KWAME NKRUMAH UNIVERSITY OF SCIENCE
AND TECHNOLOGY, KUMASI, GHANA

OPTIMISATION OF PROFIT IN THE ARTISANAL MARINE FISHING: A CASE STUDY OF SEKONDI FISHING HARBOUR.

PRESENTED BY

Cynthia Ama Mensah

(MSC. INDUSTRIAL MATHEMATICS, PG3015109)

THESIS SUPERVISOR

DR. S. K. AMPONSAH

CHAPTER ONE

1.0 INTRODUCTION

This chapter deals with the background of the study, the objectives of the study, justification of the study, statement of problem, methodology and limitations of the study.

1.1 BACKGROUND OF THE STUDY

The importance of the fisheries sector in the socio-economic development of Ghana cannot be overemphasised. With a marine coastline of five hundred and fifty (550) kilometres stretching from Aflao in the East to Half Assini in the West, the fishing industry plays a major role in sustainable livelihoods and poverty reduction in several households and communities. The sector is estimated to contribute about 3.9 per cent of the nation's Gross Domestic Product (GDP) and eleven (11) percent of the Agriculture GDP (GSS, 2008 Budget). For a long time, fish has remained the preferred and cheapest source of animal protein with about seventy five (75) per cent of total annual production being consumed locally.

In Ghana the average per capita fish consumption is said to be around 20-25kg, which is higher than the world average of 13kg. Importantly, as much as 60 per cent of animal protein in the Ghanaian diet country- wide is thought to be from fish, which accounts for 22.4 per cent of household food expenditures. As noted in an address by the Minister for Fisheries at the 2007 'Meet the Press1' Series, held on August 28th 2007, "…the Country has fish production potential that is latent. We have good soil and a large expanse of water bodies, a resource, which needs to be harnessed to the optimum. In fact, ten (10) per cent of the entire land surface of Ghana is covered by water. Also in terms of human capacity, we also have a fairly good stock of expertise and know how in the Country".

The economy of Ghana is basically agricultural. In other words, the agricultural sector dominates the economy. Ghana like other less developed countries produces and exports raw materials and mostly imports finished goods from the industrialised countries.

Export commodities include cocoa, gold and timber, which are referred to as traditional exports. Other exports include non traditional export such as pineapples, yam, sheanuts, banana, salt, etc. Ghana was the world's leading producer and exporter of cocoa since the turn of the century up to 1978. Ghana is now in the third position after La Cote D' lvorie and Brazil. The economy of Ghana, for that matter, is referred to as a mono-cultural economy. This means that the economy relies on the exportation of raw and semi-processed materials only. Thus, the importance of agricultural sector cannot be over emphasized.

1.1.1 CONTRIBUTION OF AGRICULTURAL SECTOR TO THE ECONOMY OF GHANA.

The agricultural sector is very important to the economy of Ghana because of its immense contribution to the development of the economy. According to an Institute of Statistical, Social and Economic Research (ISSER), 1992 report, the agricultural sector contributed the highest to gross domestic product (GDP). The annual contribution to GDP was the highest between 1980 and 1983 with an average of about 57%. But trend changed in 1992, when it lost its position to the service sector as the largest contributor to the GDP. A contribution of 42.2% was recorded by the agricultural sector in that year And this reduce to 39.1% in 1994. The proportion of economically active people engaged in the sector in 1994 was about 47.5% of the labour force. Agricultural sector is the only sector that produces food to feed not only the rural dwellers but also those in the urban centres.

1.1.2 CLASSIFICATION OF THE AGRICULTURAL SECTOR

The agricultural sector can be divided into six sub sections namely; food crops, export crops, industrials crops, forestry, livestock and fisheries. It is imperative to throw more light on fisheries since this study concentrates on marine fishing and also the show the importance of the sector to the economic development of Ghana, which earned the sector a whole ministry set up for it development and management (ministry of fisheries).

The total fish catch comes from two main sources namely marine and inland rivers and lakes. Inland fishing is done in lakes, lagoons and river in the country. The fishing activities in the land waters are traditional and on small-scale bases.

Ghana has been a regional fishing nation with a long tradition of a very active fishing industry dating back to as early as the 1700s and 1800s when Fante fishermen embarked on ocean fishing along the coast of Ghana. Bounded on the south by the Gulf of Guinea, Ghana has five hundred and fifty (550) kilometre coastline and a total continental shelf area of about twenty four thousand, three hundred(24,300) square kilometres to support a vibrant marine fishing industry. Ghana also has a system of rivers, lagoons and lakes that form the basis of an inland fisheries industry. Indeed, Fantes are reported to have been fishing in the coastal waters of Benin Republic and Cote d'Ivoire since the early 1900s (Atta-Mills et al, 2004). The first Ghanaian fishermen are believed to have arrived in Nigeria in 1916 (Overa, 2001) and in Liberia in the 1920s (Haakonsen, 2001). From there, Ghanaian fishermen extended to Senegal and as far as the Republic of Congo by the 1940s. By the early 1950s, the development of a semi-industrial fishing presence in foreign waters had established Ghana as a fishing power throughout West Africa (Agbodeka, 1992). However, this growth in the fishing sector was stalled from the 1970s to 1980s as economic conditions in Ghana deteriorated. The fishing industry in Ghana started as an artisanal fishery with very simple and inefficient gears and methods operating close to coastal waters, lagoons, estuaries and rivers

Marine fishing in Ghana consist of four main fishing fleets-the artisanal (canoe), in shore (semi industrial), industrial and tuna fleets. These four fleets can be classified into two types. According to Huq (1989) “the fishing industry is characterised by technological dualism, with large companies such as the state fishing company and Mankoaze fisheries using trawlers co-existing with traditional fishermen who depend heavily on canoes”. In other words the technology of the marine fishing industry is classified into Morden and traditional technologies. The most important in term of foreign exchange is the tuna fleet with annual fish-catch ranging from 50,000 to 90,000 metric tons and yield between US $ 30 to40 million dollars annually (FAO, 1998). However, the most important in terms of employment and food is the artisanal fishing sub-sector, which is conceded as the back bone of the marine fishing (Isaka, 2003). The annual fish catch from the artisanal fishing contributes to between 70% and 80% of the total annual marine catch (FAO, 1998). Artisanal fishing is a seasonal business and is very much dependant on the upwelling of the Gulf of Guinea. Artisanal fishing is practised along the coast of Ghana. It is most common along the shores of Western, Central, Grater Accra and Volta Regions and thus in 189 villages in Ghana.

1.1.3 THE ROLE OF THE FISHING INDUSTRY

(i) **Food security**

Fish is recognised as the most important source of animal protein in Ghana and is consumed by most people in all regions of the country from the rural poor to the urban rich. Various species of marine and inland fish are available in a variety of different product forms and can be bought in quantities to suit the buying power of the consumer. It provides the consumer with about 60 per cent of his or her animal protein intake. Although current information is not available, average per-capita consumption of fish is thought to be high - at between 20 and 25 kg - the world average is 13 kg. In 1987 marine fish contributed 85.5 per cent and inland fish 14 percent of per capita consumption (Vanden Bossche and Bernacsek, 1990). It makes up 22.4 per cent of food expenditure in all households and 25.7 per cent in poor households and is thus a very significant part of the diet (Campbell and Townsley, 1995).

(ii)**Poverty Reduction**

The role of the sector in terms of poverty reduction is very important. Many poor and vulnerable people rely on the fisheries sector either directly or indirectly for their livelihoods. Post-harvest fisheries activities clearly provide a wide range of full-time and seasonal livelihood opportunities to many vulnerable people. According to Mensah et al 2001, in spite of the difficulties faced by post-harvest operators and fishers on the Volta Lake, there is considerable internal migration to the area, especially from coastal communities that are faced with declines in production. New entrants take up fisheries associated activities, suggesting that fisheries offer a fall-back livelihood strategy for many displaced from other activities in other areas.

(iii) **Employment**

The fishing industry provides employment for many rural and urban people in Ghana. It has been estimated that about ten per cent of the population is involved in the fishing industry from both urban and rural areas and women are key players in post harvest activities. The sector is also important from a gender perspective. Men are involved in fish harvesting, undertaking the main fishing activities in the artisanal, semi-industrial and the industrial sectors while women are the key players in on-shore post-harvest activities, undertaking fish processing and storage and trade activities. Many are also engaged in the frozen fish distribution trade as well as marketing fish within and outside the country. It is estimated that a total of 500,000 fishermen, fish processors, traders and boat builders are employed in the Fisheries Sector. These people, together with their dependents, account for about 10 per cent of the population (Afful, 1993; Anon, 1995; Quartey et al., 1997). A canoe census conducted for the marine fisheries in 2001 estimated the number of artisanal fishermen at 120,000 (Bannerman et. al., 2001).

1.2 STATEMENT OF THE PROBLEM

The artisanal marine as well as other marine capture in the study area, like any other parts of the country, is faced with numerous problems, which include high cost of fishing inputs like nets, ropes, fuel and outboard motors. Another problem is lack of capital, lack of infrastructural facilities like cold stores, trade policies, globalization of the fishing industry, dominance of Chinese and European distance water fleets over exploitation of stocks, use of destructive methods of fishing and increased price of petroleum product on the Ghanaian market have negative impact on fish production. Moreover, government polices and economic reforms in other sectors of the economy have contributed negatively on the fishing industry and attitudes and low educational background of fishermen had also impacted negatively on the contribution of the sector to the economic development of the country as well as the Sekondi (study area) as a whole. Despite these problems, the contribution of the industry to the district in particular and the nation in general in terms of employment, income and revenue generation, protein intake and raw materials cannot be over emphasized. Although the marine fishing in the study area is perennial activity, the bumper harvest period is from July to November. Sometimes the bumper period last for only three months, however, during the bumper or peak season, there is a reduction in production cost. What is surprising is that during the lean or dry season the fishermen really go fishing or cast their nets but in most cases they only make little or no catch at all. Sometimes they stay ashore for a week or two claiming that there is no fish in the sea and in this period fishing groups or units using outboard motors naturally incur more cost. Examining the activities of these fishing groups, it becomes a serious concern of the researcher to question the viability of the marine fishing in the Sekondi as far as incomes earned from fishing are concerned.

1.3 OBJECTIVES OF THE STUDY

The primary aim underpinning this research is to explore the viability of artisanal marine fisheries in Ghana generally, and in Sekondi particular.

The study has the following specific objectives:

(i) to study the existing fishing units (gear) and resource constraints of the study area.

(ii) to formulate linear programming model to maximize the profit of fishing gears (Ali poli/Watsa and the Hook and Line).

(iii) to find out the most viable and profitable fishing units.

1.4 JUSTIFICATION OF THE STUDY

The artisanal marine fishing contributes a lot to the socio-economic development of Ghana in terms of employment, food security in a form of protein intake and also for poverty reduction in both rural and urban communities. But the industry faces a lot of challenges including high input cost, lack of infrastructure, destructive fishing methods and dominance of foreign fleets. The successful completion and recommendations of this research well considered, fishermen in Sekondi will adopt a standard mathematical model for their fishing activities.

1.5 SIGNIFICANCE OF THE STUDY

The result of this scientific-based profitability analysis may be of significance in the following ways as stated below:

(i) It will impact positively by reducing cost of fishing operation

(ii) It could lead to improvement in the technology of fishing units or gears

(iii) Other fishing groups across the country could use the model as basis to improve their fishing operation.

(iv) When the problem is well addressed and the model adopted and improved countrywide, Ghana's national output from the fishing industry will increase tremendously.

(v) The research could also be used as a reference material for further studies.

1.6 METHODOLOGY

The data to be collected is purely primary from the Albert Bosomtwin-Sam fishing harbour also known as the Sekondi harbour. The data was obtained from the field through questionnaires and were administered through interviews due to the fact that some of the respondents could not read and write. The data collected related to fuel usage, cost of canoes and other fishing gears, catch per trip in kilograms, price per kilogram, profit per trip etc. The analysis of the data was done using linear programming. Linear programming is a considerable field of optimization for several reasons. Many practical problems in operation research can be expressed as LP problems. Certain special cases of LP, such as network flow problems and multi-commodity flow problems are considered important enough to have generated much research on specialized algorithms for their solution. A number of algorithms for other types of optimization problems work by solving LP problems as sub-problems. Historically, ideas from LP have inspired many of the central concepts of optimization theory, such as duality, decomposition, and the importance of convexity and its generalizations. Likewise, LP is heavily used in microeconomics and company management, such as planning, production, transportation, technology and other issues. Although the modern management issues are ever-changing, most companies would like to maximize profits or minimize costs with limited resources. Therefore, many issues can be characterized as LP problems.

1.7 LIMITATIONS

Like any other academic research, this work was not without constraints. Time and cost posed challenges. The entire research was given a time period. However, time is needed sufficiently well enough for reviewing related literature, understanding methodologies, testing alternative algorithms to select efficient once etc. limited time at the researchers disposal lead to few items being reviewed as literature.

The quality of data not only depends on the amount of time one spend on gathering data but partially on how much money one is prepared to spend in gathering them. The researcher encountered certain difficulties in connection with data collection, the nature of the research requires the researcher to collect data on daily fishing activities at the harbour, lack of cooperation on the part of the fishermen for fear of information could be used for taxing them, no proper records on expenditure etc., limited the study to only two fishing unit, the purse seine which is locally called Ali poli/Watsa (APW) and the hook and line and also to Sekondi fishing harbour instead of the whole country.

1.8 ORGANIZATION OF THESIS

The study is divided into five chapters. The first chapter (introduction) deals with the background of the study, the objectives of the study, justification of the study, statement of problem, methodology and limitations of the study. A literature review which summarizes current philosophies of fishing industry management, along with impacts of technology and metrics used to measure the profitability of marine fishing is described in Chapter Two. The study instrument or methodology for analysis of data is reviewed in Chapter three. In Chapter Four, (data collection and analysis) empirical results of the study are presented. Finally, Summary, conclusions, and recommendations are presented in Chapter Five

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

This section reviews available literature on the artisanal fishing. It commences with a brief of available theories on marine catches. In this chapter, theoretical review of social, economic and biological on some works on cost-benefit ratio analysis and also empirical review on some works will be considered.

2.0.1 ARTISANAL FISHERIES

This is a type of fishery system with an open beach using very basic fishing methods such as the use of dug out boats (canoe) often powered with outboard motors. The use of canoes can be found in almost all 300 landing sites in 200 fishing villages along the Ghanaian coastline It is generally considered small-scale fishing because it is dependent solely on local resources. The artisanal sub-sector consists of about 11,219 traditional canoes and employs a wide range of fishing gear which includes purse seines ("poli/Watsa"), beach seines, drift gill nets (DGN), and surface set nets. Artisanal fishermen also use various forms of bottom set-nets, hook and line ("lagas"). The lagas and the DGN fleet operate beyond the 50 meter depth zone. The lagas are however well equipped with ice, food and fishing aids like fish finders and Geographical Positioning System (GPS). The artisanal sub-sector produces about 70-80 per cent of the total annual volume of marine fish catch comprising mainly of small pelagic fish species and to a much lesser extent some Valuable demersal fish species (Marine Fisheries Research Division, (Ministry of Fisheries)

2.1 THEORETICAL REVIEW

Models are widely used in all fields of endeavour. For instance production functions are helpful in estimating or forecasting the trends in production commodities. The theoretical study done on biological, social and economic aspects on cost benefit is considered as well as the model propounded by Panayotou (1985) on how to determine the profitability as well as the amount of landing by means of parameters like "effort".

2.1.1 BIOLOGICAL THEORIES

Two methods were propounded by (Panayotou, 1985), which are widely known and used, these are the single species, single gear, single community model and multistock multiproduct model. The single species, single gear, single community model placed emphasis on the relationship between "sustainable catch" and "fishing effort". The sustainable catch was defined to be the quantity of fish in terms of weight of biomass, which can theoretically be caught year after year without a change in the intensity of fishing. Fishing effort according to him is a composite index of all inputs employed for the purpose of realizing this catch. A basic production relationship was also established between output and input, but unlike other production relationships, there is no direct relationship between output and fishing effort. Also in The multiproduct and multistock model there is an attempt to measure capacity and capacity utilisation in the multiproduct industry (Bernelt and Fuss, 1985).

When there is a single input held fixed for some time period and other inputs are allowed to vary, then output-based measures capacity and capacity utilisation do not easily extend to the multiproduct case because output and capacity output are no longer scalar (Segerson and Squires,1990). Capacity also becomes problematic when there is more than a single input held fixed or quasi-fixed in time period (Bernelt and Fuss, 1989). This problem in fishing arises even when there is even just one homogeneous stock of capital held fixed because there is also the resource stock.

b) Social considerations

Panayotou talked about fishing development and fishing management. To him, fishery development aims at increasing the exploitation of under-utilized stock by expanding effective effort through allocation of additional labour and capital, technological upgrading, training etc.

c) Economic aspects

Panayotou (1985) wrote about three models under economic aspects: the static constant-price model; the static variable-price model and the dynamic model.

(i) The static constant-price model

Panayotou (1985) used this mode to determine net economic yield by considering total revenue (TR) and total cost (TC). The gross economic yield or total revenue is determined by multiplying the catch of each species at different levels of total fishing effort by its unit price (which is considered to be independent of the size of the catch). Summing up over all species and expressing the resulting aggregate value or total revenue as a function of total fishing effort as;

$$TR = P_1Y_1(E) + P_2Y_2(E) + ...P_nY_n(E)$$
$$= \sum P_iY_i(E)$$

Where Y_i (E) is the catch of species, is expressed as a function of total fishing effort, P_i is the unit price of species i, and n is the number of marketable species in the catch. Fishing costs are then introduced. The determination of the fishing cost is based on the fishing effort which is an index of fishing inputs, such as vessels, engine crew fuel and other operating costs as well as fishing time. Fishing cost (Total Cost) is TC= C.E, where C is the average cost per unit of effort assumed for simplicity sake to be constant. Net economic yield is determined by subtracting total cost from total revenue, that is;

$$\Pi = TR - TC = \sum P_iY_i(E) - C.E$$

Where ∏ is the net economic yield or resource rent.

(ii) **The static Variable-Price Model**

This model is so-called because unlike the constant-price model which assumes independent relationship between unit price and the size of the catch, the static variable-price model assumes dependent relationship between unit price and the size of the catch. Depending on consumer preference and import and export possibilities, the average price of all species combined will be relatively high at low levels of catch and relatively low at higher levels.

The level of catch depends on the fishing intensities so that when the fishing intensity is of low, the level of catches increases leading to a reduction in average price. But when the fishing is high, the level of catch reduces and average price increases.

(iii) **The Dynamic model**

this model talks about dynamic maximum economic yield (DMEY) which is obtained by expanding or reducing effort to the point where the last unit adds to the present value of the stream of future revenue as much as it add, to the present value of the stream costs. The effect of expansion or reduction of fishing effort depends on the fish stock. Profits attract new entrants, losses cause exit and stocks are reduced with entry and increased with exit corresponding changes in net natural growth. Whether an action, such as allowing a fish stock to recover from over fishing, should be taken depends on whether the benefit of waiting exceed the cost of waiting. The crucial determinants of these benefits and costs are the growth rate of the biomass, the discount rate and the rate of depreciation of fishing assets. This model is however not applicable to small-scale fisheries because its application is limited by the complexity of its mathematical formation.

d) Cost-Structure and Profitability Models

Panayotou (1985) used this model to come out with the cost structure by making a distinction between fixed costs (FC) and variable costs (VC) in fishing. In his definition of fixed cost, he added depreciation of the fishing assets and the interest repayments on borrowed capital used for the purchased of these assets. He then estimated fixed cost as:

$$FC = d + r_1 D + r_2 K$$

Where d= depreciation

r_1=interest rate on borrowed capital

r_2=opportunity cost or rate of return

D= total fishing related debt

K= own capital.

Also he estimates depreciation as:

$$d = (P - S) / L$$

He also estimates the variable cost to be the sum of cost of all inputs including labour (L),fuel cost (F), other input (OI) and the opportunity cost of family labour cost (OFL) and is given as:

$$VC = L + F + OI + OFL$$

The component of total cost is then defined between cash and input cost which is given as:

$$TC = FC + VC$$

According to Panayotou, expressing the various costs as a percentage of TC and comparing these percentages between locations, gear types and vessel size may describe the cost structure. He then determined profitability of fishing unit by using profit-operating or gross profit and net profit concepts. The gross profit (GP) is defined by total revenue (TR) minus variable cost (VC) that is:

$$GP = TR - VC$$

Where the gross profit is positive, that is when variable cost are recouped and there is a surplus to defray some of the fixed cost which are paid should the fishing unit operate or not, the fishing unit is expected to continue operating.

2.3 EMPIRICAL LITERATURE

Empirical studies on cost-benefit analysis of fisheries using theories discussed under the theoretical literature. Panaoytou's model has been used by Fernando (1985) to analyse the cost of small-scale fishing operations in Sri Lanka. Because of the fact that empirical investigations have not been done on the cost structure and profitability of different types of fishing operations in Sri Lanka. The study relied on cross-sectional data for only one year because of non-availability of time series data; as a result the general validity of the finding is limited.

At the end of the study, a lot of findings resulted from Fernando (1985) study: among which are that modern boats have the highest level of total annual revenue followed by the mechanized traditional craft, and then non-mechanised traditional craft with the lowest annual revenue. Another finding from the study came out that there was positive economic profit from the use of all the types of fishing technology and that was a sign of long –term viability. Moreover, the returns from investments of comparable risk were considered to be profitable when compared to current rate of return. Again, it came out that non-mechanised craft generally have higher rates of return than mechanised traditional or modern craft.

At the end of the study, it became explicitly clear that fishermen in Sri Lanka are already earning incomes substantially above their opportunity cost, even after inputting the unsubsidized market value of craft and gear in their cost.

A survey conducted in Rwanda showed that many small-scale fish farmers consider fish to be a cash crop.

Findings by Engle et al., (1993) indicate that fish farming provides cash to a family in addition to supplementing the diet of Rwandan farmers. Molnar et al., (1991) and Engle et al., (1993) showed that fish production represents the main cash crop for over 50% of group members and private pond holders. Previous studies used partial farm analyses and economic engineering techniques to assess costs and return of fish production (Moehl, 1993; Engle et al., 1993).

In 1995 and 1997, FAO in co-operation with fisheries research institutions and administrations in selected countries in Asia, Africa, Latin America and Europe carried out an empirical study on the economic and financial viability of the most common fishing craft and gear combinations. Information on the level of exploitation of fisheries, resources as well as government policies on fisheries management, financial services, etc was also collected. Key and knowledgeable informants of fishing units were selected for their perceived responsiveness, which helped to cross check and compared information complete with secondary data, national fisheries and other statistics.

In another study by Foday and Karin (1997) on cost and earnings in artisanal fisheries using seven countries (Benin, Cameroun, Cote d' Ivoire, The Gambia, Guinea Mauritania and Senegal), fishing units in these countries were monitored for over a year. In the study, structured questionnaires were used to collect information on operation activities, expenses, catches and income. According to them the investment cost varied according to the fishing technique both within and across countries. These costs were highest in purse seine fishing $8337 in The Gambia to $23539 in Cameroun. The lowest investment cost were in gillnets fishing varying from$2835 in Senegal to $7318 in Guinea. Net revenue was calculated using the total sales of fishing units minus their common costs. The profitability of a fishing unit was estimated as the ratio of the yearly net revenues of boat owners to the investment cost. Foday and Karin realised that the profitability rate is not only positive but also significantly high for fishing units. In the analysis on the basis of the various profitability measures, they concluded that artisanal fishing is financially attractive and that owners do get considerable profit varying with type of fishing gear.

Cassel (1990) made a study on the cost and earnings on Ghanaian canoe fisheries; five different types of canoes (Ali, Poli, Watsa Line and DGN) were used. This study was based on field works. Cost and earnings booklets were distributed in February 1990 to the secretary of the Gbese Fishermen's Association in Accra. Interviews were then carried out between; the profitability of each type of canoe was calculated by subtracting the annual total cost which is made up of trip expenses, crew share, vessel expenses and depreciation from the annual total revenues. The net present value of the various types of canoes on the study showed positive values, this is an indication of viability. The increase in fishers and canoes in the industry appears to imply that the artisanal sector is a growing source of employment. The earnings for each fisher are based on a given proportion of the value of the catch. As the number of fisher pre canoe increases the earnings per fisher decreases; when catches per canoe also decreases, earnings per fisher further erodes.

Haakonsen (1988) in his assessment of economic viability of canoe fishing argues that canoe fishermen must be well off to afford the high cost of engines and put up concrete houses. This creates the impression that canoe fishermen make enough profit.

Hernaes (1999) put it that fishermen live in a 'state of penury'; Isaka (2003) concluded that most fishermen purchase equipment on credit basis. During his fieldwork the fishermen agreed that fishing used to be a profitable venture, but due to worsening economic situations.

Afful (1993) noted that artisanal fishing even at the traditional level is heavily import dependant and suffers from the impact of structural adjustment policies being embarked upon by African countries.

Odoi-Akersie (1986) in his economic study of the canoe fishing in Ghana is quoted saying that the fact that artisanal sector continues to operate in spite of the stiff competition from the industrial sector suggests that artisanal fishermen have been operating at an element of profitability however small it might be.

Afful (1997) assessing the techno-economic viability of the fishing in Ghana came out with the following findings on profitability of the artisanal fishing subsector. His assessment revealed that profitability in the artisanal sector varies from one fishing unit to the other. The most profitable, according Afful was the Hook and Line with 52% return on investment.

2.4 TECHNOLOGY/EQUIPMENT

The marine fishing industry Ghana commenced as artisanal fishing industry in which dugout canoes were used. This is confirmed by a study conducted by (Kwei, 1974). They discovered that by the early part of 1950, the whole fishing industry in Ghana was artisanal comprising about 8000 dugout canoes, which were about 10359 in number and the largest canoe population recorded in 1966.

Artisanal fishing was characterised by the use of crude equipments not until the introduction of modern fishing gears. The crude equipment included baskets, traps, sails made from palm tree matting and bark cloth. It was an era in which little technology was in use. The arrival of European trader marked the commencement of fishing by means of “hook”. A boatyard in Sekondi in 1952 for demersal fishing to operate effectively and a charter party system was introduced. The artisanal sector has gone through revolution or innovations what Hernaes (1991) refers to as “outboardnisation”. This is basically the mechanisation of canoe fleet by affixing outboard motors on them. This was initiated by the Fisheries Department in 1959; outboard motor engine was introduced for commercial purpose in 1960. The use of motors was aimed at extending operational range, increase catch efficiency and increase income. In spite of the positive effect of the motorisation, it stands out as the most important element to the fishermen and also a determinant of profit levels pre fishing trip. The inception of the outboard motor in Ghana also propelled the development of the pre-mix fuel by the Tema oil refinery. It is the cheapest fuel on the market as compared to petrol and diesel.

Fishing gear also saw some development since 1890. These gears used by the early artisanal fleet were small in size and varied from village to fisherman. The gears were in sizes of cast nets, gillnets, seine net, trap nets and hand lines.

According to Lawson and Kwei (1974), a rope was made from boosting hemp and twine for nets and pineapple leaves until the increase in the importation of twine at the end of the 19^{th} century. The seine net and a type of gillnet known locally as “ali” net was introduced in to the Ghanaian artisanal fishing about the middle of the 19^{th} century.

A surrounding net locally ‘Watsa’ was also introduced which was later developed fully into a purse seine net, which saw another development into a new purse seine net called ‘poli’. It was later discovered that the ‘ali, poli and Watsa uses almost the same gear and method of fishing which is now known as the APW by the Fisheries Research Department.

Hook and line gear is usually long ropes carrying several hooks. The hooks are baited with small low priced fish. This unit uses medium size dugout canoes (6-12m) and fitted with insulated boxes containing ice. The fishing operation takes place inshore at depth of between 10 and 20 meters at locations with high rock formation or around coral reefs (Afful, 1997).

2.5 PROCESSING OF FISH CATCH

Landed fish is immediately sold in 30-50kg or large aluminium creates by the fishermen to the fish "mammies" who operate all handling, processing and marketing. A small portion is sold for fresh consumption and the remaining is smoked, sun-dried or salted by ether the "mammies" or their relatives.

2.6 PROFIT MAXIMISATION

Optimization techniques are applied to find out whether resources available are effectively utilized in order to achieve optimum profit from the activities of the firm, Kailasam (2001). There should be consistency in the use of various resources and the mix should be such that it brings down the cost for ensuring profit. Therefore, it is the duty of the management to exercise control over the resources and to see that the resources are effectively utilized. Similarly, organisations in general are involved in manufacturing a variety of products to cater the needs of the society and to maximize the profit. While doing so, they need to be familiar with different combinations of product mix which will maximize the profit. Or alternatively, minimize the cost of production. Since, these units are managed by experienced but not professionally trained people, Murugan (2001); they do not have the advantage of applying modern tools of management. But, in an era of globalization, these village industries mostly of tiny and small scale in nature cannot neglect the use of modern scientific and proved techniques in taking decisions pertaining to production and sale of different products which would enable them not only to earn profit but also help them provide better service to the society.

The techniques such as ratio analysis, correlation and regression analyses, variance analysis, optimization and projection methods can be adopted for ascertaining the extend of resource utilization and selection of practically viable and profitable product mixes by taking in to account all possible constraints, Tulsan and Pandey(2002). The ratio analysis helps to evaluate the performance of the organization in terms of liquidity, solvency, productivity and profitability, Manivel and Murugan (2005). The comparisons of the various ratios of the firm with that of the standards already laid down will help in the identification of the weak areas. Application of correlation and regression techniques helps to ascertain whether any relationship exists between the different variables such as expenditures, income, liabilities and assets. This helps to ascertain the reasons for very poor inter connection between the various variables, and guide better use of the available resources.

Linear programming is a mathematical technique used for determining the optimum allocation of scare resources for obtaining a particular objective, Harvey (2001). Although allocating resources to activities is the most common type of application, linear programming has numerous other important applications as well. Production allocation model, blending model and product mix model are some of the most common areas of applications. In product mix selection, the decision maker wishes to determine the level for a number of production activities during the specified period of time. These levels are constrained by technological or feasibility considerations, given in the form of linear equalities or inequalities, subject to these restrictions management seeks to optimize a particular objective function, Hiller and Lieberman (2002).

The expenditure incurred or income derived depends upon the volume of business. For example, the material cost incurred by the firm depends upon the price per unit of material and number of units purchased Aniru and Munji (2003). Similarly, labour cost also depends upon the cost of labour per unit and total labour hours required or utilized. Therefore, it is possible to extend the same idea to other types of expenditures and incomes as well. When decisions are made in an intuitive manner without applying modern appropriate tools and techniques optimum use of materials, labour and other overheads is not practically possible. There may be excessive use of materials, and other overheads. All these would lead to additional cost and, thus, would result in poor profitability. Therefore, the firms dealing in multi-products could gain a lot by applying modern tools in deciding their product mix in order to minimize the cost and there by the profit, Stanley (1985).

Non - Government Organisations (NGOs) also known as voluntary agencies normally provide services in fields such as health, agriculture, child labour and child welfare, women education and generation of public awareness (Mohan, 1991). Trusts with Gandhian ideology have however from the beginning been taking up economic programmes with a view to provide employment to semi skilled and unskilled labourers in the semi urban and rural areas, Laxmidass (1991). The economic programmes in such organizations are implemented with the fundamental objective of alleviating poverty through provision of employment. They run enterprises without profit motive. The available studies on financial performance and profit planning are mostly confined to private and public sector and to some extent to the co-operative sector enterprises, Manahar (2002). The scholars are not paying sufficient attention and not showing interest in studying enterprises run by NGOs for the reason that they are non-profit organisations Manivel

CHAPTER THREE

METHODOLOGY

3.0 INTRODUCTION

Mathematical programming is a technique for solving certain kinds of problems — notably maximizing profits and minimizing costs subject to constraints on resources, capacities, supplies, demands, and the like. An important characteristic of the industrial world is the continuous improvement of its operations. Any problem in design, operation and analysis of manufacturing plants and industrial processes can be reduced, in the final analysis, to the problem of determining the maximum value of a function of different variables. Many methods have been introduced to determine optimum processes or policies, Optimization methods provide efficient and systematic means for choosing from among infinite solutions, occurring in problems with a large number of decision variables. Optimization techniques can encompass analytical and numerical methods, which be chosen as a function of the nature of the objective function, and the restrictions which define the model.

This chapter will focus on the formulation of a production problem and the development of an algorithm for profit maximization (minimizing cost) of fish catch (production), data collection sources and methods of data collection.

3.1 DATA COLLECTION

The data collected is primary and secondary from the Albert Bosomtwin-Sam fishing harbour also known as the Sekondi harbour. The data was obtained from the field through questionnaires and were administered through interviews due to the fact that some of the respondents could not read and write. The data collected related to fuel usage, cost of canoes and other fishing gears, catch per trip in kilograms, price per kilogram, profit per trip etc. A purposive sampling technique a non probability method of sampling technique was used to select 40 fishing group made up of 20 samples each from the two fishing unit.

3.2 LINEAR PROGRAMMING (LP)

Linear programming is a considerable field of optimization for several reasons. Many practical problems in operation research can be expressed as LP problems. Certain special cases of LP, such as network flow problems and multicommodity flow problems are considered important enough to have generated much research on specialized algorithms for their solution. A number of algorithms for other types of optimization problems work by solving LP problems as sub-problems. Historically, ideas from LP have inspired many of the central concepts of optimization theory, such as duality, decomposition, and the importance of convexity and its generalizations. Likewise, LP is heavily used in microeconomics and company management, such as planning, production, transportation, technology and other issues. Although the modern management issues are ever-changing, most companies would like to maximize profits or minimize costs with limited resources. Therefore, many issues can be characterized as LP problems.

Linear programming is a subclass of allocation modelling. It is a method of allocating scarce resources to competing activities under the assumptions of linearity. The structure of the problems it deals with is made up of variables with linear relationships with each other. In the LP problem, decision variables are chosen so that a linear function of the decision variables is optimized and a simultaneous set of linear constraints involving the decision variables is satisfied. LP is a generalization of Linear Algebra. It is capable of handling a variety of problems, ranging from finding schedules for airlines or movies in a theatre, to distributing oil from refineries to markets. The reason for this great versatility is the ease at which constraints can be incorporated into the model.

3.2.1 The Basic LP Problem

A LP problem contains several essential elements. First, there are decision variables (x_j), which denotes the amount undertaken of the respective unknowns, of which there are n (j=1, 2 ..., n).

Next is the linear objective function where the total objective value (Z) equals

$c_1x_1 + c_2x_2 + \ldots\ldots + c_nxn$.

Here c_j is the contribution of each unit of x_j to the objective function. The problem is also subject to m constraints.

An algebraic expression for the i^{th} constraint is:

$$a_{i1}x_1 + a_{i2}x_2 + \ldots + a_{in}x_n \leq b_i \text{ (i=1, 2, ..., m)}$$

where b_i denotes the upper limit or right hand side imposed by the constraint and a_{ij} is the use of the items in the i^{th} constraint by one unit of x_j. The c_j, b_i, and a_{ij} are the data (exogenous parameters) of the LP model.

Given these definitions, the LP problem is to choose $x_1, x_2, \ldots, x_n$ so as to

Maximize (Max) $Z = c_1x_1 + c_2x_2 + \ldots + c_nx_n$

Subject to (s.t.) $a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n \leq b_1$

$$a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n \leq b_2$$

$$\vdots$$

$$a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n \leq b_m$$

$$x_1 \geq 0, x_2 \geq 0, \ldots, x_n \geq 0$$

3.2.2 Other forms of the LP Problem

Not all LP problems will naturally correspond to the above form. Other legitimate representations of LP models are:

Objectives which involves minimization instead of maximization i.e.,

Minimize $Z = c_1x_1 + c_2x_2 + ... + c_nx_n$. (3.1)

Constraints which are "greater than or equal to" instead of "less than or equal to"; i.e.,

$a_{i1}x_1 + a_{i2}x_2 + ... + a_{in}x_n \geq b_1$. (3.2)

Constraints which are strict equalities; i.e.,

$a_{i1}x_1 + a_{i2}x_2 + ... + a_{in}x_n = b_1$. (3.3)

Variables without non-negativity restriction i.e., x_j can be unrestricted in sign i.e.,

$x_j \geq 0$ or $x_j \leq 0$. (3.4)

Variables required to be non-positive i.e.,

$x_j \geq 0$. (3.5)

3.2.3 The Standard Form of LP

Linear programme can have objective functions that are to be maximized or minimized, constraints that are of three types (≤, ≥ or =), and variables that have upper and lower bounds. An important subset of the possible LPs is the standard form LP.

A standard form LP has these characteristics:

- The objective function must be maximized,
- All constraints are ≤ type,
- All constraint right hand sides are nonnegative,
- All variables are restricted to nonnegative.

In an algebraic representation, a standard LP form with *m* functional constraints and *n* variables is given as:

- Objective function:

  Maximize $Z = c_1x_1 + c_2x_2 + \ldots + c_nx_n$

where the c_j, the coefficients in objective function represent the increase or decrease in Z, the objective function value per unit increase in x_j.

The *m* functional constraints take the form:

$$a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_{1n} \leq b_1$$

$$a_{12}x_1 + a_{22}x_2 + \ldots + a_{2n}x_{2n} \leq b_2$$

$$\begin{matrix} . & . & . & . \\ . & . & . & . \\ . & . & . & . \end{matrix}$$

$$a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n \leq b_m$$

where b_m are the resource limits, and the a_{mn} are the coefficients of the functional constraint equations, expressing the usage resource *m* consumed by activity *n*.

3.2.4 Terminology

The function to be maximized or minimized is called the objective function. A vector, ***x*** for the standard maximum problem or ***y*** for the standard minimum problem, is said to be feasible if it satisfies the corresponding constraints. The set of feasible vectors called the constraint set. A linear programming problem is said to be feasible if the constraint set is not empty; otherwise it is said to be infeasible. A feasible maximum (minimum) problem is said to be unbounded if the objective function can assume arbitrarily large positive (negative) values at feasible vectors; otherwise, it is said to be bounded. Thus there are three possibilities for a linear programming problem. It may be bounded feasible, it may be unbounded feasible, and it may be infeasible. The value of a bounded feasible maximum (minimum) problem is the maximum (minimum) value of the objective function as the variables range over the constraint set. A feasible vector at which the objective function achieves the value is called optimal.

3.2.5 Standard Maximization Problem

A linear programming problem is in **standard form** if it seeks to maximise the objective function Maximize $Z= c_1x_1+c_2x_2+\dots + c_nx_n$,subject to the constraints

$$a_{11}x_1 + a_{12}x_2 + \dots +a_{1n}x_{1n} \leq b_1$$

$$a_{12}x_1 + a_{22}x_2 + \dots + a_{2n}x_{2n} \leq b_2$$

$$\begin{array}{cccc} . & . & . & . \\ . & . & . & . \\ . & . & . & . \end{array}$$

$$a_{m1}x_1 + a_{m2}x_2 + \dots + a_{mn}x_n \leq b_m$$

where x_i and $b_i \geq 0$, after adding slack variables, the corresponding system of constraint equation is

$$
\begin{array}{l}
a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n + s_1 \qquad = b_1 \\
a_{21}x_1 + a_{22} + \ldots + a_{2n}x_n \qquad + s_2 \quad = b_2 \\
\vdots \qquad\qquad \vdots \qquad\qquad \vdots \qquad\qquad \vdots \\
a_{mi}x_i + a_{m2}x_2 + \ldots + a_{mn}x_n \qquad + s_m = b_m
\end{array}
$$

Where $S_i \geq 0$

3.2.6 Economic Assumptions of the Linear Programming Model

In formulating this problem as a linear-programming model, one must understand the economic assumptions that are incorporated into the model. Basically, one assumes that a series of linear (or approximately linear) relationships involving the decision variables exist over the range of alternatives being considered in the problem. For the resource inputs, one assumes that the prices of these resources to the firm are constant over the range of resource quantities under consideration. This assumption implies that the firm can buy as much or as little of these resources as it needs without affecting the per unit cost. Such an assumption would rule out quantity discounts. One also assumes that there are constant returns to scale in the production process. In other words, in the production process, a doubling of the quantity of resources employed doubles the quantity of output obtained, for any level of resources. Finally, one assumes that the market selling prices of the two products are constant over the range of possible output combinations. These assumptions are implied by the fixed per-unit profit contribution coefficients in the objective function. If the assumptions are not valid, then the optimal solution to the linear-programming model will not necessarily be an optimal solution to the actual decision-making problem. Although these relationships need not be linear over the entire range of values of the decision variables, the linearity assumptions must be valid over the full range of values being considered in the problem.

3.2.7 Linear Programming Methods

There are several methods of solving LP Problems. These are:

(i) the Graphic method

(ii) the Vector method

(iii) the Systematic Trial-and-Error method

(iv) the Interior Point methods (Primal-Dual) and

(v) the Simplex method

3.2.8 Graphical solution of the linear programming problem

Various techniques are available for solving linear-programming problems. For larger problems involving more than two decision variables, one needs to employ algebraic methods to obtain a solution. For problems containing only two decision variables, graphical methods can be used to obtain an optimal solution. For this approach, graph the feasible solution space and objective function separately and then combine the two graphs to obtain the optimal solution.

3.2.9 Primal-Dual Interior Point Methods for Linear Programming

In linear programming, the problem to solve in standard form is:

$$\text{Minimize} \quad c^T x$$

$$\text{subject to } Ax = b \qquad x \geq 0,$$

where c, x ε R^n, b ε R^m and A is an m × n matrix. This problem is called the primal problem. Associated with it, is the dual problem, which can be formulated as:

$$\text{maximize} \quad b^T y$$

$$\text{subject to:} \quad A^T y \leq c,$$

or, in standard form maximize $b^T y$

subject to $A^T y + s = c, \quad s \geq 0,$

3.2.10The simplex method

For linear programming problems involving two variables, the graphical solution method is convenient. However, for problems involving more than two variables or problems involving a large number of constraints, it is better to use solution methods that are adaptable to computers. One such method is called the simplex method**,** developed by George Dantzig in 1946. It provides us with a systematic way of examining the vertices of the feasible region to determine the optimal value of the objective function.

The simplex method is used for this model because it is a step-by-step procedure for moving from corner point to corner point of the feasible solution space in such a manner that successively larger (or smaller) values of the maximization objective function are obtained at each step. The procedure is guaranteed to yield the optimal solution in a finite number of steps. The corner point is point in the feasible region which intersects at two or more boundary lines. It is acknowledged that if an optimal solution to the objective function exists, it must occur at a corner point of the feasible region. The simplex method determines:

- The combination of factor inputs that maximizes profit or minimizes cost for the organisation
- The maximum profit or value of the organisation or the minimum cost
- Shadow prices for resources or inputs used in the organisation.

3.3 Steps in Formulating A Linear Programming Model

Linear programming is one of the most useful techniques for effective decision making. It is an optimization approach with an emphasis on providing the optimal solution for resource allocation. How best to allocate the scarce organisational or national resources among different competing and conflicting needs (or uses) forms the core of its working. The scope for application of linear programming is very wide and it occupies a central place in many diversified decisional problems. The effective use and application of linear programming requires the formulation of a realistic model which represents accurately the objectives of the decision making subject to the constraints in which it is required to be made.

3.3.1 The basic steps in formulating a linear programming model are as follows:

Step I. Identification of the decision variables. The decision variables (parameters) having a bearing on the decision at hand shall first be identified, and then expressed or determined in the form of linear algebraic functions or in equations. Thus formulate the problem in the standard manner. After, the inequalities have to be converted to equalities by introducing slack variables. These should be balanced or symmetrical so that each slack variable appears in each equation with a proper co-efficient.

Step II. Identification of the constraints. All the constraints in the given problem which restrict the operation of a firm at a given point of time must be identified in this stage. Further these constraints should be broken down as linear functions in terms of the pre-defined decision variables. Thus Design an Initial Programme (a Basic Feasible Solution), Design the first programme so that only the slack variables are included in the solution. Place this programme in a simplex table. In the objective row above each column variable, place the corresponding coefficient of that variable from step 1.

Table 3.1 Tableau (Basic Solution)

	c_j	c_1	c_2	…	c_n	0	0…	0		
Basic		x_1	x_2	…	x_n	S_1	$S_{2\ldots}$	S_m	b_j	RHS(b_j/a_{ij})
S_1	0	a_{11}	a_{12}	…	a_{1n}	1	0 …	0		
S_2	0	a_{21}	a_{22}	…	a_{2n}	0	1 …	0		
.	.	.	.	.	.	.	.	.		
.	.	.	.	.	.	.	.	.		
.	.	.	.	.	.	.	.	.		
S_m	0	a_{m1}	a_{m2}	…	a_{mn}	0	0 …	1		
z_j	Z_1	Z_2	Z_{mn}	...	Z_{11}	Z_{12}	...	Z_{1m}		
$c_j - z_j$	$c_1 - z_1$	$c_2 - z_2$	$c_{mn} - z_{mn}$	...	$c_{11} - z_{11}$	$c_{12} - z_{12}$	...	$c_{1n} - z_{1n}$		

Test and revise the table

Calculate the net-evaluation row. To get a number in the net-evaluation row under a column, multiply the entries in that column by the corresponding numbers in the objective column (Z_j), and add all the products (C_j), then subtract this sum from the number listed in the objective row (Z_j) at the top of the column. Enter the result in the net-evaluation row under the column. Examined the entries in the net-evaluation row for the given simplex tableau. If all the entries are zero or negative, the optimal solution has been obtained

Step III. Identification of the objective. In the last stage, the objective which is required to be optimized (i.e., maximized or memorized) must be dearly identified and expressed in terms of the pre-defined decision variables. Obtain the optimal solution by repeating step 3 until an optimal solution has been derived.

The general mathematical programming problem we will treat is:

$$\begin{array}{ll} \text{Optimize} & F(X) \\ \text{Subject To (s.t.)} & G(X) \ \varepsilon \ S_1 \\ & X \ \varepsilon \ S_2 \end{array}$$

Here X is a vector of decision variables. The level of X is chosen so that an objective is optimized where the objective is expressed algebraically as F(X) which is called the objective function. This objective function will be maximized or minimized. However, in setting X, a set of constraints must be obeyed requiring that functions of the X's behave in some manner. These constraints are reflected algebraically by the requirements that: a) G(X) must belong to S_1 and b) the variables individually must fall into S_2.

3.3 ADVANTAGES OF LINEAR PROGRAMMING

Advantages of Linear Programming .Following are some of the advantages of Linear Programming approach

1. Scientific Approach to Problem Solving. Linear Programming is the application of scientific approach to problem solving. Hence it results in a better and true picture of the problems-which can then be minutely analysed and solutions ascertained.

2. Evaluation of All Possible Alternatives. Most of the problems faced by the present organisations are highly complicated - which cannot be solved by the traditional approach to decision making. The technique of Linear Programming ensures that'll possible solutions are generated - out of which the optimal solution can be selected.

3. Helps in Re-Evaluation. Linear Programming can also be used in .re-evaluation of a basic plan for changing conditions. Should the conditions change while the plan is carried out only partially, these conditions can be accurately determined with the help of Linear Programming so as to adjust the remainder of the plan for best results.

4. Quality of Decision. Linear Programming provides practical and better quality of decisions' that reflect very precisely the limitations of the system i.e.; the various restrictions under which the system must operate for the solution to be optimal. If it becomes necessary to deviate from the optimal path, Linear Programming can quite easily evaluate the associated costs or penalty.

5. Focus on Grey-Areas. Highlighting of grey areas or bottlenecks in the production process is the most significant merit of Linear Programming. During the periods of bottlenecks, imbalances occur in the production department. Some of the machines remain idle for long periods of time, while the other machines are unable toffee the demand even at the peak performance level.

6. Flexibility. Linear Programming is an adaptive & flexible mathematical technique and hence can be utilized in analyzing a variety of multi-dimensional problems quite successfully.

7. Creation of Information Base. By evaluating the various possible alternatives in the light of the prevailing constraints, Linear Programming models provide an important database from which the allocation of precious resources can be don rationally and judiciously.

8. Maximum optimal Utilization of Factors of Production. Linear Programming helps in optimal utilization of various existing factors of production such as installed capacity, labour and raw materials etc.

3.4 LIMITATIONS OF LINEAR PROGRAMMING.

Although Linear Programming is a highly successful having wide applications in business and trade for solving optimization' problems, yet it has certain demerits or defects. Some of the important-limitations in the application of Linear Programming are as follows:

1. Linear Relationship. Linear Programming models can be successfully applied only in those situations where a given problem can clearly be represented in the form of linear relationship between different decision variables. Hence it is based on the implicit assumption that the objective as well as all the constraints or the limiting factors can be stated in term of linear expressions - which may not always hold well in real life situations. In practical business problems, many objective function & constraints cannot be expressed linearly. Most of the business problems can be expressed quite easily in the form of a quadratic equation (having a power 2) rather than in the terms of linear equation. Linear Programming fails to operate and provide optimal solutions in all such cases. e.g. A problem capable of being expressed in the form of:

$ax^2+bx+c = 0$ where a # 0 cannot be solved with the help of Linear Programming techniques.

2. Constant Value of objective & Constraint Equations. Before a Linear Programming technique could be applied to a given situation, the values or the coefficients of the objective function as well as the constraint equations must be completely known. Further, Linear Programming assumes these values to be constant over a period of time. In other words, if the values were to change during the period of study, the technique of LP would lose its effectiveness and may fail to provide optimal solutions to the problem. However, in real life practical situations often it is not possible to determine the coefficients of objective function and the constraints equations with absolute certainty. These variables in fact may, lie on a probability distribution curve and hence at best, only the Iikelil1ood of their occurrence can be predicted. Moreover, the value changes due to extremely well internal factors during the period of study. Due to this, the actual applicability of Linear Programming tools may be restricted.

3. No Scope for Fractional Value Solutions. There is absolutely no certainty that the solution to a LP problem can always be quantified as an integer quite often, Linear Programming may give fractional-varied answers, which are rounded off to the next integer. Hence, the solution would not be the optimal one. For example, in finding out 'the pamper of men and machines required to perform a particular job, a fractional Larson-integer solution would be meaningless.

4. Degree Complexity. Many large-scale real life practical problems cannot be solved by employing Linear Programming techniques even with the help of a computer due to highly complex and Lengthy calculations. Assumptions and approximations are required to be made so that given problem can be broken down into several smaller problems and, then solve separately. Hence, the validity of the final result, in all such cases, may be doubtful:

5. Multiplicity of Goals. The long-term objectives of an organisation are not confined to a single goal. An organisation, at any point of time in its operations has a multiplicity of goals or the goals hierarchy - all of which must be attained on a priority wise basis for its long term growth. Some of the common goals can be Profit maximization or cost minimization, retaining market share, maintaining leadership position and providing quality service to the consumers. In cases where the management has conflicting, multiple goals, Linear Programming model fails to provide an optimal solution. The reason being that under Linear Programming techniques, there is only one goal which can be expressed in the objective function. Hence in such circumstances, the situation or the given problem has to be solved by the help of a different mathematical programming technique called the "Goal Programming".

6. Flexibility. Once a problem has been properly quantified in terms of objective function and the constraint equations and the tools of Linear Programming are applied to it, it becomes very difficult to incorporate any changes in the system arising on account of any change in the decision parameter. Hence, it lacks the desired operational flexibility.

CHAPTER FOUR

DATA COLLECTION AND ANALYSIS

4.0 INTRODUCTION

This chapter deals with data collection, analysis of data collected, thus: formulation of the model and the sensitivity analysis. This study considers two fishing gears or units, namely Purse Seine (Ali/Poli/Watsa) and Hook and Line.

4.1 DATA COLLECTION

Table 4.1 Canoe, gear and maintenance cost distribution for Purse Seine (Ali Poli/Watsa fishing gear (APW))

investment cost	fixed cost (depreciation)	operational cost (repairs maintenance)
canoe GH¢ 7800	canoe(10%) 780	canoe (5%) 390
gear and acc. GH¢ 4500	gear (20%) 900	gears(5%) 225
motor (40hp) GH¢ 3130	motor(30%) 939	motor (20%) 625

Source: field survey, 2011

Table 4.2 Canoe, gear and maintenance cost distribution for Hook and Line fishing gear

investment cost	fixed cost (depreciation)	operational cost (repairs maintenance)
canoe GH¢ 4700	canoe(10%) 470	canoe (5%) 235
gear and acc. GH¢ 2500	gear (20%) 500	gears(5%)125
motor (40hp) GH¢ 3330	motor(30%) 999	motor (20%) 666

Source: field survey, 2011

Tables 4.1 and 4.2 show the investment, fixed and operational and maintenance cost for the ali/poli/watsa (APW) and Hook and Line fishing gear or unit respectively. The fixed cost in the artisanal fishing industry is the same as the cost of depreciation. The fixed cost comprise of depreciation on canoe, gear (net and accessories) and outboard motor, and these are depreciated 10%, 20% and30% respectively per annum on their purchased cost.

Also operation and maintenance cost are the cost of repairing and mending of canoe, motor and gear (net) on each fishing trip and is given as 5% for canoe and gear and 20% for motor.

Table 4.3 Monthly fishing distribution of the Purse Seine (Ali poli/Watsa) gear

month	fish catch in metric tons	revenue from fish GH¢	fuel consumption (gallons)	cost of fuel consumed	remuneration to crew
January	35	7500	387.5	1065.625	645
February	25	7100	375	1031.25	756
march	30	8350	375	1050	823
April	20	7520	387.5	1123.75	843
may	43	8356	375	1125	824
June	58	9402	375	1125	678
July	89	7180	350	1050	587
august	110	4243	337.5	1012.5	844
September	150	4340	362.5	1087.5	735
October	172	3967	375	1125	824
November	67	5202	375	1125	835
December	55	3332	375	1125	825
total	854	76492	4450	13045.625	9219

Source: field survey, 2011

Table 4.3 shows the average monthly fish catch (in metric tons), cost of fuel and quantity of fuel consumed, remuneration(cost) to crew and revenue of the APW fishing unit for 2011 season out of the twenty(20) fishing group sampled.

Table 4.4 Monthly fishing distributions for the Hook and Line gear

month	fish catch in metric tons	revenue from fish	quantity of fuel (gallons)	cost of fuel consumed	remuneration to crew	bait and ice
January	15	8532	90	247.5	656	56
February	30	8368	90	252	655	55
march	24	7844	90	252	625	53
April	20	8234	87	270	752	44
may	25	9222	90	270	678	67
June	32	8752	87	261	772	65
July	50	6432	87	261	882	52
august	65	6455	87	261	564	49
September	110	5892	90	270	668	39
October	95	5645	87	270	566	57
November	22	8364	90	270	845	55
December	56	9621	90	270	988	58
total	519	93361	1065	3154.5	8651	650

Source: field survey, 2011

Also Table 4.4 shows the average monthly fish catch (in metric tons), cost of fuel and quantity of fuel consumed, remuneration(cost) to crew and revenue of the Hook and Line fishing unit for 2011 season out of the twenty(20) fishing group sampled.

Table 4.5 Major upwelling seasonal distribution for both gears

fishing gear	fish catch (quantity in metric tons)	cost of fuel GH¢	cost of labour or crew GH¢	bait and ice GH¢	operation and maintenance cost GH¢	profit GH¢
Ali poli/Watsa	579	5404.5	3668	-	1607.8667	18451.633
Hook and Line	352	1323	3452	262	1247.829	26691.171
Total	931	6727.5	7120	262	2855.696	

Source: field survey, 2011

Table 4.5 shows the profitability analysis of the major (bumper) season for the two fishing units. The major season lasts for five month and the APW unit makes 150 fishing trips whiles the Hook and Line unit also make 36 fishing trips per year on the average.

Table 4.6 Minor upwelling seasonal distribution for both gears

type of gear	fish catch (quantity in metric tons)	cost of fuel GH¢	cost of labour or crew GH¢	bait and ice GH¢	operation and maintenance cost GH¢	profit GH¢
Ali poli/Watsa	275	7645.625	5551	-	2251.134	31912.241
Hook and Line	192	1831.5	5199	388	1747.121	51019.379
Total	467	9477.125	10750	388	3998.255	

Source: field survey 2011

Table 4.6 also shows the profitability analysis of the minor (lean) season for the two fishing units. The minor season lasts for seven month and the APW unit makes 150 fishing trips whiles the Hook and Line unit also make 36 fishing trips per year on the average.

4.2 FORMULATION OF LP MODEL FOR THE SEKONDI ARTISANAL MARINE FISHING

Formulation of linear programming model involves three basic steps.

(i) specifying the decision variable

(ii) specifying the objective function

(iii) specifying the constraints

4.2.1 LP MODEL FOR THE MAJOR UPWELLING SEASON ON BOTH GEARS

a) Decision variables:

Let X_1 represent the quantity of fish from Ali/Poli/Watsa and X_2 represent the quantity of fish from Hook and Line gears for the major season.

b) Objective function

• The key decision is to determine the most viable and profitable fishing gear and the optimum volume of production (fish catch) of each unit

• Let X_1 and X_2 represent quantity of fish during the given period.

• The feasible alternatives are set of values of X_1 and X_2, where X_1 and $X_2 \geq 0$

• The profit per gear X_1 and X_2, as shown in table 4.5 in thousand Ghana cedi respectively.

The objective is to maximise the total profit of the two fishing gear for the major season;

Maximise Z $= 1845.1633\chi_1 + 26691.171\chi_2 \ldots\ldots (4.1)$

c) Constraints

The main problem in the process fishing business is the shortage of resources like quantity of fish catch, labour, fuel and overheads. Therefore, the need to impose restrictions on the use of these resources. The restrictions may be due to the availability of resources. And may be expressed as follows, the inputs required for profit maximisation is less than or equal to maximum availability of inputs. Inputs are categorized into a) quantity of fish catch b) cost of fuel consumed c)labour or crew remuneration d)baits and ice e)operation and maintenance cost. Hence they form the resource constraints in the model for each period or season. They are:

(i) Quantities of fish X_1 and X_2 catch per each fishing season for the two gears respectively.

(ii) Cost of fuel consumed per each fishing season for the two gears X_1 and X_2 respectively.

(iii) Cost or expenditure on labour or crew members for the two gears X_1 and X_2 respectively.

(iv) Bait and ice cost on the fishing gears X_1 and X_2 respectively.

(v) Operation and maintenance cost per each season and gear X_1 and X_2 respectively.

Therefore the model is:

Maximise Z $= 1845.1633\chi_1 + 26691.171\chi_2$ (4.1)

Subject to the following constraint:

$579x_1 + 352x_2 \leq 931$ $(quantity\ \ of\ \ fish\ catch)$ (4.2)

$5404.5x_1 + 1323x_2 \leq 6727.5$ $(\cos t\ of\ \ fuel)$ (4.3)

$3668x_1 + 3452x_2 \leq 7120$ $(\cos t\ of\ \ labour)$ (4.4)

$0x_1 + 262x_2 \leq 262$ $(\cos t\ of\ \ bait\ and\ ice)$ (4.5)

$1607.8667x_1 + 1247.829 \leq 2855.696$ $(operation\ and\ maintenance\ \cos t)$ (4.6)

$X_{1,}\ X_2 \geq 0$

4.2.2 LP MODEL FOR THE MINOR UPWELLING SEASON ON BOTH GEARS

a) Decision variables:

Let X_1 represent the Ali/Poli/Watsa and X_2 represent the Hook and Line gears for the minor season.

b) Objective function

• The key decision is to determine the most viable and profitable fishing gear and the optimum volume of production (fish catch) of each unit

• Let X_1 and X_2 represent quantity of fish during the given period.

• The feasible alternatives are set of values of X1 and X_2, where X_1 and $X_2 \geq 0$

• The profit per gear X_1 and X_2, as shown in table 4.6 in thousand Ghana cedi respectively.

The objective is to maximise the total profit of the two fishing gear for the minor season:

Maximise Z $= 31912.241x_1 + 51019.379x_2$ (4.7)

Subject to the following constraint:

$275x_1 + 192x_2 \leq 467$ (*quantity of fish*) (4.8)

$7645.625x_1 + 1831.5x_2 \leq 9477.125$ (cost of fuel) (4.9)

$5551x_1 + 5199x_2 \leq 10750$ (cost of labour) (4.10)

$0x_1 + 388x_2 \leq 388$ (cost of bait ice) (4.11)

$2251.134x_1 + 1747.121x_2 \leq 3998.255$ (*operational* cost) (4.12)

$X_1, X_2 \geq 0$

4.3 Graphical method for the Major upwelling season

Which is the objective of the function? [Maximize ▾]

Function: [18451.633] X1 + [26691.171] X2

Restrictions:

579	X1 + 352	X2	=	931
5404.5	X1 + 1323	X2	=	6727.5
3668	X1 + 3452	X2	=	7120
0	X1 + 262	X2	=	262
1607.8667	X1 + 1247.829	X2	=	2855.696

Maximise Z $= 1845.1633\chi_1 + 26691.171\chi_2$ (4.1)

Subject to the following constraint:

$579x_1 + 352x_2 \le 931$ (*quantity of fish catch*) (4.2)

$5404.5x_1 + 1323x_2 \le 6727.5$ (cos*t of fuel*) (4.3)

$3668x_1 + 3452x_2 \le 7120$ (cos*t of labour*) (4.4)

$0x_1 + 262x_2 \le 262$ (cos*t of bait and ice*) (4.5)

$1607.8667x_1 + 1247.829 \le 2855.696$ (*operation and maintenance* cos*t*) (4.6)

$x_1, x_2 \ge 0$

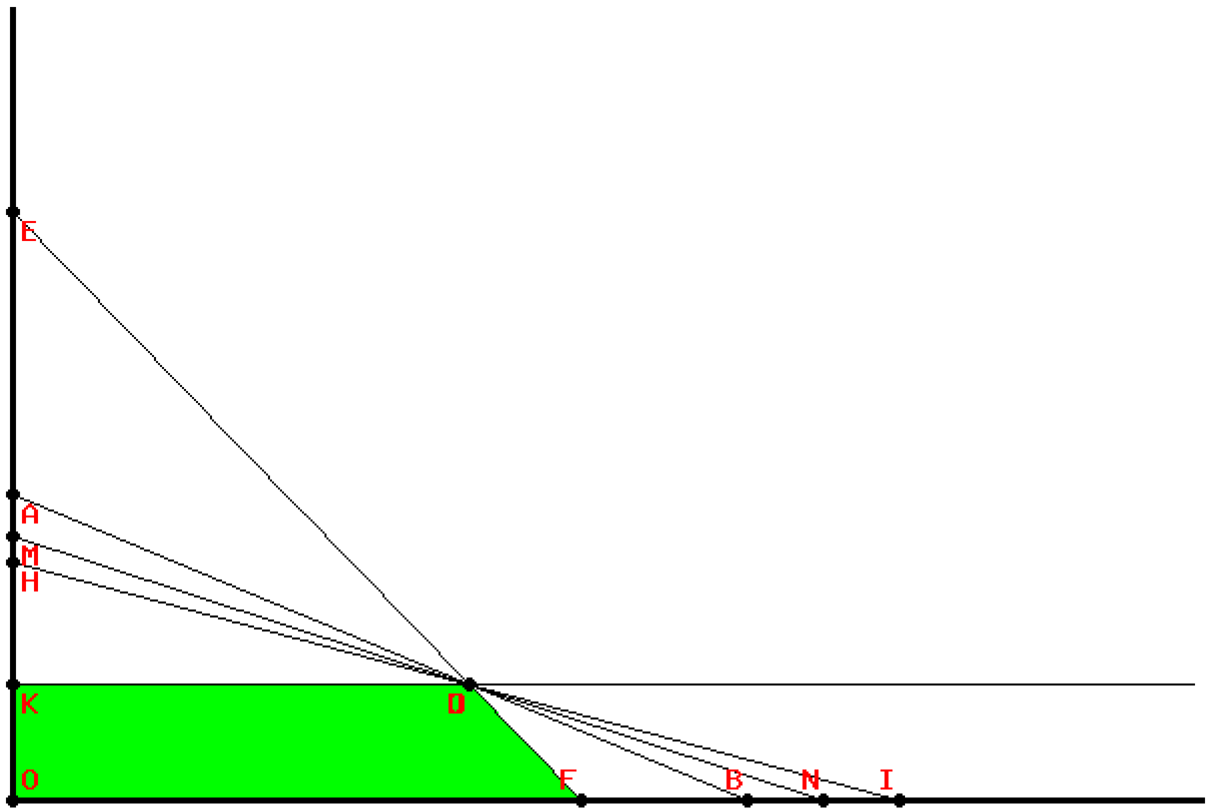

Figure 4.1 feasible region and optimal solution of the major season.

The fields where the solution coordinates are, appears in the shaded region. The fields where is not possible to find the solution, appears in unshade region. Thus the shaded part is the feasible region, which is any quantity of fish from the APW and Hook and Line within the region OKC

Table 4.7 output of fish catch for APW(X_1) and Hook and Line(X_2)

	X coordinate	Y coordinate	F value
O	0	0	0
A	0	2.64488636364	70595.1142074
B	1.6079447323	0	29669.2060846
C	1	1	45142.804
D	0.999999325343	1.00000110973	45142.8211716
E	0	5.08503401361	135725.512398
F	1.24479600333	0	22968.5190133
G	0.999999914029	1.00000035119	45142.8117875
H	0	2.06257242178	55052.4732097
I	1.94111232279	0	35816.6921919
J	1.00000106399	0.999998869435	45142.7934562
K	0	1	26691.171
L	1.00000018658	1	45142.8074428
M	0	2.28853152155	61083.5861805
N	1.77607758156	0	32771.5317144

Source: field survey, 2011

`The fields where the solution coordinates are, appears in green colour, and where is not possible to find the solution, appears in red colour in table 4.7.

From figure 4.1 and table 4.7, it could be seen that profit is optimised at point C. The output or quantity of fish that maximised profit of GH¢45142.804 should be one metric ton by each fishing gear. Comparing this optimal value to any other point on the feasible region will lead to trade off between resources, for instance, at point A in table 4.7 indicates that to maximised profit GH¢ 70595.11, the APW should not go to fishing at all meaning zero quantity and 2.645 metric tons by the Hook and Line unit. At point A there is a GH¢25452.306 profit higher than the optimal profit. Assuming point A is chosen, it implications are that there will be underutilisation of resources on the APW unit, crew or fisher folks on this unit will be left idle or there will be unemployment. Investment and fixed cost on canoe, motor and gear cannot be paid and this is true for any point other than at point C, where all two fishing gears will be fully utilised for the major season.

4.3.2 Two-Phase Simplex Method for the major season

Which is the objective of the function? Maximize

Function: 18451.633 X1 + 26691.171 X2

Restrictions:

579 X1 + 352 X2 = 931

5404.5 X1 + 1323 X2 = 6727.5

3668 X1 + 3452 X2 = 7120

0 X1 + 262 X2 = 262

1607.8667 X1 + 1247.829 X2 = 2855.696

Maximise Z $= 1845.1633\chi_1 + 26691.171\chi_2$

Subject to the following constraints

$$579x_1 + 352x_2 \leq 931$$
$$5404.5x_1 + 1323x_2 \leq 6727.5$$
$$3668x_1 + 3452x_2 \leq 7120$$
$$0x_1 + 262x_2 \leq 262$$
$$1607.8667x_1 + 1247.829 \leq 2855.696$$

$X_1, X_2 \geq 0$

Transforming the problem to standard form by adding slack, variables as appropriate;

$$
\begin{aligned}
&\textit{Maximise } Z = 18451.633x_1 + 26691.171x_2 + 0s_3 + 0s_4 + 0s_5 + 0s_6 + 0s_7 \\
&\textit{subject to}: \\
&579x_1 + 352x_2 + s_3 \leq 931 \\
&5404.5x_1 + 1323x_2 + s_4 \leq 6727.5 \\
&3668x_1 + 3452x_2 + s_5 \leq 7120 \\
&0x_1 + 262x_2 + s_6 \leq 262 \\
&1607.8667x_1 + 1247.829x_2 + s_7 \leq 2855.696
\end{aligned}
$$

$$x_1, x_2, s_3, s_4, s_5, s_6, s_7 \geq 0$$

Table 4.8 first board of Phase I from Two-Phase Simplex Method

Board 1			18451.633	26691.171	0	0	0	0	0
Base	Cb	P0	P1	P2	P3	P4	P5	P6	P7
P3	0	931	579	352	1	0	0	0	0
P4	0	6727.5	5404.5	1323	0	1	0	0	0
P5	0	7120	3668	3452	0	0	1	0	0
P6	0	262	0	262	0	0	0	1	0
P7	0	2855.696	1607.8667	1247.829	0	0	0	0	1
Z		0	-18451.633	-26691.171	0	0	0	0	0

Table 4.9 second board of Phase I from Two-Phase Simplex Method

Board 2			18451.633	26691.171	0	0	0	0	0
Base	Cb	P0	P1	P2	P3	P4	P5	P6	P7
P3	0	579	579	0	1	0	0	-1.34351145038	0
P4	0	5404.5	5404.5	0	0	1	0	-5.04961832061	0
P5	0	3668	3668	0	0	0	1	-13.1755725191	0
P2	26691.171	1	0	1	0	0	0	0.00381679389	0
P7	0	1607.867	1607.8667	0	0	0	0	-4.76270610687	1
Z		26691.171	-18451.63	0	0	0	0	101.874698473	0

Table 4.10 third board of Phase I from Two-Phase Simplex Method

Board 3			18451.633	26691.171	0	0	0	0	0
Base	Cb	P0	P1	P2	P3	P4	P5	P6	P7
P3	0	0	0	0	1	0	-0.1578516	0.7362749942353	0
P4	0	0	0	0	0	1	-1.47341875682	14.3635173608	0
P1	18451.633	1	1	0	0	0	0.000272628135	-0.0035920317	0
P2	26691.171	1	0	1	0	0	0	0.00381679389	0
P7	0	0.0002999	0	0	0	0	-0.438349700109	1.01280215564	1
Z		45142.804	0	0	0	0	5.03043429662	35.5958465957	0

The optimal solution Z is GH¢45142.804

X_1=1

X_2=1

Table 4.10 shows that to maximise a total profit of GH¢45142.804 for the major season the same quantities thus one (1) metric ton of fish must be produced by the APW and Hook and Line fishing unit.

4.4 Graphical method for the minor upwelling season

Which is the objective of the function? Maximize

Function: 31912.241 X1 + 51019.379 X2

Restrictions:

275 X1 + 192 X2 = 467

7645.625 X1 + 1831.5 X2 = 9477.125

5551 X1 + 5199 X2 = 10750

0 X1 + 388 X2 = 388

2251.134 X1 + 1747.121 X2 = 3998.255

Maximise Z $= 31912.241x_1 + 51019.379x_2 \ldots\ldots(4.7)$

Subject to the following constraint:

$275x_1 + 192x_2 \leq 467$ $(quantity\ of\ \ fish)\ldots\ldots(4.8)$

$7645.625x_1 + 1831.5x_2 \leq 9477.125$ $(\cos t\ of\ \ fuel)\ldots\ldots(4.9)$

$5551x_1 + 5199x_2 \leq 10750$ $(\cos t\ of\ \ labour)\ldots\ldots(4.10)$

$0x_1 + 388x_2 \leq 388$ $\qquad (\cos t\ of\ \ bait\ ice)\ldots\ldots(4.11)$

$2251.134x_1 + 1747.121x_2 \leq 3998.255$ $(operational\ \cos t)\ldots\ldots(4.12)$

$X_1, X_2 \geq 0$

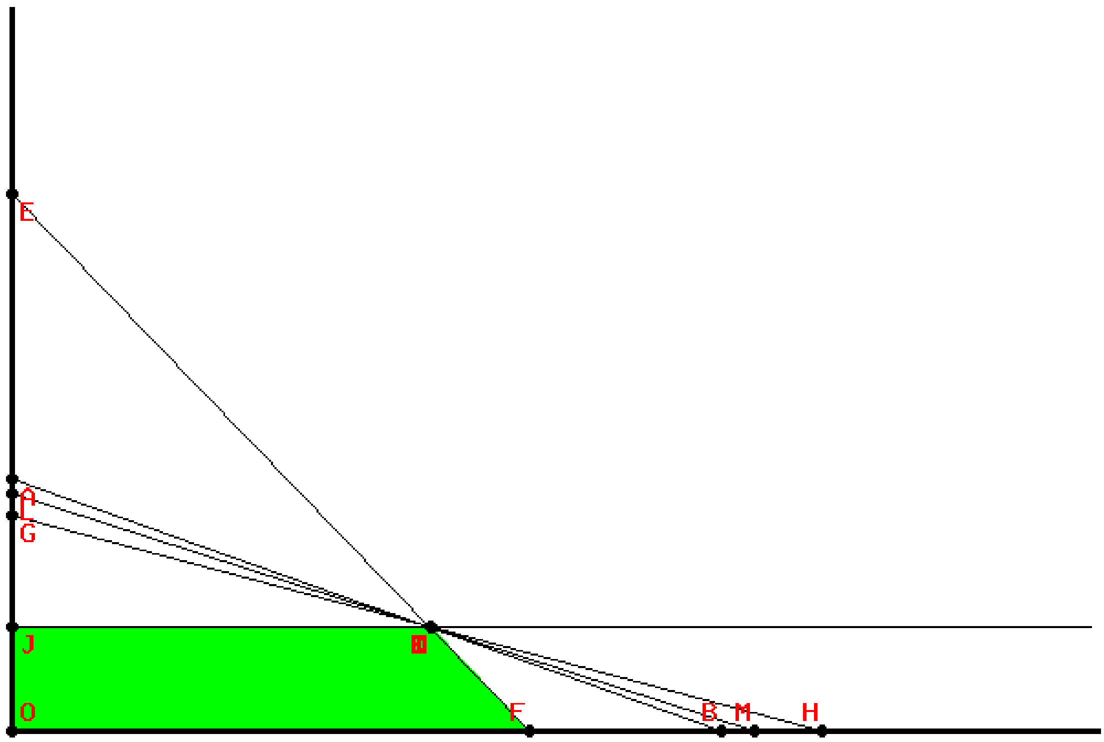

Figure 4.2 feasible region and optimal solution the minor season.

Table 4.11 output of fish catch for the APW(X) and Hook and Line(Y)

Point	X coordinate	Y coordinate	F value
O	0	0	0
A	0	2.43229166667	124094.01038
B	1.69818181818	0	54192.7874436
C	1	1	82931.62
D	1	1	82931.62
E	0	5.17451542452	264000.563585
F	1.23954876155	0	39556.7788097
G	0	2.06770532795	105493.041787
H	1.93658800216	0	61800.8630427
I	1	1	82931.62
J	0	1	51019.379
K	1	1	82931.62
L	0	2.28848202271	116756.931651
M	1.77610706426	0	56679.5566765

Source: field survey, 2011

Table 4.11 shows the fields where the solution coordinates are, appears in green colour, and where is not possible to find the solution, appears in red colour. It can be seen from the table that there is an infinite solution to the problem.

Also from figure 4.2 and table 4.11 indicates an infinite solution to the problem, thus more than one point on the feasible region can be the optimal solution, but the same quantities, one metric ton of fish should be catch by the two fishing method or unit. Thus at points C, D, I and K will be the optimal solution and profit is maximised at GH¢ 82931.63. Although other points in table 4.11 have profit higher, it implies that one of the fishing units must completely shut down which is not the best. For example at point G, there is GH¢22561.4217 profit higher than the optimal solution of GH¢82931.62 in the minor season.

4.4.2 Two-Phase Simplex Method for the minor upwelling season

Which is the objective of the function? Maximize

Function: 31912.241 X1 + 51019.379 X2

Restrictions:

275 X1 + 192 X2 = 467

7645.625 X1 + 1831.5 X2 = 9477.125

5551 X1 + 5199 X2 = 10750

0 X1 + 388 X2 = 388

2251.134 X1 + 1747.121 X2 = 3998.255

Maximise Z $= 31912.241x_1 + 51019.379x_2$ ……(4.7)

Subject to the following constraint:

$275x_1 + 192x_2 \leq 467$ (*quantity of fish*)……(4.8)

$7645.625x_1 + 1831.5x_2 \leq 9477.125$ (cos*t of fuel*)……(4.9)

$5551x_1 + 5199x_2 \leq 10750$ (cos*t of labour*)……(4.10)

$0x_1 + 388x_2 \leq 388$ (cos*t of bait ice*)……(4.11)

$2251.134x_1 + 1747.121x_2 \leq 3998.255$ (*operational* cos*t*)……(4.12)

$X_1, X_2 \geq 0$

Transforming the problem to standard form, adding slack variables as appropriate;

$$Maximise\ Z = 31912.241x_1 + 51019.379x_2 + 0s_3 + 0s_4 + 0s_5 + 0s_6 + 0s_7$$

$$subject\ to$$

$$257x_1 + 192x_2 + 1s_3 \leq 467$$

$$7645.625x_1 + 1831.5x_2 + 1s_4 \leq 9477.125$$

$$5551x_1 + 5199x_2 + 1s_5 \leq 10750$$

$$0x_1 + 388x_2 + 1s_6 \leq 388$$

$$2251.134x_1 + 1747.121x_2 + 1s_7 \leq 3998.255$$

$$x_1, x_2, s_3, s_4, s_5, s_6, s_7 \geq 0$$

Table 4.12 first board of Phase I from Two-Phase Simplex Method

Board 1			31912.241	51019.379	0	0	0	0	0
Base	Cb	P0	P1	P2	P3	P4	P5	P6	P7
P3	0	467	275	192	1	0	0	0	0
P4	0	9477.125	7645.625	1831.5	0	1	0	0	0
P5	0	10750	5551	5199	0	0	1	0	0
P6	0	388	0	388	0	0	0	1	0
P7	0	3998.255	2251.134	1747.121	0	0	0	0	1
Z		0	-31912.241	-51019.379	0	0	0	0	0

Table 4.13 second board of Phase I from Two-Phase Simplex Method

Board 2			31912.241	51019.379	0	0	0	0	0
Base	Cb	P0	P1	P2	P3	P4	P5	P6	P7
P3	0	275	275	0	1	0	0	-0.494845360825	0
P4	0	7645.625	7645.625	0	0	1	0	-4.72036082474	0
P5	0	5551	5551	0	0	0	1	-13.3994845361	0
P2	51019.379	1	0	1	0	0	0	0.00257731958763	0
P7	0	2251.134	2251.134	0	0	0	0	-4.50288917526	1
Z		51019.379	-31912.241	0	0	0	0	131.493244845	0

Table 4.14 third board of Phase I from Two-Phase Simplex Method

Board 3			31912.241	51019.379	0	0	0	0	0
Base	Cb	P0	P1	P2	P3	P4	P5	P6	P7
P3	0	0	0	0	1	0	0	0.0552305223506	-0.122160653253
P4	0	0	0	0	0	1	0	10.5729989	-3.39634379828
P5	0	0	0	0	0	0	1	-2.2959527997	-2.46586831348
P2	51019.379	1	0	1	0	0	0	0.0025773195876	0
P1	31912.241	1	1	0	0	0	0	-0.00200027593882	0.000444220557284
Z		82931.62	0	0	0	0	0	67.6599570193	14.1760734812

The optimal solution GH¢82931.62

X_1=1

X_2=1

Table 4.14 shows the optimal solution to the problem. Thus to maximise a total profit of GH¢ 82931.62 for the minor season, the same quantities one (1) metric ton of fish must be produced by the two fishing units.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 INTRODUCTION

This chapter focuses on the outcomes of the analysis in chapter four and considers the extent to which the objectives of the study have been realized. This chapter covers summary, conclusions and recommendations.

5.1 SUMMARY

This research involved a study that sought to develop a model that will maximise total profit of the artisanal fishing industry in Sekondi with emphasis on the APW and Hook Line fishing units for the major and minor upwelling season. Fishing is perennial activity, the bumper harvest last for only three months instead of the expected five to six months. There is a glut of fish in the peak season and severe shortage in the lean season leading to a considerable price fluctuation at the beach.

In spite of the numerous problems, the industry remains to be of a considerable importance to the Sekondi district. In terms of employment, income generation, protein intake and supply of fish for industrial or manufacturing processing, its contribution cannot be underestimated.

However, it was observed that apart from the initial or investment cost, the major cost in the fishing business is cost of fuel as more fishing trips are made leads to more fuel consumption for the two fishing units.

5.2 CONCLUSIONS

The focus of the study seek to study existing fishing units and resource constraints, formulate a mathematical model to maximise total profit and also find out which fishing unit is most viable and profitable in Sekondi. First, it was observed that both the APW and Hook line fishing units in the Sekondi artisanal fishing industry is very profitable in both major and minor upwelling season and that no fishing unit should be redundant in any season using linear programming.

Secondly, to maximise a total profit of GH¢45142.804 and GH¢82931.62 in the major and minor seasons respectively, both APW and Hook and line fishing unit must produce one (1) metric ton of fish each for the whole fishing season. This is an indication that every kilogram of fish contributes greatly to maximise a certain level of profit.

Finally, it was discovered that Sekondi fishing industry is limited by input cost most especially cost of fuel and most often not readily available for fisher folks to buy. There is also the high cost of fishing net (gear) , depletion of fish stock and face major competition with foreign fleets.

5.3 RECOMMENDATION

(i) From the results based on this study, it recommended that all fishing units with the Sekondi artisanal marine industry should be fully employed throughout the fishing season.

(ii) Individual fishing groups should pull their resources together to fish to reduce fuel cost and also increase fish catch.

(iii) Fishing regulation relating to mesh, size of net and fish landed at the harbour should be reviewed and penalties imposed and enforced.

(iv) There should be equitable distribution of per-mix fuel to all fishermen.

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APPENDIX A

ANNUAL FISH PRODUCTION IN METRIC TONS IN GHANA

Year	Marine Fisheries Landing (MT)	Inland Fisheries Landing (MT)	Total Fish Landing (MT)
1997	395839.70	76200	472039.70
1998	376361.90	76300	452661.90
1999	332641.00	89400	422041.00
2000	379793.70	87500	467293.70
2001	365741.20	88000	457741.20
2002	290008.10	88000	378008.00
2003	331412.00	82450	413862.00
2004	352405.20	82450	434855.20
2005	322789.60	82654	405443.50
2006	323617.10	83168	406784.60

APPENDIX B

CANOE FRAME SURVEY-2004

	Volta	grater Accra	central	western	national
fishing village	29	48	43	75	195
landing beaches	63	68	103	100	334
canoes	736	2781	4450	3246	11213
outboard motors	323	2144	2097	1841	6405
levels of motorisation%	43.9	77.1	47.1	56.7	57.1
fishermen	17382	35168	44303	27366	124219

APPENDIX C

MONTHLY FISHING DISTRIBUTION OF THE ALI POLI/WATSA GEAR

month	fish catch in metric tons	revenue from fish GH¢	fuel consumption (gallons)	cost of fuel consumed	remuneration to crew
January	35	7500	387.5	1065.625	645
February	25	7100	375	1031.25	756
march	30	8350	375	1050	823
April	20	7520	387.5	1123.75	843
may	43	8356	375	1125	824
June	58	9402	375	1125	678
July	89	7180	350	1050	587
august	110	4243	337.5	1012.5	844
September	150	4340	362.5	1087.5	735
October	172	3967	375	1125	824
November	67	5202	375	1125	835
December	55	3332	375	1125	825
total	854	76492	4450	13045.625	9219

APPENDIX D

MONTHLY FISHING DISTRIBUTIONS FOR THE HOOK AND LINE GEAR

month	fish catch in metric tons	revenue from fish	quantity of fuel (gallons)	cost of fuel consumed	remuneration to crew	bait and ice
January	15	8532	90	247.5	656	56
February	30	8368	90	252	655	55
march	24	7844	90	252	625	53
April	20	8234	87	270	752	44
may	25	9222	90	270	678	67
June	32	8752	87	261	772	65
July	50	6432	87	261	882	52
august	65	6455	87	261	564	49
September	110	5892	90	270	668	39
October	95	5645	87	270	566	57
November	22	8364	90	270	845	55
December	56	9621	90	270	988	58
total	519	93361	1065	3154.5	8651	650

Source: field survey, 2011

APPENDIX D

MEAN RANGE OF PRICES/COST (THOUSAND GHANA CEDIS) OF CANOES, FISHING GEARS AND OUTBOARD MOTORS IN THE REGIONS.

gears	Volta	G/Accra	Central	Western
Ali	1500-3000	1500-2500	2000-3500	2500-3000
Poli/Watsa	5000-9000	4000-10000	6000-9000	2000-3000
Beach Seine(big)	6000-15000	5000-10000	5000-15000	5000-10000
Beach Seine (small)	1000-3000	1000-1800	800-1500	800-1200
Set Nets	500-20000	200-600	300-500	200-600
Line	100-300	100-300	120-400	100-400
drift Gill net	400-1000	300-1000	300-1000	250-600
Lobster Net	150-1000	100-800	120-400	100-300
CANOES				
Ali	3000-5000	2500-4000	2500-4000	2000-4000
Poli/Watsa	5000-15000	5000	5000-9000	4000-7000
Beach Seines	7000-9000	8000	7000-12000	4000-7000
one man canoe	-	7000-15000	-	-
MOTORS				
Yamaha 40hp	2500	2500	2600	2600
Yamaha 25hp	1800	1800	1800	1800
yamaha15hp	1500	1500	1600	1500