings (Murang'a County, 2013), procurement delays, lack of organized market for fish (Nyandarua County, 2013) and cultural negative attitude towards fish consumption (West Pokot County, 2013). In Isiolo County, fish ponds stalled due to lack of community support and water following a drought in the area (Isiolo County, 2013). There was slow uptake of fish farming even in counties where fishing is the predominant activity despite the dwindling natural fish stocks (Homa Bay County, 2013).

The targets of constructing fish ponds may have been met but the expected output of increased fish production to improve nutritional status, against massive investments, are yet to be realized. Given that the government allocated equal amounts of inputs/resources across 160 constituencies, it was assumed that production levels in each constituency would not vary significantly. The fish farming ESP policy made an assumption of homogeneity of the constituencies as far as fish production and consumption is concerned. However, it is rare to find areas within a country with the same ecological, institutional, cultural and infrastructural similarities, and this could have led to varied outputs and, therefore, outcomes of the programme in the targeted areas.

An evaluation of the ESP intervention in fish farming will provide information on how each constituency contributed to the overall goals of the programme. Knowledge on fish production levels at the county level is important given the current devolved government structure. Some studies on the implementation of the ESP in fisheries exist, but these reports are for specific constituencies, districts or counties, and not on the efficiency of the whole ESP programme on fish farming.

1.3 Objectives of the Study

The overall purpose of this study is to evaluate the performance of fish farming in Kenya under the Economic Stimulus Programme. The specific objectives are to:

1. Assess the efficiency of the counties in fish production.
2. Determine the optimal fish production from the allocated resources.

Research questions

1. At what levels of efficiency did the counties operate?
2. What is the maximum quantity of fish that can be produced from the same inputs?

1.4 Justification

Fish is not only important for food and nutrition security, but is also one of the solutions to hidden hunger (a micronutrient deficiency of mainly vitamins and minerals that leads to poor nutrition, poor health, reduced productivity and therefore increased poverty and decreased economic growth). The Government of Kenya is keen to reduce hunger and malnutrition by promoting production of nutrient-rich foods such as fish and by encouraging dietary diversity as stipulated in the National Food and Nutrition Security Policy (FNSP) 2011. Vision 2030 identifies fisheries as an enterprise that can be promoted to raise incomes, while the Jubilee Manifesto (2013) encourages every school to have a model agriculture and fish farm. Among the flagship projects in the Medium Term Plan II (2013-2017) is expanding the area of fish farming from the current high potential areas to arid and semi-arid lands (ASALs).

An interrogation of the efficiency of government intervention in previous fish farming programmes will inform future and similar interventions. The study will provide information to national and county level policy makers on future targeting of fish farming and farmers in sub-counties most suitable for fish farming. Continuing to allocate funds for fish farming without evaluating the performance of the ESP will lead to inefficient allocation of the government's scarce resources. The findings will thus give an indication of how much fish production differs across counties, and provide and knowledge on the best performing constituencies in terms of efficient resource allocation.

2. Literature Review

This section reviews both the theoretical foundations and empirical literature of the study.

2.1 Theoretical Literature

The foundation of stimulus intervention in the economy is based on the Keynesian theory (Keynes, 1932). It states that, in the short run, during economic slumps, economic output is strongly influenced by aggregate demand (total spending in the economy). It is based on the belief that economic slumps can be prevented and optimal economic performance can be achieved by influencing a country's aggregate demand. Therefore, through an economic stimulus programme (ESP), a government injects more money and increases spending to jump-start the economy, boost economic growth and lead the economy out of an economic slowdown (Palley and Horn, 2013).

The study further borrows from the theory of efficiency and productivity to measure the performance of firms (any type of decision making unit which converts inputs into outputs, Coelli et al., 2005). The attainment of greater efficiency from scarce resources is a major criterion for priority setting. There are three major concepts of efficiency: productive, technical and allocative. Debreu (1951) introduced the concept of resource utilization and a measure of the loss involved when a situation is non-optimal, indicating how far it is from being optimal. This was the first measure of productive efficiency which Fare et al. (1994) add that it is a radial measure of technical efficiency and focuses on the maximum feasible reduction of inputs or the maximum possible expansion of outputs (frontier), independent of the measurement unit. Measuring the productive efficiency of an industry or sector is important in economic planning so as to know how far a given sector can raise its output without allocation of further resources (Farell, 1957). Both Debreu (1951) and Farell (1957) provide an interpretation of performance or efficiency by measuring the distance to the frontier (Fare et al., 1994).

Productive efficiency refers to the production of a given output by using the minimum possible amounts of inputs, or producing the maximum possible output using a given amount of inputs (Duran, 2010). Technical efficiency is the physical relation between resources (capital and labour). A technically efficient position is achieved when the maximum output is obtained from a given set of inputs (Fare et al., 1994). An intervention is technically inefficient if the same (or greater) outcome could be produced with less of one type of input. However, technical efficiency cannot directly compare alternative interventions where one intervention produces the same (or better) outcome with less (or more) of one resource and more of another.

Allocative efficiency measures the ability of the firm to use the inputs in optimal proportions given their respective prices (Uri, 2001). In our context, therefore, technical efficiency addresses the use of given resources to maximum advantage; productive efficiency of choosing different combinations of resources to achieve the maximum fish farming benefit for a given cost; and allocative efficiency of achieving the right mixture of fish farming programmes to maximise the outcomes. Although productive efficiency implies technical efficiency, and allocative efficiency implies productive efficiency, none of the converse implications necessarily hold. Faced with limited resources, the concept of productive efficiency will eliminate as "inefficient" some technically efficient resource input combinations, and the concept of allocative efficiency will eliminate some productively efficient resource allocations. The study therefore links the ESP to the theory of efficiency to assess the performance of the programme to ascertain the value for the money that was allocated across the counties for fish farming.

2.2 Empirical Literature

Studies exist that evaluate the efficiency of different agricultural, livestock, fisheries, aquaculture and environmental issues at both the farm and regional levels using different approaches. However, there are no related studies on fish farming in Kenya and, therefore, this study borrows from those conducted in mainly Asia, Africa and other parts of the world. This section reviews studies that have assessed the benefits of fish farming, the different approaches used in fish farming in Africa and Kenya, variables applied in fish farming efficiency studies and methodologies used, factors that affect efficiency, and regional and farm level studies that evaluate resource utilization initiatives.

Fish farming contributes to food and nutrition security by increasing food availability, and providing highly nutritious animal protein and vital micronutrients. Additionally, it offers employment and incomes that farmers can use to buy other food products (United Nations-Committee on World Food Security (UN-CWFS, 2014). Household fish farming improves nutritional status directly through access to fish protein and indirectly by increasing the purchasing power of the household, therefore enabling access to other types of food (Aiga et al., 2009). It has a higher potential to produce readily available farmed fish for home consumption in relatively short periods, and requires small areas of land (Murnyak, 2010). Integration of fish farming into an already existing agricultural system increases production, overall farm productivity, and produces up to sixfold improvement in profitability (AGRA, 2014; Wetengere and Kihongo, 2011) and improves both food and income security with little or no external input (Brummett and Noble, 1995).

Although fish farming provides fish for consumption in the household and for sale (Gordon et al., 2013), growth in per capita fish consumption in SSA has been low and fish farming is yet to develop (Beveridge et al., 2013). In Africa, it is often integrated in the existing farming systems and has been almost entirely initiated and implemented by donors, Governments, agencies and other institutions for the sole purpose of increasing fish supply and creating fish farmers (Brummet and Noble, 1995). Fish farming is still struggling to realize its full potential despite more than 40 years of research and development, and hundreds of millions of dollars spent. Substantial gains in the much needed food security and economic growth especially in rural areas have generally not been achieved. Lack of good quality fingerlings, feed and technical advice; poor market infrastructure and access; and weak policies that impede expansion, largely by emphasizing central planning over private sector initiative persist and constrain broader growth of the sector (Brummet et al., 2008).

African governments intervened to develop aquaculture (fish farming) in their countries using different approaches. Egypt used a commercial tilapia model, which had both interventionist (government-led) and immanent (market-led) models; Nigeria used a commercial catfish model (market-led); Malawi used both an evolutionary approach model with mainly donor funds and the Presidential Initiative on Aquaculture Development; Kenya used the high input interventionist model with large public sector funding through the ESP strategy to jump-start fish farming; while Ghana applied the commercial cage culture development initiative. All the approaches led to an increase in the production of aquaculture (Jamu et al., 2012). The contribution of Sub-Saharan Africa to the global fish farming production increased to 359,790 tonnes in 2010, a 0.6 per cent of the global production. Boto et al. (2013) attribute this growth to rapid development of freshwater fish farming in Egypt, Nigeria, Uganda, Zambia, Ghana and Kenya. However, in 2011, Kenya's share of aquaculture production in Africa was only 1.6 per cent compared to Egypt, Nigeria and Uganda whose contribution was 70.6, 15.8 and 6.1 per cent, respectively (Gordon et al., 2013).

Fish farming in Kenya is practiced in 38 counties and data from the State Department of Fisheries (2014) shows that Kiambu (6.2%), Kakamega (5.7%), Murang'a (4.7%) and Meru (4.7%) counties are the main fish producers. Fish produced is mainly sold to the local community and within the local markets in the constituencies (de San (2013); Nyeri CIDP (2013); Oyieng et al. (2013)). Agriculture-fish farmers consume more animal protein than agriculture farmers (Dey et al. (2006) and fish production and fish consumption at household level are used as indicators of household nutritional status (Kawarazuka (2010). A characterization of fish production and marketing by smallholder fish farmers in Eastern Kenya (Oyieng et al., (2013) and a study in Malawi (Dey et al., 2006) on integrated aquaculture agriculture showed that an increase in fish production leads to a higher household income and purchasing power. At the same time, increased supply of fish leads to a decrease in fish prices and an increase in accessibility of fish for many more people, hence an increase and improvement in nutritional status. Rural diets may not be particularly diverse, which necessitates good food sources rich in essential nutrients. In addition to providing food, fish contributes to nutritional security in these areas in various ways, such as direct consumption of fish and cash income, which leads to a higher overall food consumption (Kawarazuka, 2010).

An ex-post analysis of the development of small scale integrated agriculture-aquaculture farming system in Malawi by Dey et al. (2007) in Allison (2011) quantified the benefits of the farming system as 10 per cent improvement in farm productivity and 134 per cent increase in per hectare farm income, 61 per cent increase in total farm income, 40 per cent increase in technical efficiency (financial input-output ratio), 208 per cent increase in household consumption of fresh fish, and 21 per cent increase in consumption of dried fish. A lower prevalence of malnutrition among children in fish farming households than those in the non-fish farming households in all the malnutrition indicators of anthropometric measurements for stunting, underweight and wasting was observed in Zomba District, Malawi by Aiga et al. (2009). The authors estimated the impact of household level fish farming on the nutritional status of 6-59 months old children. A sample of 66 children each from fish farming and non-fish farming households was drawn and both bivariate and multivariate analysis applied on 21 variables. Structured interviews with the children's parents showed a higher proportion of income from fish farming to total income. The authors therefore concluded that fish farming may have contributed both directly and indirectly to lower prevalence of underweight children through increased frequency of oil and fats intake by the strengthened purchasing power of the households.

Integrated fish farming is more beneficial than alternate farming systems, according to a study by Ahmed et al. (2011) on rice-fish farming in Bangladesh. Using a sample of 80 rice-fish farmers, and 172 rice-only farmers, the authors used Data Envelopment Analysis (DEA) to assess the efficiency of both farming systems. A costs and returns analysis showed that fish fingerlings and feed contributed the highest cost in the rice-fish farming system, while annual fertilizer cost was the highest cost in the rice monoculture farming system. The input variables used for the DEA relevant for this study were fish fingerlings and fish feed while fish production in kilograms/hectare/year was the output variable. The authors concluded that rice fish farming provides better resource utilization, diversity in the system, increased productivity, production efficiency and food supply. However, despite the many benefits, the authors concluded that few farmers in Bangladesh have adopted rice-fish farming and attributed this to socio-economic, environmental, technological and institutional constraints. The key constrains identified were lack of technical knowledge, floods, drought, high production costs and poor water quality.

Farm size and productivity efficiency relationship is non-linear, with efficiency first falling and then rising with size according to a study by Bhatt and Bhat (2014) in Pulwana and Kashmir districts in India. Primary data from 461 farmers for the year 2013/14 was analysed using DEA, and the results showed that the average technical efficiency was 48 per cent, with most of the farms operating at a lower level of technical efficiency. Using a Two-Limit Tobit Regression Model, the authors used occupation, farm experience, household size, farm size, membership and seed type as factors that influence the discrepancies in technical efficiency across farm sizes. Onumah et al. (2009) used a cross-sectional data of 150 farmers from 3 regions in Ghana to analyze the productivity of family labour, hired labour, feed, seed, land and other cost and extension visits and found that the variables had reaffirming influence on fish farm production. Results also indicated that with the combined effects, family and hired labour used in fish production in Ghana may be equally productive. However, individual effects may not be significant. Using the same sample, Onumah and Acquah (2011) assessed the technical efficiency and its determinants of fish farms in Ghana and used the quantity of fish harvested in kilogrammes as the output, while the input variables were labour in man-days, cost of fish feed, quantity of fingerlings in kilogrammes, total area of ponds in hectares, and other costs that comprised chemicals, fertilizer, fuel, electricity, farm rent, maintenance cost and depreciation cost. The inefficiency determinant variables used by the authors were gender of the decision maker; cultural system (monoculture or poly-culture); age; education; pond type (earthen or concrete); and location and region, which were used to capture regional influence on technical efficiency of production. Using Stochastic Frontier Analysis (SFA), the efficiency of the fish farms was found to range from 34.3 to 98.4 per cent, with 32.7 per cent of the farms operating at 90 per cent and above efficiency levels. There was no regional effect on the technical efficiency of fish production

An assessment of the technical efficiency of small scale fish farmers in Oyo state Nigeria by Osawe et al. (2008) showed that the mean efficiency of the farmers was 90.6 per cent. From a sample of 82 fish farmers, 65.9 per cent of them were over 90 per cent efficient while the technical efficiency of the remainder (34.1%) ranged from 50-90 per cent. The authors used a stochastic frontier production function and used the pond size as a proxy for farm size, total feed used in kilogrammes and stocking rate (pieces) as inputs while the output was the quantity of harvested fish in kilogrammes. The significant determinants of inefficiency in the study were educational level, years of experience, pond type and cooperative membership. The authors concluded that these agreed with the a priori expectation that increase in education level and experience are positively correlated with adoption of improved techniques of production.

A provincial evaluation of resource utilization efficiency across the nine South African provinces was conducted by Van Heerden and Rossouw (2014). Using a multi-stage DEA, the authors assessed the use of production capacity and total under-utilization to identify the weak-performing industries. The results showed that the electricity industries, water, agriculture, forestry and fishing were the least scale efficient. To meet the targets of job creation, growth and development within the agriculture, forestry and fishing sectors, the authors recommended additional managerial and/or government intervention. Sekhon et al., (2010) assessed crop production efficiency in different regions of Punjab State to show how the regions had adopted the latest technology. A stochastic frontier production function analysis showed a wide variation of the average efficiency across the regions. Since the policy intervention to improve efficiency was not the same for all the regions, the authors concluded that the state would benefit more if the policy interventions are developed at the local level.

The performance of financial support for agriculture can be evaluated as carried out by Huang et al. (2012) in Guizhou Province, China. Using a secondary relative benefit model based on DEA, the study used nine prefecture level cities in Guizhou Province as decision making units (DMUs), "developing agricultural production, increasing farmers' income, increasing the grain yield" as the principle to determine agricultural financial expenditure as the input, while the output indicators were total agricultural output value, per capita net income of rural households, and grain yield. Results showed that the performance score of the production effectiveness determined by objective natural conditions and management effectiveness of all regions (as DMUs) in the use of financial fund for supporting agriculture in Liupanshui City and Southwest Guizhou was very low. The authors recommended that the technical efficiency and management efficiency in most regions needed to be improved.

The levels and determinants of farm-level technical efficiency of 90 shrimp farmers in Bangladesh were estimated in a study by Begum et al. (2013). Shrimp production was measured in kg/ha and the input variables were pond size (ha), labour (man-days), fingerlings (number/ha), feed (kg/ha), lime (kg/ha), organic fertilizer (manure) in Kg/ha and pesticide in kg/ha. The variables assessed to determine the causes of inefficiencies were farmers' education, age, total non-farm income, and family size. Using a stochastic production frontier, the results showed significant inefficiency of the farmers as they operated at 18 per cent below the production frontier. The authors further determined that by operating at full efficiency levels, shrimp production could increase from a yield of 225.56 to 265.28kg/ha. The significant determinants of inefficiency in the study were education, age, non-farm income, and distance of the pond from the water channel.

There is an inverse relationship between farm size and technical efficiency as evidenced in a study on Philippine's pond aquaculture by Irz and Stevenson (2012). Using a multi-product ray production function estimated in a stochastic frontier framework, the authors found that the agrarian reform was not the key to unlocking the production potential of aquaculture in the country. The authors noted that it is possible for management to differ across regions and, therefore, included a regional dummy in the analysis. They added that data from the different regions was used. Using DEA-analyzed efficiency and productivity as cross-sectional data in combination with regression techniques would not produce any variability, as the input and output markets are relatively well integrated within regions.

Nastis et al. (2012) assessed the efficiency and performance of 40 organic alfalfa farms in Greece, which had participated in a subsidized programme whose objective was to promote a switch to organic farming. Using bootstrap Data Envelopment Analysis (DEA) and a Tobit analysis, results showed that larger farms had lower yields and lower efficiency scores. Higher efficiency scores were observed with more experienced farmers. The authors added that given the recent economic crisis that had prevailed during the study, pressure was exerted to use public funds more productively and efficiently.

2.3 Overview of Literature

From previous studies, the benefits of fish farming for food security are clear, both from direct consumption of fish and through increase in income. The government intervention in fish farming in Kenya would therefore contribute to the intended outcomes through increased fish production. An assessment of the efficiency with which the ESP in fish farming was implemented will provide further insights into the high input approach that the government used. Fish production is affected by various economic, social and environmental factors, which lead to differences in efficiency levels.

Both the farm and regions, for example, provinces in a country or prefecture level cities in a province can be used as the unit of analysis in evaluation and efficiency studies. The literature shows that the evaluation and assessments analyzed focused on parametric or non-parametric models to measure efficiency. DEA and Stochastic Frontier Analysis (SFA) are the commonly used frontier methods that use an efficient frontier to identify the efficiency of individual DMUs relative to a reference set of DMUs. The DEA approach is non-parametric and identifies the efficient frontier through mathematical programming, while SFA is parametric and hypothesizes a functional form where data is used to estimate the function parameters using all the DMUs.

The study used an output-oriented DEA model. The results are hoped to inform choices that maximize the fish farming outcomes gained from the resources allocated for fish farming. The concept of productive efficiency is borrowed for the study, as it focuses on the maximization of output for a given input cost. In fish farming, productive efficiency enables assessment of the relative value for money used in interventions, with directly comparable outcomes. It cannot address the impact of reallocating resources at a broader level, for example, from Constituency A to Constituency B, because the fish farming outcomes are incommensurate.

3. Methodology

3.1 Conceptual Framework

It is conceptualized that the government through the ESP, Fish Farming Enterprise and Productivity Programme (FFEPP) and the Kenya Economic Recovery, Poverty Alleviation and Regional Development Programme provided equal inputs (monetary allocation) to the 160 constituencies (38 counties) that were the Decision Making Units (DMUs). The DMUs used the allocated money as inputs to: identify the suitable sites to construct fish ponds; identify the farmers and farmer groups to be targeted; provide extension services, train and conduct fish farming demonstrations to farmers; pay labour for the construction of 300 fish ponds in each constituency; and purchase and distribute fingerlings, fish farming inputs, fish feeds and seine nets to farmers. All these activities were inputs meant for the production of one main output, fish. The expected outcome was improved nutrition and creation of employment and income opportunities (Figure 3.1).

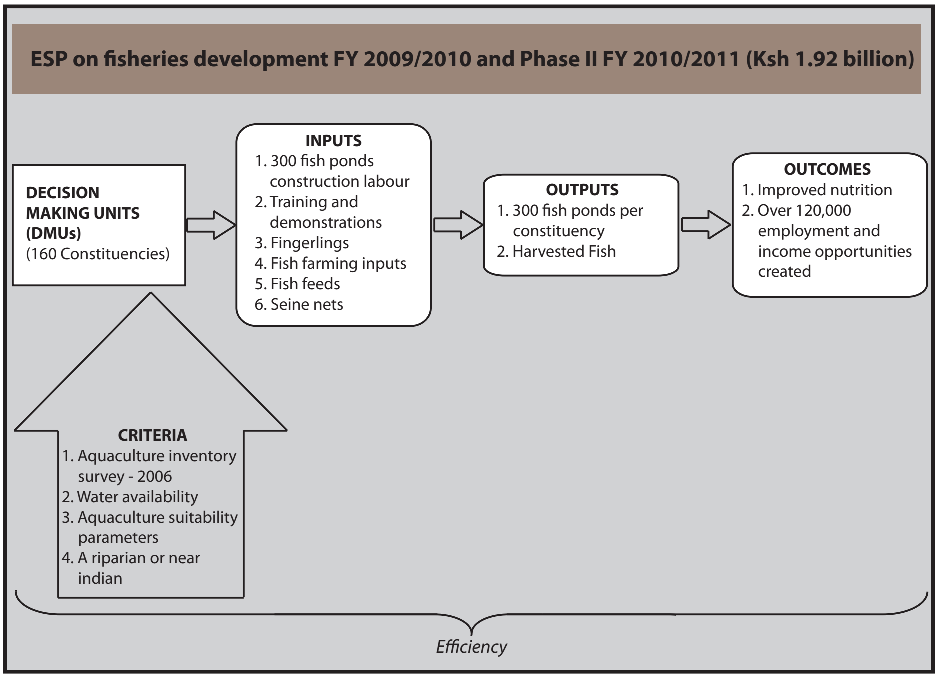


Figure 3.1: A conceptual framework of the ESP on fisheries development

Source: Author's Illustration from the ESP Manual, 2009

The preconditions for the constituencies to be targeted for the ESP implementation were the potential for fish farming, construction of ponds of not less than 300m^2, and identification of unemployed youth and women to manage the ponds for profit. The overall outcomes were increased fish production to improve nutrition and create over 120,000 employment and income opportunities.

Efficiency is one form of evaluation that measures whether resources are being used to get the best value for money. In this study, fish farming is an intermediate product, in the sense that it is a means to the outcomes of improved nutrition, employment creation and income generation. Efficiency links resource inputs (money/capital) allocated by the government for fish farming) and either intermediate outputs (fish production) or final fish farming outcomes (improved nutrition, employment creation and increased income). This evaluation uses the intermediate output due to data limitations and lack of baseline information necessary for assessing the ESP fish farming outcomes.

3.2 Analytical Framework

To evaluate the efficiency of any DMU, it is necessary to define a best performance to be used as the benchmark for assessment of the actual performance of the unit, in this case the county. There are two approaches of setting the benchmark, either to compare the actual output to the maximum output that can be produced from the inputs actually used by the county, or use the maximum output per county. The study used a benchmark from the observed data. Efficiency can be measured using a parametric and econometric approach such as the Stochastic Frontier Analysis (SFA) or a non-parametric method such as the Data Envelopment Analysis (DEA), which uses a mathematical programming technique (Ray and Chen, 2010). SFA has a stochastic frontier while DEA is axiomatic and has a deterministic frontier. DEA was introduced by Farell (1957) and (Charnes, Cooper, and Rhodes - CCR, 1978) as a non-parametric method for comparing the efficiency performance of various DMUs and hence the DEA-CCR model (Banker, 1993). The assumption was that production exhibits constant returns to scale and that there are no dis/ economies of scale as the output production level changes. Banker, Charnes, and Cooper - BCC (1984) advanced the DEA-CCR to DEA- BCC that allows for a more realistic assumption of variable returns to scale (Cullinane and Wang, 2007).

The non-parametric approach is appropriate when the output and input prices are not available. Due to data constraints, an output-oriented DEA with input levels held fixed was used to compare the relative performance of the counties given that they all used similar inputs to produce the same product and operated under comparable circumstances (Coelli, et al., 2005; Shafiq and Rehman, 2000). The preconditions for the constituencies to qualify for fish farming development make them comparable in this study. DEA estimates a production frontier that shows where the counties perform in relation to this frontier. Each county assessed, therefore, produces fish using the same kind of inputs. The results are compared with the best county in fish production.

Unlike SFA, DEA does not account for random variation in the output (Tingley et al., 2005). This is ideal in this study as the secondary data used is limiting and does not provide information on the reasons for varied production across the counties, which can best be captured through primary data collection methods. DEA can be done for each year, and then the mean scores used for analysis. It can either be input-oriented or output-oriented, where by the input-oriented DEA method defines a frontier by seeking the maximum possible proportional reduction in input usage with output levels held constant for each county. An output-oriented DEA method seeks the maximum proportional increase in output production with input levels held fixed. The number of variables should be lower than the DMUs.

3.3 Data Sources

The study used secondary data obtained from the County Development Profiles for the 38 counties. Data on fish production in 160 constituencies (which was collated into county production), expected production per 300m^2 fish pond and number of existing fish ponds, across the counties, was obtained from the State Department of Fisheries, Department of Aquaculture. The percentage access to water from different sources per county and the percentage rural area per county were obtained from the KNBS.

3.4 Model Specification

In specifying the DEA approach, efficiency is measured as the ratio of the weighted sums of outputs (virtual output) and the weighted sums of the inputs (virtual input) (Kao and Hung, 2005; Martic et al., 2009). The DEA model as specified by Charnes, Cooper and Rhodes-CCR (1978) and Banker, Charnes and Cooper-BCC (1984) is represented as:

$$\text{Maximize } h_o = \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i}^{m} v_i x_{io}}$$

Subject to:

$$\frac{\sum_{r=1}^{s} u_r \, y_{rj}}{\sum_{i=1}^{m} v_i \, x_{ij}} \leq 1$$

j =1, ... ,n, with u_r, v_i > 0, i = 1, ..., m; r =1, ..., s.

y_{rj}, x_{ij} > 0 represent output and input data for decision making unit $(DMU)_j$

where,

j are DMUs; 1...n

r is outputs; r=1...s

i is inputs; i=1...m

u_r is the weight of output r

v_i is the weight of input i

y_{rj} is the r^{th} output of the j^{th} DMU

x_{ij} is the i^{th} input of the j^{th} DMU

s, and m are the number of outputs and inputs used in production, respectively

h_o is the relative efficiency of DMU_o which is a ratio of the weighted sums of their outputs and the weighted sums of their inputs.

If Max h_o=h_o*=1, it means that the DMU_o is efficient. However, if h_o*<1, then DMU_o has not achieved efficiency. It is considered relatively inefficient if it is possible to expand any of its outputs without reducing any of the inputs (output orientation), or if it is possible to reduce any of its inputs without reducing any output (input orientation) (Martic et al, 2009).

Variables in the Model

The variables used in the study are:

Variables	**Description**
Output (Y)	Aggregate quantity of fish production in the County (tonnes)*
Inputs	
Total allocation	Money allocated per county (Ksh million)
Fingerlings	Total value of fingerlings stocked (Ksh million)
Feed	Total value of feed applied in fish ponds (Ksh million)

County specific variables	
County water sources	Percentage of the various sources
Rural	Area of county that is rural (%)
Fingerling production	No. produced per county (No.)

** Total production was used, as data on production by fish species was not available.*

4. Results and Discussion

Data from 38 counties that were targeted in the ESP was analysed and the results are presented in this section.

4.1 Descriptive Statistics

The 160 constituencies targeted in the ESP for fish farming were grouped into 38 counties. The number of constituencies per county ranged from one (Narok) to nine (Kakamega) (Table 4.1). The allocations per county were a minimum of Ksh 12 million to a maximum of Ksh 108 million. A total of 42,566 fish ponds of 300m^2 each were constructed and the number varied from 68 to 3,500 across the countries. Fingerlings were stocked in the fish ponds at the rate of 1,000 per fish pond. The average cost of a fingerling was Ksh 15 and the total value of fingerlings used per county ranged from Ksh 1 million to Ksh 52.5 million. Each fish farmer received 5 bags of 20kg each of fish feeds at a cost of Ksh 200 per kg to use for 8 months. The average cost of fish feeds was Ksh 22.4 million. The amount of fish harvested varied from 95 and 963 tonnes in Narok and Kiambu counties, respectively.

Table 4.1: Summary statistics of variables for DEA estimation (n=38)

Variable	Mean	Std. Dev.	Min	Max
No. of constituencies	4	1.93	1	9
Inputs				
Total allocation Ksh	50.5	23.2	12	108
No. of ESP ponds	1120	821.96	68	3500
ESP pond area (m$^{2)}$	336,047.4	246,588.9	20,400	1,050,000
Fingerlings (million Ksh)	16.8	12.3	1	52.5
Fish feeds (million Ksh)	22.4	16.4	1.4	70
Outputs				
ESP production (tonnes)	412.2	208.39	95	963
County characteristics				
Water sources (%)				
Pond or dam	1.30	3.58	.01	16.93
Lake	4.55	5.28	.08	20.79
Stream	27.28	14.97	.14	58.72
Spring well	37.37	19.17	7.18	78.47
Piped to dwelling	4.9	4.76	0.64	23.42
Piped	19.23	14.53	1.61	52.68

Jabia and rain harvested	1.24	1.69	0.08	7.45
Water vendor	3.87	4.26	0.32	16.45
Rural	74.95	18.28	0	93.4
No. of fingerling production ('000)	2,260.44	3,318.85	0	13,000

Source: Author's computation from CIDP, State Department of Fisheries Data and KNBS data

Among the preconditions for fish farming was a riparian or near Indian Ocean. Almost all the counties (36) have 100 per cent access to water from different sources except in Baringo and Tana River counties, which have 97 and 95 per cent total access, respectively. The selected area had to be a rural area, and the mean area that was rural across the counties was 75 per cent, with Nairobi being the only all urban county to be included in the fish farming intervention.

4.2 DEA Results

A Constant Returns to Scale (CRS)-output oriented Data Envelopment Analysis was used to assess the efficiency of the counties. Total fish production in tonnes per county was the output against the inputs (monetary); ESP allocation for construction of fish ponds; value of fingerlings; and value of feed per county. The results are presented in Table 4.2.

Table 4.2: CRS-output oriented DEA efficiency results for 38 counties

DMU	Rank	Efficiency Score (%)	DMU	Rank	Efficiency Score (%)
Lamu	1	100.0	Machakos	10	70.7
Nakuru	1	100.0	Nyeri	11	68.2
Nyamira	3	97.5	Narok	12	67.9
Trans Nzoia	4	91.1	Migori	13	67.3
Kisii	5	85.4	Baringo	14	65.6
Bomet	6	87.8	Murang'a	15	64.6
Tana River	7	79.7	Nandi	16	63.8
Vihiga	8	74.1	Busia	17	62.3
Kajiado	9	72.3	Kericho	18	61.4
Elgeyo Marakwet	19	61.4	Embu	29	56.1
Nairobi City	20	60.6	Kwale	30	54.9
Siaya	21	59.9	Kakamega	31	54.4
Nyandarua	22	59.0	Uasin Gishu	32	53.6

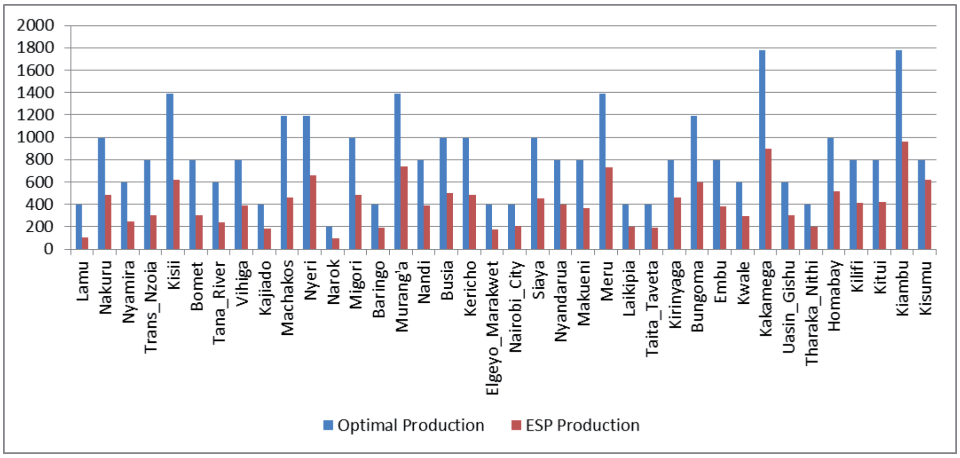
Makueni	23	59.0	Tharaka Nithi	33	53.2
Meru	24	58.7	Homa Bay	34	52.6
Laikipia	25	57.5	Kilifi	35	51.8
Taita Taveta	26	56.3	Kitui	36	51.1
Kirinyaga	27	56.2	Kiambu	37	50.8
Bungoma	28	56.1	Kisumu	38	42.1

Source: Author's computation

The overall efficiency of the counties was 65 per cent, with Lamu and Nakuru counties being the most efficient. Kisumu County was relatively inefficient in fish farming with an efficiency score of 42 per cent.

The optimal fish production estimated by the State Department of Fisheries per fish pond was 660kg for a pond measuring 300m^2. There is therefore room for expansion of fish farming in all counties and at maximum efficiency. Fish farming production could be improved by 16,017 tonnes with the same inputs to reach a maximum production of 31,680 tonnes. Kakamega and Kiambu counties could double their ESP production (Figure 4.1).

Figure 4.1: A comparison of optimal and ESP fish production (tonnes) across 38 counties



Source: Author's illustration

Further analysis shows that there are 24 counties that produce fingerlings from private and public hatcheries. However, while 16 have a surplus production, the fingerling production in 8 counties could not produce the fingerlings required for fish farming then. Water availability and an area that has a riparian or near the

Indian Ocean were some of the preconditions for a constituency to qualify for fish farming. Analysis on water access across the counties shows that the main sources of water for the best performing counties were spring, well and borehole (58%), stream (24%) and piped water (18%). All the counties targeted were rural except Nairobi County.

5. Conclusions and Recommendations

5.1 Conclusions

The results show that the ESP was implemented uniformly with the same allocations per constituency and same inputs. However, counties lie in different agro-ecological zones with different economic, social and cultural factors, and efficiency cannot be the same. Overall, 88.7 per cent pond construction was achieved. However the quantity of fish produced was only 49.4 per cent of the target. Busia, Nairobi, Nandi and Tana River counties met the exact target of the fish ponds that were to be constructed. Fourteen (14) counties surpassed the target while the remaining 20 did not meet the target. This could be explained by the varying cost of labour across the counties. The different number of ponds hence the area under fish farming in a county had an effect on the total fish production in the county.

Out of the 38 counties, 60.5 per cent were below the overall efficiency level. With all the targeted ponds constructed and its level of efficiency, Lamu County can improve fish production by 72.8 per cent and 23 counties can also improve by more than 50 per cent. At optimal production, the country would harvest 31,680 tonnes of fish. Efficiency has been linked to farm size in literature and from the results.Kiambu County, which was most targeted with 9 constituencies, was 0.49 (49%) relatively inefficient compared to Lamu County, which was most efficient and only had 2 constituencies. One can therefore conclude that a large number of fish farmers who needed training and demonstrations on fish farming may not have been reached by the fisheries extension staff at the onset of the programme.

Most counties (63.2%) have either public and/or private hatcheries for fingerling production. The fingerlings were sourced from both public and private hatcheries and while the value of the fingerlings were used in this study, it is possible to have varying sizes and weight of fingerlings, and this has an effect on the harvested fish given the same production duration. The fingerlings were supplied to the farmers at the rate of 1,000 fingerlings per 300m^2 fish pond. However, there are no statistics on the survival rate of the fingerlings, and this would have an effect on efficiency if all the fingerlings do not survive to maturity.

Contrary to the preconditions for the fish farming intervention, the lake, pond or dam were not major sources of water for any of the counties. Kisumu, Kilifi and Homa Bay counties were among the bottom five in terms of efficiency. This could be interpreted to mean that the population in these counties preferred to catch wild fish from the lake, Ocean and dams other than farm fish. However, Lamu County, which is near the Indian Ocean, has challenges of fishing in the high seas. The CIDP identifies some of the fishing challenges to be increased insecurity in the high seas as a result of piracy, in addition to the other challenges facing the fishing industry in Kenya, for example, lack of ready markets for fish, lack of storage facilities and lack of modern fishing gear. The challenges may have moved part of the fishing community into fish farming as an alternative source of fish in Lamu.

5.2 Policy Recommendations

The efficiency of 23 counties out of the 38 counties is below the overall efficiency, and this can be improved to increase fish farming production by 50 per cent.

Counties near large water bodies such as lakes and rivers where farmers can hunt fish need a different approach to fish farming to reduce over-dependence on hunting for fish. Kenya can borrow from Egypt and Nigeria, the leading fish farming producers in Africa, an approach which is both an intervention by the Government and a market-led approach to increase fish production and provide an incentive for the fish farmers to produce for the market.

Public hatcheries for fingerling production need to be developed in the counties without any, and necessary conditions such as improved roads and provision of hauling tanks with aeration or oxygen put in place for the movement of fingerlings from the surplus to the deficit and non-producing counties. The 65 per cent efficiency score in Murang'a County could be improved if there was a public or private hatchery for fingerling production.

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