# COMPUTERIZATION OF LEAST-COST RATION FORMULATION IN FISH-FEED COMPOUNDING BY LINEAR PROGRAMMING. A CASE STUDY OF NATIONAL INSTITUTE FOR FRESHWATER FISHERIES RESEARCH (NIFFR), NEW- BUSSA. NIGER - STATE.

**BY**

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**PGD/MCS/268/97/98**

A PROJECT SUBMITTED TO THE DEPARTMENT OF MATHEMATICS AND COMPUTER SCIENCE OF THE FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA FOR THE AWARD OF POST-GRADUATE DIPLOMA IN COMPUTER SCIENCE.

**DEC. 1999**

## CERTIFICATION

This project has been read and approved as meeting the requirements of the award of Post Graduate Diploma in Computer Science, Department of Mathematics and Computer Science, Federal University of Technology, Minna.

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## DEDICATION

This project is dedicated to :

**Late Julie `Bihawu Ikusemoran**

(MY MOTHER)

I was too young to remember,
I neither knew when she died
nor the woman my mother was
I neither knew when she was buried
nor the sides on which she layed.
A mother died like a childless woman
A man lives in a motherless world
But God, please take control.

Yomi '99

**ACKNOWLEDGEMENT**

Glory be to the Almighty God who has seen me through the course of this project. It is Him who started the work with me and who has sustained me to the end. If each of my hair is a tongue, they are not enough to say - Thank you, God.

I really appreciate the assistance of my supervisor, Dr. Yomi Aiyesimi who did not only gave me academic support but also a strong Uncle on whom I relied upon. He discussed intensively with me and gave very valuable pieces of advice. I am also grateful to Prof. K.R. Adeboye, the Head of Department and Prince Badmus - the Course Co-ordinator for all the time assistance rendered to me. The services and dedication of the following lecturers cannot be overemphasised. They are Messrs Ezeakor, Kola, Wale and Mrs. Mgbachi.

I want to register my gratitude to Uncle David Olu, Ebenezer, Tusi, Sunday and also Mrs Marion Olu for their endurance and understanding when I could not play my role as a "helper" to the family during the course work. Bolanle Ene, too,for bearing with me

How would I say "thank you" to Uncle Jimmy Atte for his moral and financial support? I am grateful. I also say thank you to my numerous friends Dominic Mokikan, Tope Atte, Yemi Ibejigba and Femi Apena for their kindness towards me.

I am particularly grateful to the family of Uncle Samuel Atte who made the programme and the project possible. You were vessels used by God to see to my success. Your wife, Femi, Funsho, Yomi and Iye really tried for me.

At this juncture, I have to mention few of my younger ones who placed joy and happiness at my disposal even when the going was

rough- Victor Atte and Shade Ayeni are wonderful people so too are Job, Simeon and Taiye.

Nothing could have been achieved without the assistance of Dr. A.A. Eyo all the necessary materials, devoted much time to me and moreover gave me fatherly pieces of advice. I also thank the following people Messrs Okomoda, Ogunleye, Adesina, DR G. I. Mbagun and Ajibade all staff of National Institute for Freshwater Fisheries Research (NIFFR) Mr. and Mrs Ojo is also remembered for their financial assistance. Mr. Baiyere Zaccheaus who gave me the zeal for this programme. I love you.

Much appreciation go to my students Chinemerem Achonwa, Precious Taiwo and Esther Eyo for the time they took in going through the scripts.

Finally, I thank all individuals or groups of individuals whose names are not mentioned here, but had contributed in some ways directly or indirectly to the success of this project.

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# ABSTRACT

This project is concerned with the need to develop a comprehensive computerized procedures for the Least-cost Ration Formulation in Fish-Feed Compounding by Linear Programming, based on the National Institute for Freshwater Fisheries Research (NIFFR), New - Bussa, Niger State.

The main emphasis is the computerization of the Least-cost Ration Formulation in Fish Feed compounding to replace the existing manual system of the Pearson's Square Method.

The project first discussed National Institute for Freshwater Fisheries Research and the existing manual System of Fish-Feed compounding, procedures for Linear programming and recommended that a computerization systems need to be designed.

Finally, the mode of operation of the proposed system is analysed, and its stages of implementation. The implementation is developed in a way to ensure reliability and continuity of fish-feed compounding in National Institute for Freshwater Fisheries Technology, New-Bussa, Niger State.

# CHAPTER ONE

# INTRODUCTION

## 1.1 Background to the Study

Nigeria, just like other Tropical countries are blessed with a very wide variety of fish feeds materials which like other resources are yet to be tapped. Faced with this, the feed producer and fish farmer should not have much problems in feeding fish in fish farms. The decision as to which feed materials to combine in order to arrive at a compounded feed is that of the feed producer.

The feed producer obviously wants to produce the compound at the least possible cost, the author, therefore, looks at the chemical composition of the materials and their market prices at the same time. These two important factors continuously interplay to determine the choice of any feed materials and the formulation.

## 1.2 Objective of the project

The main objective of this project is to illustrate the use of Linear programming tool to formulate least cost rations which meet specified nutritional requirements of intensive fish enterprises using readily available feed ingredients in National Institute for Freshwater Fisheries Research (NIFFR) New Bussa, Niger State.

## 1.3 Status before the commencement of the project

Compounding fish feed involves:

(i) **Dough-** This means mixing of fish feed ingredients such as Maize, Groundnut cake, Soyabeans, Blood meal, Fish meal, Bone meal, and Vitamins/mineral premix, to give the desired protein level required by the fish.

(ii) **Pelleting** - The dough formed in (i) above is placed in the receiver or funnel of a pelleting machine and then pellets are produced when the machine is put on.

(iii) **Drying and Bagging**- After pelleting, the pellets are dried in the sun or oven. The pellets are latter weighed and labelled.

All the above processes are manually done and moreover, no effort has been made to formulate least cost ration in compounding fish feed. The introduction of a suitable computerized Linear programming to formulate least cost ration is expected to reduce the manual work load on the staff, minimize waste in feed compounding. Beside, the quantitative improvement in data generation, and managerial decisions, based on a systematic flow of information are the major advantages expected from computerization.

### 1.4 Historical Background of NIFFR

National Institute for Freshwater Fisheries Research (NIFFR) is one of the establishment inhabiting New-Bussa's "paradise of Nature", depending much on the pride of Nature for it's nourishment.

The Research Institute was considered suitable in New-Bussa because of the presence of the first man-made lake in the country. Though, the primary aim of constructing the lake was for Power Generation, the citing of the dam offered great opportunities for a variety of developmental projects such as Fisheries, Irrigation, and Improved Navigation from the coast up to the Republic of Benin.

Numerous problems initially arose from the construction of the Lake Kainji, which include the settlement of about 44,000 people displaced by the lake from 237 villages and two towns; the flooding of the traditional dry season grazing lands for cattle in the River Niger Valleys; the adverse effect of the changes of the flood regime of the River Niger and by the regulation of the water flowing downstream into the traditional swamps for flood plain fisheries and agriculture.

Knowing the future of these changes in the environment on the inhabitants as well as the ecosystem, the Federal Government of Nigeria made adequate provision for the pre-impoundment research studies by several research teams, which yielded good results for the understanding of the problem in the area.

As a result of the aforementioned purposes, the Federal Government of Nigeria in 1965, requested assistance from the United Nations to set up a research project in New-Bussa area to undertake a post impoundment studies. It's long term purpose is to assist in the comprehensive development of the Kainji dam resources through research and surveys.

The National Institute for Freshwater Fisheries Research was established in 1968 as the Kainji Research Project, with assistance from the United Nations Development Project (UNDP). The Food and Agricultural Organization (FAO) was the executing agency, while the Federal Ministry of Agriculture and Natural Resources was represented.

The original objectives were to research into the Limnology behaviour and the characteristics of the Lake Kainji and other man-made lakes and their effects on the fish and other aquatic lifes. The abundance, distribution and other biological characteristics of species of fish and practical methods of their rational exploitation in the said lakes and Wildlife and their conservation as well as range ecology in New-Bussa area, the public health problems arising from the construction of dams and the resettlement of people around them. The development of irrigated crops along the lakes and the Socio-economic effects of the construction of the lakes on their neighbouring rural population.

The project was under the management of Food and Agricultural Organization from 1969 to 1974. During this period, research programmes were set up in the Field of Fisheries Limnology, Fisheries Biology, Boat Building, Fisheries Technology, Wildlife Range Ecology, Public Health, Irrigation, Agronomy, Sociology, Economics and Statistics. In 1975, qualified Nigerians took over the mantle of leadership of what later came to be known as Kainji Lake Research Institute.

In 1987, the mandate of the Institute changed to that of Mono-commodity and Research activities, specializing in the areas of Freshwater Fisheries and other Aquatic Resources, such as genetic improvement of Freshwater Fishes and other aquatic resources, hydrological behaviour of natural and man-made lakes, Limnology of surface and ground water, rational exploitation and utilization of freshwater aquatic resources; ecological and socio-economic effects of the development of man-made lakes, aquaculture and other related matters.

The mandate also gave the Institute the responsibilities of carrying out an extension research, liaison with Federal and State Ministries, Primary producers, Industries, and other users of research results on Nigeria Fisheries and Aquatic Sciences Database, as well as to provide laboratory and others concerned with Freshwater Fisheries problem.

The Research Institute is housing a College of Technology in New-Bussa. The School, known as the Federal College of Freshwater Fisheries Technology, was established in 1978. The college train middle level manpower in Fisheries management at Ordinary and Higher Diploma levels, Vocational training in the different aspects of fisheries in different categories of fisheries personnel are also available.

So far, the National Institute of Freshwater Fisheries Research has changed the life of Nigerians in so many ways. It has achieved among others, the resettlement of the displaced population in New-Bussa, the studies of Wildlife population and other characteristics, yearly production of fingerling from broadstock of Mudfish Clarias and Tilapia and other culturable fish species and sale to farmers in various parts of the country at subsidized prices, construction of a Green House for Mass production of Natural fish food. Assisted Government and private establishments in different parts of the country by setting up fish hatcheries and farms, pollution studies of major Rivers and Lakes, with recommendations and strategies for control made by the appropriate bodies. Investigations and calculation of potential fish yields in respective water bodies, transfer of large number of Tilapia fingerlings and Clupeid live sardines from Jakara reservoir into Ruwan Kanya Lake, both in Kano State and also from Kainji into midwaters of Tiga Lake also in Kano State, aimed at improving fish production in the country, and identification of some major parasites affecting both cultured fishes and those in the wild at different water bodies in Nigeria.

The Institute has also been offering consultancy services in the areas of fish farming feasibility studies; Hatchery design, construction and management; fish aquaculture techniques and management; Technique for mass production of zooplankton; Gear design construction and repair; Fish stock reservoirs; Frame survey;Wetland ecological survey; water quality assessment in Lakes, Rivers and Reservoirs as well as Environmental Impact Assessment.

The Kainji Gas Smoking Kiln is a product of the NIFFR, New Bussa. It was invented in 1981 and has been found very efficient.

NIFFR has recommended culturable fish species in Nigeria as Tilapia, Mudfish, Red mudfish, African bony tongue common carp, Niger perm, Nile perch, Silver catfish, and Trunkfish. Others that are not commonly cultured are Niger perch and Grey catfish.

In 1987, the Federal Ministry of Science and Technology re-organised NIFFR, hence, the mandate of the Institute changed from multi-commodity to that of mono-commodity with emphasis on freshwater fisheries and Aquatic Resources in Nigeria.

## 1.5 Methodology

The approach of this project was based on the following strategies.

(i) Studying the existing systems and procedures

(ii) Identifying areas requiring improvement and modification for computerization and generation of reports.

(iii) Develop an underlying system to timely Management Information System requirement in various areas.

(iv) The new system is to achieve some set goals that have not been embarked upon before in the Institute under the present manual system.

## 1.6 Problem Definition

The problem is to look into the possibilities to which Linear programming can be used to formulate least cost ration in fish feed compounding.

Before the above problem can be solved, there must be a clear definition of such problem. However, the following questions may help in defining the problem:

(i) What is the problem?

(ii) Details of the problem

(iii) How significant is the problem?

(iv) What are the feasible solutions to the problem.

In the cause of defining the problem, if reasonable margin of profit is to be maintained in the face of rising feed costs, either the prices of products will have to be significantly increased or the increase in the efficiency of production (in terms of yield per fish and efficiency of feed utilization) must be more than proportionate to the increase in the cost of production. But, a substantial rise in product prices will dampen demand, lead to a cut back in production and create excess capacity in the industry. It would appear that the most reasonable cause of action is a combination of measures designed to reduce the cost of feeds through improvement in feeding practical and the quality of diets such that high level of animal performance and feed efficiency could be obtained.

## 1.7 Feasibility Study

This stage is otherwise referred to as the preliminary investigation. It is a preliminary stage that is embarked upon to determine whether or not the proposed project is desirable. Therefore, it involves the study of the existing system in details in order to provide the management with details information about the proposed computerization system.

The feasibility study covers three major areas;

(a) Designing the computerized system

(b) Testing and implementation of the computerized system.

To test project feasibility, the following are to be considered

(i) **Operational feasibility:-**This relates to the workability of the proposed information system when developed and installed.

(ii) **Technical feasibility**: This test seeks to clarity if the proposed project can be done with current equipment, existing software technology and available personnel.

(iii) **Economic feasibility**: The test for financial feasibility is undertaken to assess cost of implementing a proposed project, that is, the benefit derived from implementing the project.

### 1.8 Facts Finding Technique

Three basic methods were employed to collect data.

(i) **Interview**. It is a fact finding tool used for collecting information from individual or holding discussion with people that are involved in the day to day operation of the system in order to ascertain their suggestions and comments and also the relevance of any particular report or statement required from the department. Interview is one of the most satisfactory ways of obtaining information particularly to get information about objectives, constraint, allocation of duties, problems and failures in the existing system.

(ii) **Observation** This involves watching an operation for a period to see what happens by oneself.

(iii) **Special purpose Records** These are records that contains specific records in an organization which may be files, journals, seminar papers, or even textbooks.

### 1.9 Scope and Limitation of study

This study concentrates on only NIFFR New-Bussa. The study is also limited to the few raw materials and ingredients selected for the project. The data for the constrains are based only on *Clarias gariepinus* fingerlings.

It is also assumed that responses to the questions and data obtained from special purpose records are correct. The authenticity of the information collected therefore, is limited to the level of respondents' fairness, biasedness, suspicion and their general perceptions in the questions involved. Furthermore the study is limited to the Tropics, the climatic and vegetational location of New-Bussa.

Finally, it is the candid opinion of the researcher that there are other factors responsible for fish growth other than fish feed, such factors include; fish type, fish population, Fish ground (size and shallowness) biotic (Plants and animals) and other environmental factors such as season and weather condition.

**1.10 Definition of Terms**

(i) **Computerization** An art of using electronic device which accepts and processes data by following a set of instruction (programme) to produce an accurate and efficient result (information).

(ii) **Linear programming** This is one of the few mathematical tools that can be used in the solution of a wide variety of large and complex problems that involve decision making. Each linear programming has an objective function and a set of constraints. Maximizing or minimizing constrain are the common objectives.

(iii)**Least cost** The most reasonable course of action from a combination of measures designed to reduce the cost of feeds through improvement in feeding practices and the quality of diets such that high level of animal performance and efficiency could be obtained.

(iv) **Ration formulation or Feed Compounding**

The collection, defining and mixing together of various raw materials putting the ingredient level into consideration so as to produce a given weight of any ration which meets specific nutritional requirement of a given animal or bird.

# CHAPTER TWO

# REVIEW OF RELEVANT LITERATURE

## 2.1 INTRODUCTION

This Chapter attempts a review of relevant literature. This will enable the researcher not only to have ideas or plans underlying the rationale of the study but also appraise the previous work done on fish feed formulation.

## 2.2 Feed formulation and Animal Performance

In his contribution to feed formulation, Bisi (1988) opined that the problem of feed formulation should be considered from two broad perspectives,

(i) The problem of feed formulation as it affects the feed compounder

(ii) The problem of feed formulation as it affects the Fish producers.

The objective of the two participants are somewhat different; so also are the economic criteria which guide the attainment of their objectives.

The feed compounder is interested in maximizing returns on the capital invested in plant, equipment and buildings. His pre-occupation is, therefore, the plan as optimum production policy for the mill as a unit, given the capacity of the mill and his market potential.

Following the above, the fish compounder sets out to minimize the cost of producing a given weight of any ration which meets specific nutritional requirements of a given animal or bird. For, it is by so doing that the feed compounders can maximize profit given the cost of ingredients and the selling prices of compounded rations. It is important to note however, that, as far as the feed miller is concerned, the compounded rations need not necessarily be the ones that can produce the maximum rate of liveweight gain when fed to animals or birds.

The Fish farmer also aims at maximum profit within the fixed capital structure of his farm, but one of the ways to achieve this objective is to maximize returns over feed costs. Unlike the feed compounder owner, the livestock producer is mainly interested in using the least-cost ration to achieve the maximum live-weight gain per unit of feed. In other words, the livestock producer is interested not only in diets that meet certain nutritional specification at the lowest cost, but also in the response of the animal or bird to such feeds. To the extent that the benefit of least cost ration can be passed down to the livestock farmer, he will gains in terms of better animal performance and reduced feed cost.

### 2.3 Fish Feed Formulation and Linear programming for formulating

Fish require a well balanced diet for the supply of energy, sufficient indispensable amino acids, essential fatty acids, specific vitamins and minerals to support life and to promote growth. Fish in their natural habitat meet their nutritional requirements by feeding on the abundant natural food in the water bodies. Under semi-intensive or intensive culture systems characterized by high stocking density, artificial feeds must be supplied to supplement the limited natural food in the culture system.

The importance of fish feed in fish culture is supported by the fact that the highest proportional cost of a fish culture system is expended on fish feeds accounting for over two-thirds of the variable cost of a fish culture operation. The rapid expansion and success for commercial fish culture therefore depends largely upon the availability of good quality and cheap feeds. Apart from nutritional consideration and cost, fish feeds must be in the form that would render them readily available to the fish.

Eyo (1995), asserted that, the need to supply a well balanced diet to supplement the natural fish food in the culture system is important for two main reasons:

(i) To enable the fish attain optimal growth within a reasonably short period in order to make fish farming a profitable venture.

(ii) To ensure good health of the cultured fish.

With the wide range of feed materials available in the country, the problem envisaged is one of obtaining a minimum proportion that would satisfy all the nutrient requirements of the fish and be of least cost. An essential pre-requisite to formulating least cost fish feed is the knowledge of the nutritional value and technological properties of each feed ingredient. For some processed feedstuffs, individual samples can differ widely in their nutritive value. Such differences may be attributed in part to the quality of the raw materials and in part to the damaging effects of the processing methods employed. Unless the amount and availability of nutrients supply by the ingredients are known with a reasonable degree of accuracy, formulation of efficient diet becomes very difficult. A knowledge of the technological properties of feed ingredients is required if the produced feed is to remain stable in water and float or sink as desired, thus, reducing feed wastage.

In the feed production industry, the producer is given a number of parameters which guide his formulation. Lower and higher limits are set for some of the ingredients and the relevant important nutrients. With these limits, an empirical solution to the optimization problem accompanying their objectives become positive.

## 2.4 Basic Biochemistry of the elements in Fish nutrition.

Eyo (1995) a reknown principal research officer and a fish nutrition specialists, shed more lights on fish nutrition that the elements of fish nutrition are:

(i) **Protein and Amino Acids**

Protein are complex organic substances occurring naturally and formed from combinations of amino acids. Proteins are the most important constituent of fish tissues and automatically the major component of fish body. They are made up of carbon, oxygen, hydrogens and nitrogen. Proteins are varied in shape, size, composition physical properties and functions. They act as enzymes, structural elements, receptors, antibodies and hormones.

Protein requirement of fish is limited to a few species, carnivorous species appear to require more protein in their diets than herbivorous ones. The cat fishes require more protein than Tilapia (Eyo '95).

(ii) **Amino Acids**

Amino Acids are regarded as the building blocks of protein and about twenty three amino acids have been isolated. These Amino Acids can be classified into two groups - Dispensable (non - essential) and indispensable (essential). The dispensable Amino Acids are those that could be synthesized readily by the fish. The indispensable amino acids are those that cannot be synthesized at the rate needed by the body. That is, the body does not possess the necessary carbon skeleton to synthesize the indispensable, and therefore must be supplied by the food. Fish are known to require ten amino acids in their diets. They are: orginine, histidine, isolencine, leucine, lysine, methionine, phenylanine, threonine, tryptophane and valine. A knowledge of the requirement of indispensable amino acids is important in feed formulation in that if only one out of the ten indispensable amino acid is present at 50% of the required level, only 50% of the dietary protein will be used for protein synthesis and the rest will be carbolised for energy.

(iii) **Lipids and Fatty Acids**

Lipids are fat soluble compounds found in plant and animal tissues and made up of fats, phospholipid, sphingonylins, waxes and sterol. Lipids are made up of the chemical elements of carbon, hydrogen and oxygen which are contained in carbohydrates. Dietary lipids provide energy which is about twice as much as energy produced by carbohydrates. Fats help as a vehicle for absorption of fat soluble vitamins, increase feed palatability and serves as precursors for steroids, hormones and other compounds.

Too much fat is not desirable in fish feed because it can cause an imbalance of protein and energy in the ration, it can cause excess fat in the fish and it can affect binding of the feed components during pelleting (Hastings, '76).

Excess amounts of lipids in feeds may result in the deposition of too much fat in the flesh which reduces the real flesh of the fish, reduces the frozen storage period, changes in taste and flavour known as Rancidity (Eyo '90).

(iv) **Carbohydrates**

Carbohydrates represent a broad group of compounds which are composed of carbon and oxygen with Hydrogen and oxygen present in the ratio of 2:1

Sufficient amounts of starch in feeds allows fish to use dietary protein mainly for growth, reproduction and maintenance, instead, of utilizing it as energy source. The merit of this sparing effect of carbohydrates on protein is that it reduces feed cost since carbohydrates is the cheapest source of energy in fish diet. Apart from being a source energy, carbohydrates also act as a binder in pelleted feeds by texturizing the pellets and thereby reduce their disintegration.

v. **Vitamins**

Vitamins are organic chemical compounds which are required in small amounts for normal growth, reproduction, health and maintenance of fish metabolism. Vitamins are grouped into the eight water-soluble B Vitamins, the macrovitamins L - ascorbic acid, choline and myo-inositol, and the fat soluble vitamins A, D, E. and K. Vitamins requirements are effected by the size, age, growth rate of fishes and by environmental factors and nutrient interrelationship (NRC, 1983).

Eyo (1995) opined that fish grown in ponds seldom suffer from vitamin deficiency diseases due to the abundant natural food in the pond. He continued that vitamin premixes in common use in this country are the poultry premixes which are formulated for the growth of birds and not for fish.

(vi) **Minerals**

Mineral requirements of fish is similar to those of terrestrial animals. Calcium, phosphorous potassium, chlorides, magnesium, iron, manganese, zinc, copper, iodine, cobalt and fluoride. Of all these, calcium and phosphorous are required of large quantity. Fish can however, absorb some of the minerals in the suited and this reduces their requirements.

**2.5 Types of Artificial Feeds**

(i) **Fresh wet feeds**

These are mainly animal slaughter by-products and fish offals which are fed directly to the fish. Good feed value have been found for beef liver, spleen, heart, cod ovaries, crustacea and poor value for lung, kidney, trimmings, intestines, fish offals and Ovaries (Gluttino, 1972). The fresh wet feed has on advantage of making it possible to utilize the wastes generated by fishing industry and processing as well as scrap fish unusable for human food or animal feed without supplemental processing. The main advantages of moist pellet is its suspectability to microbial spoilage unless stored in refrigerators.

(ii) **Pellet Feeds**

Pelleting involves the use of moisture, heat and pressure to agglomerate ingredients into larger homogenous particles (NRC, 1983). Good quality pellets are resistant to crumbling or disintegration while in water and this is a function of the amount of fat, fibre or starch is the formula.

(iii) **Cooked-Extruded**

Feeds extrusion involves passing finely grounded ingredients which have been cooked with steam or hot water, through a die from a zone of high temperature and pressure to the lower temperature and pressure. During the cooking process, starch is gelatinized which allows strong intermolecular bonding. However, the additional hasting increase digestibility of starch and gives extruded feeds better in water stability than pelleted feeds. The main advantages of extruded feeds are :

(i) Extruded feeds float so that the problem of the feed being unavailable for the fish is minimized.

(ii) Fish farmers could easily access the level of feed intake by the fish, especially in ponds where the stocking rate is not known.

However, because of the additional cost of extrusion machine which cost 10 to 20% more than pelleted machines, pelleted or sinking diets are more common locally. The machines ferbricated locally are able to produce pellets that are hard enough and do not disintegrate readily in water before the fish could get to them. (Eyo, 1995).

## 2.6 Linear programming applications

All decisions including business decisions involve selecting from a set of alternative courses of action available to one. Each course of action, if selected will be carried out in some future "State of the world" and the cause of action will depend on which of the many futures actually occurs.

Adeboye, (1998) wrote that, in most business situations, each outcome will give rise to a profit or loss and it is the comparison of these expected gains or losses under the various possible future states' that determines which course of action is selected.

Adeboye, (1998) classified Linear programming into:

(i) Decisions under certainty, that is, when sufficient data and information are available

(ii) Decisions under uncertainty, where no statistical data is available to help in decision making process.

Linear programming is defined as one of the few mathematical tools that can be used in the solution of a wide variety of large or complex problems that involve decision making. Such problems are characterized by the goods and restrictions (constraints). Each linear programming has an objective function and a set of constraints. Maximizing profits or minimizing cost are common objectives.

**Linear programming problem**

A linear programming problem is one where the feasible region is a subset of the non-negative portion defined by linear equations and inequalities and/or the objective function to be minimized or maximized is linear, that is, of the form $P(X_1, X_2 \ldots\ldots X_n) = a,x,+ a_2 x_2 + \ldots. ax+$

General Format for Linear programming problem

Maximize or Minimize X = [Pijxj, j = 1,2...n subject to:

{Aij x j(<,>, =)b

i =1,2.....M

The Xj, j = 1, 2.... n are called the decision

variables

$P_j$, is the per unit effect of the activity

j on the objective. The total number of constraints or restrictions

$b_i$, is the upper limit or lower limit that cannot be exceeded or below which we cannot go

$A_{ij}$, is the per unit consumption of the 5th constraint by the activity J.

**Assumptions of Linear Programming**

(i) **Optimization** - It is assumed that an appropriate objective function is either to be maximized or minimized

(ii) **Fixedness** - At least a non-zero right hand side co-efficient.

(iii) **Finiteness** - a finite number of activities and constraints to be considered so that a solution may be sought.

(iv) **Determinism** - The limits of the constraints must be observed.

(v) **Hormogenity** - All units of the same resources or activities are identical

(vi) **Additivity** - The activities are assumed to be additive, that is, the total product is the sum of the individual products.

(vii) **Proportionality**- The gross margin and resources requirements per unit of activities are assumed to be constant regardless of the level of the activity.

Adeboye, (1998) concluded that Additivity and proportionality together define linearty as the activities, thereby giving rise to the name. Linear programming.

**Types of Linear programming problems**

Adeboye,(1998), classified linear programming problem into three

(i) **Resource Allocation problem** This is to determine how to use limited assets to maximum gain or minimum loss.

(ii) **Transport problems** - Finding the cheapest means of transportation of goods-

(iii)**Diet problems** - Finding the best food-mix that would result in the maximization of profit or net gain in value and/or minimize cost of services.

It is on this latter problem that researcher base his work.

# CHAPTER THREE

## RESEARCH METHODOLOGY

### 3.1 Analysis

The fish feed formulation activities of the National Institute of Freshwater Fisheries Research (NIFFR) are recorded by a manual process using a fairly adequate set of document which could be modified to form the base for a computerized information system. From my personal investigation and study, the present problems of diet formulation computerization centre around inadequate follow up rather than the absence of proper procedures.

The analysis is concerned with the study and gathering of data about the existing manual system used for fish feed formulation. The identification of problems and difficulties encountered by the feed compounder and the factor that influence the management of introducing computer into diet formulation. The system analysis is therefore, concerned with the NIFFR management objective in converting information and data from manual processing to the method of computerization.

Full and detailed analysis was carried out of the current manual system of diet formulation to establish the following

(a) procedures

(b) Information flow

(c) Method of work, organization and control.

The procedure is concerned with the procurement and formulation of ingredients and nutrients and their restrictions as well as the cost involves in fish feed compounding. The information flow is triggered by management action plan for a particular period of time, the information flow circle runs from the action plan through procurement, distribution, formulation and feedback, Since the fish nutritional activities are recorded by a manual processing using a fairly adequate set of documents which could be modified, the addition of few new formats to form the base for a computerization information system becomes necessary.

### 3.2 The Existing System

Beside the varieties of artificial feeds such as Fresh wet feeds, pellet feeds and cooked-Extruded feeds as highlighted in Chapter two, and the manual compounding of fish feeds like dough, pelleting and drying and bagging which is also discussed in Chapter two, fish feed are manually prepared as below:

#### 3.2.1 Preparation of fish feeds

(a) Materials - Plastic bowls, Grinding machine, pelleting machine, or hand pelleter, oven weighing balance, Nylon bags, pan and pot.

(b) Ingredients Maize, groundnut cake, soyabean, blood meal, fish meal, vitamin and mineral premix and bone meal.

(c) Preparation of Ingredients

(i) **Maize** The maize is ground to a fine powder. The chaff after extracting the starch can also be used.

(ii) **Groundnut cake** This can either be bought from companies or can be prepared locally as we do when preparing "kulikuli". The groundnut cake is ground to a fine powder.

(iii) **Blood meal** Cow blood meal is collected with a plastic bowl from the abattoir and cooked in a pot to a semi-solid-blackish form. The coagulated blood is dried in the sun or oven (electric or gas) and then ground into powder.

(iv) **Soyabean meal** Soyabean meal is toasted by roasting on a hot pan or pot for a short while usually ten to fifteen minutes. If it is in the oven where temperature is under control, then toasting can be done for 30 minutes at 1000□C. The toasting improve the quality of the soyabean as well as making it easier for the hull or outer coat to be removed. The soyabean is ground in a grinder and the hull is winnowed away before final grinding into a fine powder.

(v) **Fish meal** Fish meal is any fish or parts of fish that has been dried and ground into a powder. The quality depend on the parts of fish that have been used for fish meal. So a fish farmer can prepare his fish meal by simply collecting tilapia in a bowl, drying the fish in the sun and grinding them to powder. Any fish can be used e.g Clupeids, tilapia or other small fishes or fish waste.

(vi) **Vitamin and Mineral Premix** These are added to the fish to supply vitamins and minerals which the feed ingredients could not supply. The premixes used for poultry rations can be used since those for fish are not easily available. These can be bought in the agricultural product shops.

(vii) **Bone meal** The bone meal supply additional minerals to the fish and can be prepared either by steaming or burning cow bone.

When all the above ingredients are manually prepared or supplied, the compounding is done by mixing them together in different proportions so as to give the desired diet level required by the fish.

### 3.2.2 Balancing food level

PEARSON'S SQUARE METHOD is the most popular method in NIFFR used in determining the proper dietary proportions of feedstuffs provided the ingredient requirement of the fish is known. Eyo (1995) on pearson's square method gave an example of a fish farmer who intends to feed his fish with yellow maize with crude protein (C.P) of 10.8% and groundnut cake c.p 40.6% to give a 30% crude protein in the diet. A square is constructed and the desired percentage of crude protein in the final mixture is placed protein of yellow maize (10.8%) is placed on the upper left corner and that of groundnut cake 40.6% on the lower left corner. Then the percentage crude protein in yellow maize (10.8%) is subtracted from the percentage of crude protein desired in the mix (30.0) and the difference (19.2) is placed on the corner of the square diagonally opposite from the maize. Similarly, the percentage crude protein desired in the mix (30.0) is subtracted from the percentage crude protein in the supplement (40.6%) and the difference (10.6%) is placed on the corner of the square diagonally opposite from the supplement. The positive and negative signs are ignored.

The above remainders represent the proportions of these two feeds which will provide a mix containing the desired percentage crude protein. The amounts are thus converted to percentage.

10.8          10.6

30

40.6          19.2

29.8

$$\frac{10.6}{29.8} \times 100 = 35.6\% \text{ Yellow maize}$$

$$\frac{19.2}{29.8} \times 100 = 64.4\% \text{ Groundnut cake}$$

## 3.3 System Design

This is the stage where the proposed system is designed for both clerical and computer procedure, data capture and management information system.

The method selected for the new system is the selection of same of the present set of documents been used, which are fairly adequate to be modified with the design of few new formats to form the base for computerized information system. The files and programs are kept as simple as possible to be users friendly in relation to computerization of least-cost ration in fish-feed formulation.

### 3.3.1 The design of the proposed system

After the system analysis which produces detailed description of the existing manual systems and highlights the areas where improvement is needed, then the next stage of the proposed system is the system design.

The initial step toward system design is the identification of system requirements, and the formulation of design alternative.

The requirements are those factors or details that have to be incorporated to the propose system to produce the desired result. In designing the system, the following strategies are adopted.

(i) Identifying areas that require improvements and/or modifications for computerization by the organization (NIFFR)

(ii) Develop an underlying system to achieve the computerization requirements of the least-cost diet formulation.

(iii) Ensure that the proposed system is easy to operate, understood by all the staff of fish nutrition, and which requires minimum changes in the existing systems.

(iv) **Flexibility**:- The propose system should be possible to modify in future to enhance efficiency.

(v) **Maintainability**:- The system should be subject to changes and to be sustained in the long run.

(vi) The staff members must be adequately trained to carry out the new system.

(viii) The system must be able to minimize human error associated with a manual system.

(ix) It must be efficient, portable and user-friendly.

### 3.3.2 Construction of Basic Matrix for Least Cost Ration

The stages in the construction of least cost linear programming model are as follows:

(i) Listing the available ingredients which represent the activities to be considered in the model

(ii) Specifying the levels, in percentage terms, of the nutrients which are crucial to growth and good performance of the different categories of fish. These are often referred to as nutrient constraints.

(iii) Listing the prices per tone of component ingredients (price coefficient).

(iv) Specifying the nutrient composition (technical coefficient), also in percentage terms of individual ingredients

(v) Specifying the limit, in percentage terms, of inclusion of certain feed ingredients in the ration (ingredient constraints).

These steps are explained with reference to the basic matrix in Table 1 in respect of the formulation of least cost in fish feed compounding.

### 3.3.3 **Ingredients or Activities in the Model.**

Table 1 shows the various feed ingredients that could be used in a typical fish feed ration, including their nutrient composition and prices per tone. The list of ingredients is not exhaustive and can vary from locality to locality, depending on their availability. Any set of the combination of ingredients can meet the nutritional specification of fish. However, the set of ingredients selected in the optimum solution should not only meet the ingredient and nutrition constraints but must do so at minimum cost.

Fourteen (14) ingredients are considered in this model. They include grains, mostly maize which usually form a significant proportion of the energy-yielding nutrients in fish feeds and contribute reasonable quantities of amino-acids, particularly the sulphur amino-acids, methionine plus cystine. These ingredients are available from local source, although their supply is subject to seasonal variations. The quality also varies, depending on the variety and efficiency of storage and processing.

Blood meal, fish meal and soya beans supply bulk of the fish protein in the diet. They are also readily available from local sources and are subject to wide variation in quality, depending on the processing techniques used. Both vegetable and cod-liver oil provides bulk of the required energy.

Calcium and phosphorus are to be supplied largely by Oyster shell, Bone meal and Duckweed. Water fern, Rice bran and Duckweed supply bulk of the fibre.

The vitamins and other minerals are to be supplied through the inclusion of vitamin mineral premix which are usually imported.

Differences in composition and quality of ingredients often arise due to differences in variety, local processing techniques, storage practices and agronomic treatment prior to processing. There may also be variations in the kinds of available ingredients from country to country and from region to region within the same country; the composition of ingredients may also vary from time to time. What is important however, is that the nutrient composition of each ingredient must be accurately determined before being used for least cost ration formulation.

(i) The price co-efficient

The price coefficient represents the cost of purchasing a tone of each ingredient.

(ii) The Technical Co-efficient

The nutrient compositions are equivalent to the technical co-efficient in the basic matrix of the optimization model. For example, yellow maize was estimated to contain 10.0% crude protein, 2.3% fibre 0.25% Lysine, 0.7% phosphorus. Other ingredients in the basic matrix have been similarly estimated for their nutrient composition.

3.3.4 **Restriction in the Basic Model**

Three distinct groups of restrictions are specified in this model - These are:

(i) The nutrient requirement specifications

(ii) The ingredient level specification

(iii) The quantity of the total mix of ingredients, generally refereed to as weight constraint.

The formulation of these constraints requires a very good understanding of animal nutrition and Biochemistry. Least cost ration formulation, therefore, requires an inter-disciplinary approach involving Agricultural Economist and Animal nutritionist. (Ogunfowora 1988).

The performance of intensive fish enterprise is largely determined by nutrient content and balance, as well as the intake of the rations. The level of intake is, in turn, a function of palatability and particle size or texture of the feed.

The intake of nutrients affect the growth rate and carcass conformation. Also, the energy supplied to fish greatly influences the rate of live weight gain. When fish are fed with unbalanced rations, growth rate and efficiency of liveweight gain are reduced, resulting in low levels of profit. It is important therefore, when formulating rations, to ensure that all the important nutritional factors are provided in adequate quantities and ratios.

(ii) Ingredient constraints.

Certain restrictions on the level of inclusion of available ingredients are imposed to conform with proper nutritional requirements and take account of their availability and costs. The forms in which same nutrients exist in the ration influence the efficiency of utilization, for example, allowance is made in the model for the nonavailability of phosphorus from grains and vegetable sources by ensuring that the ration contains reasonable percentages of Oyster shell or bone meal.

(iii) The weight constraint

The weight constraint fixes the quantity of the mix within which the nutrient requirements and the ingredients specifications must be met. The model is constrained to produce exactly 1.0 tone of ration.

### 3.4 **Cost - Benefit Analysis**

This is a technique for choosing from among alternatives to identify a preferred choice when objectives are far less specific than those expressed by such clear quantities as sales, costs or profits. The system is an improvement over the traditional marginal analysis. It is a technique of weighing alternatives where the optimum solution cannot be conveniently reduced to some other specific measure.

The major features of cost effectiveness are concentration on output from a program or system, weighing the contributing of each alternative against its effectiveness in serving desired objectives, and comparison of costs of each in terms of its effectiveness.

Although cost benefit analysis involves the same steps as any planning decision, the major features that distinguish cost effectiveness are:

(i) Objectives are normally output or end-result and usually imprecise.

(ii) Alternatives ordinarily represent total systems, programs, or strategies for meeting objectives.

(iii) The measures of effectiveness must be relevant to objectives and set in as precise terms as possible, although some may not be subject to quantification.

(iv) Cost estimates are usually traditional and normal, but may include nonmonetary as well as monetary costs, even though the former may be eliminated by expressing them as negative factors of effectiveness.

(v) Decision criteria, while definite but not usually as specific as highest profits, may include achieving a given objectives at least cost, attaining it with resources available, or providing for a trade-off of cost for effectiveness, particularly in the light of the claims of other objectives.

Cost effectiveness can be made most systematic through the use of models such as: the Net

Cash Revenue, Cost of Investment, Terminal or Salvage value of investment, and The interest or Discount rate to use.

Among the cost concepts that are used in decision making, such as marginal cost, sunk cost, and differential cost, the differential cost is found most appropriate to the introduction of the system in the Institute.

In differential cost, there are times when the business person must make a decision on whether to modify methods and equipment even though there may be no significant changes in revenue. Often, new machinery is introduced into the production process because it provides better control over quantity or quality of output, or because it reduces cost of production. Before the decisions to change is made, the differences in cost between the existing situation and the proposal should be examined.

There is no doubt that the system may result in the elimination of  involving routine, monotonous  and sometimes hazardous tasks. However, the loss of these jobs has been offset by the creation of more challenging ones carrying greater responsibilities and offering more opportunities.

Finally it should be noted that the cheapest alternative is not always the most effective, particularly when effectiveness is measured by various factors and although the change may not bring in additional revenue, if there are any cost savings such as time or energy as a result of the change, they represent the eventual net effect on revenue.

### 3.5 **Features of Basic Programming**

The proposed system is recommended to be Basic programming.

Basic stands for Beginner's All-purpose symbolic instruction code. The language was developed in 1964 at Dartmonth College, U.S.A. by Professors J. Kenny and Thomas Kurtz(1). It is a high-level programming language whose method of coding and syntax is oversimplified for whatever class of user, literate children inclusive, and hence from the name it is meant for beginners.

One very vital characteristic of BASIC is its availability of on all Disk Operating System (DOS). It is sufficient therefore to say that if a system runs on DOS then it have the BASIC interpreter.

A computer is often called a sequential machine and this structure is incorporated in the design of the language. BASIC programs have line numbers, each number per statement and that reflects the order of processing of the instructions. In effect, it helps beginners to be able to design their program in a chronological order.

The BASIC interpreter like a language translates the program, statement by statement and executes it before going to the next statement that contains no error while the interpreter signifies the line thereafter that contains the error. Therefore you keep debugging the statement at the direction of the interpreter giving the statement number.

There are various versions of BASIC interpreter depending on the version of DOS available. To mention a few, the versions are:

1. GWBASIK available on DOS 3.3
2. BASIC and BASICA available on DOS 4.01
3. QBASIC available on DOS 5.0, DOS 6.0, DOS 6.1 and DOS 6.2

It is on the latter (QBASIC) that this programming language is baked.

### 3.5.1 **Features of QBASIC Programming.**

It is worth mentioning here that each version of BASIC depending on the version of DOS, shows certain superiority, that is enhancement over the lesser versions.

(i) Line numbering is optional in QBASIC and very necessary for those in lower versions of DOS, say GWBASK and BASICA.

(ii) QBASIC support blocked operations particularly structured programming than those before it. For example, Blocks of IF- THEN -ELSE-ENDIF, DO WHILE - UNTIL, LOOP. WHILE - UNTIL and many others.

(iii) QBASIC supports instant syntax checking as instructions are entered and gives instant help on errors.

### 3.5.2 Advantages of Basic programming

Basic programming possesses the following advantages:

(i) As the name implies, it is meant for `beginners' because of the flexibility and simplicity and writing and computation.

(ii) Basic is available on all Disc operating system (DOS) hence making it to be less machine dependent.

(iii) It gives instant error checking since it translates the program statement by statement and executes them before going to the next statement.

Beside all the above merits, Basic programming also possesses the general characteristics of computer which add to it's usefulness.

(i) **Accuracy** The computer produces highly accurate results once the input is correct. Machine errors rarely occur because of in-built error detecting schemes within the computer. In most cases, errors in computing are due to errors in input from the users.

(ii) **Reliability** A computer is consistent and diligent in it's mode of operation, which means it is reliable. Being a machine, it does not suffer from the human traits of tiredness and lack of concentration. It will perform the last task with the same speed and accuracy as the first task given to it, no matter the number of tasks involved.

(iii) **Storability** The computer can store and process large volumes of data without accuracy being affected. Data is stored in the memory sections of the computer. Memory is built up in K (kilo) modules where K equals 1024 memory locations. This ability makes it possible to increase the level of useful data and information supplied to management control and decision making.

(iv) **Speed** A computer has a very high speed of operation. Electrical pulses travel at incredible speeds and because the computer is electronic, its internal speed is virtually instantaneous. Complex calculations are performed within fractions of a second and results obtained first. The speed of operation is usually measured in milliseconds (thousandths of a second), microseconds (millionths of a second), nano-second (thousand-millionths of a second) and pico-second (million-millionths of a second.

(v) **Flexibility** Modern general purpose computers are flexible in that they can be used for a variety of purposes e.g concurrent batch and on-line processing, multi-programming, real time processing and so on.

(vi) **Task ability** Due to the programmable ability of a computer, it can perform almost any task provided the task can be reduced to a series of logical steps.

(vii) **Automatic** Once a program is in the computer's memory, the individual instructions are executed without the need of any human intervention.

## 3.6 Form Design

The existing formats, especially that of the pearson's square method have been for manual operations. For the new program, the formats need modifications for computerization as well as for preparation of least cost Ration formulation. The changes also take care of improvements in their functional efficiency and effectiveness.

The following forms have been designed for inputs data into the computer.

(i) Ingredient constraint form

(ii) Nutrient constraint form

(iii) Price co-efficient form

From design describes all data inputs of the proposed system in order of flow of documents.

The following strategies were adopted in the form design.

(i) Codification of locations and products

(ii) Required minimum modification and changes in the existing system.

# CHAPTER FOUR

# IMPLEMENTATION

## 5.1 Introduction

Implementation is the process of applying the developed system for the purpose it is meant for system implementation involves the development of quality assurance procedures, including data security, back-up, recovery and system control system implementation objective is to complete the orderly and unobstructive installation of the new system. During the system implementation, now system. During the system implementation, now system installed, in a test directory, where users received the opportunity to operate the new system "in parallel" with the existing system.

The system implementation comprises the following task:-

(i) Application system installation: The installation of the developed software

(ii) Documentation: To provide used manuals

(iii) Users Training: Training of users personnel on all aspects of the operation of the system.

(iv) Parallel system Testing: The program developed in the new system run parallel against the existing system.

(v) Data conversion: Upon the conclusion of the parallel testing task, the system analyst assist the users personnel in the conversion and transfer of all required data from existing system into new system.

(vi) Acceptance of Testing: The system analyst assisted by the user's personnel in conducting the testing of the developed new system to ensure that the system meet all users need and requirements.

## 4.2 Model Specification

The Linear programming model in this study is assumed to have the objective function of minimizing cost of feed production through various combinations of feed ingredients subject to the restrictions imposed by the dietary inclusion levels of the raw materials and the nutrient requirements of fish. The specified Linear programming model for the attainment of this objective is given by equation (1) That is, the objective function, through equation (9)

Equation I: Minimize 2 = [icj xj

subject to:

Equation 2: Cpi = Ebijxj - crude protein

Equation 3: MEi = Σaijxj - Estimated Metabolizable energy

Equation 4: EEi = Σeijxj - Ether Extract (Lipid)

Equation 5: CFi = Σeijxj - Crude Fibre

Equation 6: Lyi = Σeijxj - Lysine

Equation 7: METi = Σgijxj - Methionine

Equation 8: Cai = ΣLijxj - Calcium

Equation 9: PHi = Σkijxj - Phosphorus

Equation 10:MCi = ΣLijxj - Methioninetlystine

Where Z= Sum of the total cost of the various feedstuffs used in the diet formulation programme such as Fishmeal, Soyabean, Yellow maize, Azolla and others.

C = Per Unit Cost of the different feedstuffs aijbij ----Lij = the coefficients (technical) of the component of the particular nutrient found in the given feedstuffs as obtained from proximate analysis.

Based on the features of the ration described above, the cost minimization model for fish can be implicitly expressed as follows:

$$\text{Minimize } Zo = \sum_{j=i} Cj\,x\,j$$

Where:

Zo = the cost of one tone of the ration to be minimized;

Cj = the net price per unit of the jth ingredient, n=1--- -14 in this model.

Xj = is the quantity (percentage) of the jth ingredient in the optimum ration.

The objective function, Zo, is to be minimized subject to the following constraints

(i) Crude protein < or> $\sum_{j=1} aijxj$

(ii) Energy = $\sum_{j=1} bij\ xj$

(iii) Ether Extract (lipid < $\sum_{j=i} Rijxj$

(iv) Crude Fibre > $\sum_{j=i} Eijxj$

(v) Lysine > $\sum_{j=1} Eij\ xj$

(vi) Methionine > $\sum_{j=i} Fijxj$

(vii) Calcium < $\sum_{j=i} Gijxj$

(viii) Phosphorous > or < $\sum_{j=i} Kij\ xj$

(ix) Methionine + Cystine > $\Sigma Kij\ xj$
$j=i$

(x) $Xj > 0$

Where: aij; --- rij --- Kij, represent the percentage provisions of crude protein, energy, fibre and others of the jth feed ingredient, while xj is the percentage contribution by weight of the jth ingredient in the ration.

The constraints take the form of linear inequalities and mean that the total nutrients provided by all the ingredients used for compounding the ration must be equal to, less than, greater than, less than or greater than a specified nutrient level which has been found to be needed for optimum fish growth and performance.

Thus, applying the Linear programming model to the data on fish feed formulation, we have:

Minimize:

$C + 20xi =+ 35x_2 + 120x_3 + 104 + 5x_5\ 6x_6 + 5x_7 + 5x_8 + 10x9 + 25x1o + 300x_{11} + 250x_{12}\ H5x_{13}$
$+ 20x14$

Subject to:

(i) Crude protein:

$10x_1 + 42x_2 + 65x_3 + 89.2x_4 + 12.8x_5 + 28.8x_6 + 25x_7 + 0.2x14 > 32 < 40$

(ii) Energy ME:

$3432X_1 + 2700X_2 + 2860X_3 + 3080X_4 + 2860X_5 + 3491X_6 + 34950X_7 + 1716X_9 + 8170X_{10} +$
$8200X11 + 3400x14 > 2618$

(iii) Ether Extract (Lipid):

$3.6X1 + 3.5x2 + 9.6X3 + 1.3X4 + 13.7X5 + 14.1\ X6 + 10.5X7 < 5$

(iv) Crude Fibre

$$2.3X_1 + 6.5X_2 +0.7X_3 + 1.0X_4+11.1X_5 + 14.07 X_6+10.52X_7+0.08 X_{14} < 16$$

(v) Lysine:

$$0.25X_1 + 2.8X_2 +4.72X_3 + 6.33X_4+0.52X_5 +0.52 X_5+0.72X_6 +0.72X_7 + 0.08X14 < 6$$

(vi) Methionine:

$$0.17X_1 + 0.59X_2 +1.75X_3 + 0.88X_4+0.5X_5 +0.73 X_6+0.44X_7 +0.58X_9 > 0.03$$

(vii) Calcium:

$$0.03X_{14} + 0.2X_2 +5.19X_3 + 0.29X_4+0.03X_5 +0.52 X_6+9.06X_7.+62X_{89} + 37X9 < 1.5.$$

(viii) Phosphorous:

$$0.28X_1 + 0.6X_2 +2.88X_3 + 0.24X_4+0.27X_5 +0.7X_6\ 0.28X_1.+0.5X_7 + 0.07X_8 +15x9 >$$

$$0.5\ 0.7.$$

(ix) Methionine + Cystine:

$$0.39X_1 + 1.21X_2 +0.31X_3 + 2.12X_4+0.33X_5 +0.8X_6+0.68X_7.+0.73X_9 > 0.74.$$

## 4.3 DISCUSSION OF RESULT

Simplex method is one of the linear programming tools for solving problems involving the optimization of a linear function subject o a system of solving linear programming problems. It is based on the property that the optimum solution to a linear programming linear constraints. The simplex method is the most general and powerful method of all available method for solving linear programming problem. If it exists can also be found in one of the Basic feasible solutions.

In minimisation case of the simplex method, it is required to covert the inequalities into equalities by subtracting rather than addition of Planck variables. In most cases we observe that the non-negativity constraints for the variables does not make any sense in terms of physical interpretation of the slack variables. This situation could be avoided by the introduction of artificial slack variables into the original inequalities with infinitely large co-efficient. Hence, if artificial slack variable are introduced, then the problem can be formulated by minimization.

**Degeneracy in Linear programming Problem.**

When applying the simplex algorithm, one needs to identify the pivot column and the pivot row in order to proceed from solution to the next. However, two problems could be faced while attempting to select the pivot row.

i) The initial simplex tableau may be such that one or more of the variables currently in the basis has or have value zero. It will then appear that the replacement process cannot be continued for the variable to be replaced is already zero.

ii) The Minimum non-negative replacement ratio for two or more variables currently in the basis may be the same . In this case, there is a tie in terms of selection of the they row . Removal of one of the tied variables will also reduce the other tied variables to zero.

The two conditions above give rise to a phenomenon known as degeneracy. Attempts to solve degenerate Linear Programming problem will show that either:-

a) After a finite number of interactions the l optimal solution can be obtained.

b) the problem begins to circle, thereby preventing the attainment of the optimal solution. A problem circles if, during the solution stage, we keep returning to the same basis.

**Solving a Degenerate Problem**

When a degenerate problem arises, the following steps should be taken to resolve it

i) Identify the tied variables or rows

ii) For each of the column in the identity (Starting with the extreme left hand column of the identity and proceeding one at a time to the right) compute a ratio by dividing the entry in each tied row by the key column number in that row.

iii) Compare ratio, column by column proceeding to the right. The first time the ratios are unequal, the tie is broken.

iv) Of the field rows, the one in which the smaller algebraic ratio falls is the key row

v) If the ratio in the identify do not break the tie from similar ratios for the column of the main body and select the they row as described in three to four.

**The Result**

The first page of the output shows the total input in rows comprising the fourteen variables from x1 to x14. -Z represents the cost while the RHS depicts the right hand side. The G and L stands for Greater than and less than respectively. The tableau shows the constraints at the RHS. For instance, x15 shows the minimum constraint for protein while x16 shows the maximum constraint for the same ingredient. The pivot at this stage is 8200.

The output was iteracted six times before a final result was given which appear on the final page of the output.

The following steps are necessary for computing simplex methods in minimization case.

The first step is to check whether the constraints on the right hand side of the variables are already non-negative. If no, re-arrange the original system of equation so that all the constraints terms are positive or zero either by changing where necessary the signs of both sides of any of the equation.

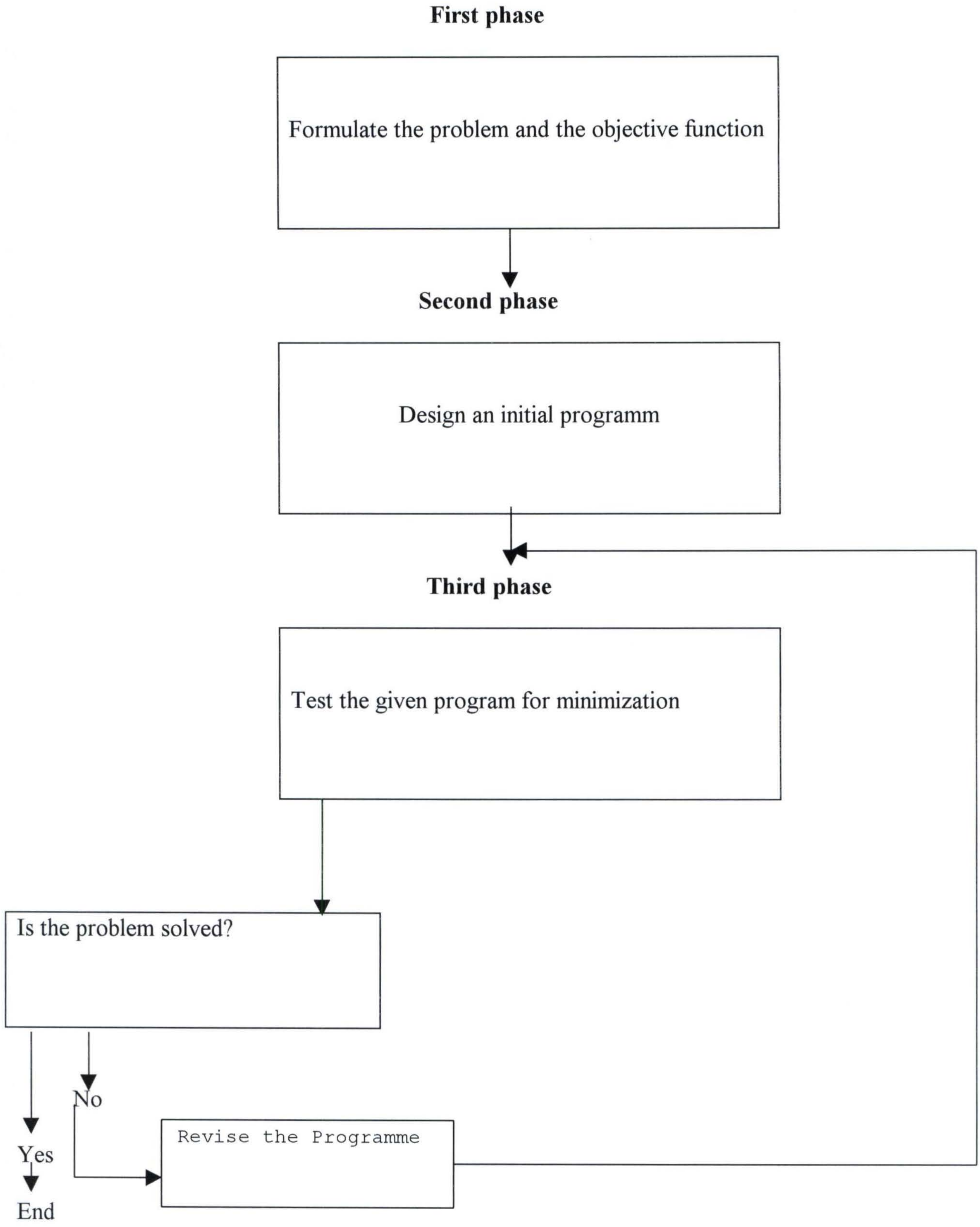
The second step is to ascertain that the constraints are not only in standard form but also in canonical form by adding artificial variables.

The next step is to design the feasibility form by putting the variables in complete array. This array can be written in canonical form with basic variables, since this canonical system could provide an initial basic feasible solution before starting the phases of simplex method.

Step four involves the checking the basic feasible solution and ensure that it does not contain any of the artificial variables and the last values is equal to zero. If this condition is met, then, phase one is completed.

The last step consists of starting phase two computation by dropping the "zero value" row from further consideration. The result of phase two are again shown in table form. When all the ration are non-negative, phase two of the simplex is completed.

The above discussion are the steps involved in solving linear programming method by manually. For mechanical approach, the following diagram is a schematic representation of the simplex method algorithm.


First phase
Formulate the problem and the objective function
Second phase
Design an initial programm
Third phase
Test the given program for minimization
Is the problem solved?
No
Yes
End
Revise the Programme

## 4.4 System Testing

After the installation of the new system, if the system must undergo a test; once all the programs have been written and the training of the departmental personnel is completed. The system testing is to ensure that all the programs have been efficiently and correctly written. The system testing entails the execution of the program with text data so as to enable the system developer and the management to know the operational efficiency of the system.

The system testing will also enable the designer to correct errors and delete programs that are not efficient by dobugging process with text data input into the programs so as to produce the desired output deports.

During this task, the programmers or the System Designers assists the project staff in conducting the testing of the developed system so as to ensure that the system meets all the users needs and requirements. System testing entails the testing nd certification of the system developed. Testing is conducted in order to determine if the physical data model implemented, properly represents the conceptual model. This phase ensured that all required features, functions, and capabilities are present in the system developed, and that all other requirements are met. Any necessary revision are made during the system testing.

## 4.4 Hardware Requirement

Major options for system design include mainframe computers, minicomputers, and microcomputers. The choice depends on the task to be done and the financial capability of the Institute. Factors in selection of the Hardware requirements depend on the software package developed for the system.

The system design should be able to establish the volume and capacity of the software package before determining the hardware requirement.

In this system, the hardware requirements are:-

(a) Microcomputer with RAM 640KB, CPU model 80586, Hard disk (MB) 30, Floppy 3□, Basic Interpreter of DOS 5.0,

(b) Peripherals; Dax matrix print, Laser Jet printer, Tape Drive for Back up.

Microcomputers represent the small-scale and of the continuum. Since the entire central processing Unit (CPU) is on a single microprocessor clip, it is possible to house the entire microcomputer system in a desk-top or even a portable unit. While it is possible to configure microcomputers as multi-user machine, they are usually stand-alone, single user machine.

Microcomputer based system make computer experimentation more financial feasible, not only because of relatively low cost but also because implementation can proceed in gradual stages.

Since microcomputers require less support personal than either mainframe or minicomputers, recurrent cost are substantially lower.

The computer should have a speed of at least 40 MHZ to aid fast processing of records and a UP5 which can store power for a period of time - about forty five (45) minutes to safeguard against power failure.

## 4.5 Change over

The change over from old to the new system may take place when the system has been proved to the satisfaction of the new system analyst and the other implementation activities have been completed. The users managers (NIFFR) must have been satisfied with the result of the system tests, the training of the staff and the reference manuals.

The method and approach used for the change over is the parallel running system. The parallel system testing means processing current data by both the old and new system to cross check the results. The main advantage is that the old system is kept alive and operational until the new system has been proved for at least one system circle. Using full live data in the red operational environment of the equipments, people and data. The results of the new system will be compared with the old system to ensure the efficiency, capability and durability before acceptance by the user.

The changeover task is designed to ensure that the software developed replicate the functionality of the system to be replaced. Once the changeover ends, the user staff complete their training and the parallel system testing is successful, the change over system will move to an on-line directory, and users may commence the operation.

# CHAPTER FIVE

# CONCLUSION, RECOMMENDATIONS AND SUGGESTIONS FOR FURTHER STUDIES

## 5.1 Conclusion

Computerization involves issues of people and management as well as hardware and software information, is a resource requiring effective management as much or more than any other organization. It is evident that the advantage of computer system facilitates handling of large amount of data, a high degree of accuracy, suitability for processing edges that reflect themselves over and over, suitability for performing must complex calculations, speed and using common data for served different procedures.

Although computerization of fish feed may result in documentation of information access and use, the overall information management function should not be equally decentralized in this content the role of the information manager becomes especially critical. These role has these major elements.

(a) Understanding the new computerization and the impact it will have on the roles of organization staff;

(b) Developing and implementing services and support that match end-users (management) need.

(c) Providing direction for the organizations overall information management strategy:

(d) Managing the process of information sharing among location points of data processing in the system.

For any computerization project to be successful, it is essential that, before taking the plunge on appropriate strategy is developed such strategy should take into account the organizational factors, such as critically of the application area being considered, monetary budget, manpower and above all the organizations ability to sustain the new system.

Since fish feed production is one of the problems of aquacultural development in Nigeria, more attention should be given to the development of this aspect of fish husbandry.

This could be done by funding of Research. Institutes to conduct appropriate research, training of fish farmers in the liaison services. Useful information for the development of appropriate formula for the local species will only come after painstaking research over a period. It may not take Nigeria so long to get a suitable formula for the fast growing local species if the research efforts are properly coordinated and funded. Feed back from the farmers to Researchers through the appropriate authority will enable researchers determine where to channel their research efforts in fish feed formulation and diet development for the locally culturable fish species.

The Linear programming techniques for least cost ration formulation offer a much wider scope for considering a wide range of alternatives than the conventional methods. The use of Linear programming, based on the use of micro-computers, has been found to result in significant savings in feed costs while ensuring flexibility and adaptability to changing economic and technological circumstances as well as supply of feed ingredients.

The use of Linear programming is subject to certain guidelines and pre-requisites.

- The nutritional composition of all ingredients must be readily ascertainable. Research must be intensified to develop and update, on a continuing basis, the nutrient requirement of different fish enterprises.
- The nutritional standard requirements of different classes of fish must be developed and subjected to periodic review through experimentation.
- efforts must be made to develop improved and standardized processing and storage technology

for all ingredients in order to minimize loss of nutrients.

- Intensive research must be carried out to breed crop varieties with high nutrient content and balance.
- micro-computers and programmers must be available. Animal scientists must graduate from the old fashion and tedious desk-calculator approach to ration formulation to the use of faster and more accurate method based on computerization.

The Linear programming matrix is usually constructed using single value estimates of technical coefficients of the various ingredients. But, it is well known that the variation in quality and composition of different batches of the same ingredients may be considerable. Consequently, there is a need to establish a range of compositional values obtained through extensive analysis of different batches of several commonly used feed ingredients. Rapid test that would screen ingredients and discard those that are severely defective would also go a long way to make the use of this technique more effective.

It is important to note that this model ignores other costs of feed production. However, such costs as labour, machine and building depreciation, insurance, marketing costs, bags and so on, are essential common costs, which usually vary between mills depending on their scales of operation, capacity utilization and management efficiency and organization. Consequently, it is not considered necessary to include these costs in order to formulate least-cost rations, although models could be constructed to maximize returns while taking account of capacity utilization, market demands and operating costs.

While cost reduction may be achieved through Linear programming, this must, in all cases, be related to fish performance as it is clearly known that the cheapest rations are not necessarily the most efficient. In order to relate least cost ration to fish performance, a feed growth production formation must be quantified in such a way that an iso-growth curve could be derived for the given rate of liveweight gain.

Finally, the analysis of compounded ration must be carried out to ensure that specified nutrient requirements are adequately provided. In this regard on Farm feeding trials, are the surest way to confirm the quality of compounded rations.

5.2 **Suggested Solutions to Fish Feed Industrial Problems**

Presently, there seems to be an unresolved controversy over the capability of Nigeria to meet its fish feed raw materials. This is partly borne out of the long standing tradition of importation of most of the raw materials by the existing feed producers. A rapid expansion of our fish farms in a bid to bridge the demand and supply gap of fish should not be allowed to face the feed raw material problem which almost crippled the poultry industry. Other problems militating against fish feed industries are: Inadequate machinery and spare parts for the fish feed Industry; Inadequate capital: Non-availability of skilled manpower among others.

In the consideration of the author's strategies for solving the major problems of fish feed industry to meet the future requirements of fish feeds in Nigeria, the following solutions are preferred and outlined briefly below:

- Stimulate the awareness of the feed producers towards the large scale production of oil seeds. This could be achieved through establishment of own farms and/or making contract with outgrowers for the production of basic raw materials.
- Recognition by government of the close similarity between the requirements of fish feed industry and poultry feed industry such that adequately high loam facilities can be extended to

the industry as to poultry.

- Training of skilled manpower for proper maintenance to handling of the essential plants and equipment. There is also need for locally developed technologies and know-how. This is however, dependent on the availability of flat sheets for the fabrication of equipment.
- Promotion of fish feed industry by government through mass media to create public awareness and deliberate program of education to include finance houses on the profitability of the venture, hence instilling confidence for loan advancement.
- Restructuring Research Institutes: Information emanating from our research Institutes that would engender to the rapid development of fish feed industry in Nigeria must be disseminated without delay by means of well coordinated extension research liaison services.
- Cost reducing measures

(i) The potential investors can either buy up or team up with the existing feed millers and purchase extrudes and pelleting Units to augment the existing machines so as to produce pelleted fish feed.

(ii) Small medium size fish farms should have feed processing units of a capacity of about 1-2 tones capacity per hour, capable of satisfying their fish feed needs.

(iii) Through the inclusion of low-cost, high quality plant protein like soyabean to replace the very expensive fish protein sources like blood-meal, fish meal and others.

5.3 **Recommendations**

(i) The high cost of pelleted fish feed is the major factor militating against the use of pelleted fish feeds in fish culture. This could be reduced if fish farmers could also engage in farming the major feed ingredients such as soyabean, groundnut, maize, guinea corn depending on their locality.

(ii) Fish farmers should be properly trained on fish feed formulation using the available agro-products. The assistance of the State and Federal Fisheries Departments as well as Agricultural Development Project (ADP) is needed in this regard.

(iii) Establishment of feed mills by private agencies and government would help to ease the availability of pelleted feeds but such pelleted fish feeds should be sold at a rate affordable by the local fish farmers probably by subsidization.

(iv) Information on the nutrient requirement of the local fish species are still vary scanty. Fisheries Institutes and Fisheries Departments in Universities should be properly funded to tackle this problem which is a prerequisite to formulating nutritionally balanced diets for our local fish species.

(v) Government should encourage the production of low cost feed ingredients by subsidizing agricultural inputs. This will help fish farmers to produce nutritionally adequate fish feed at minimum cost.

(vi) Fish farmers should always seek for guidance from fish nutritionists on fish feed formulation to avoid the use of substandard fish feeds.

From the feasibility study on the computerization of least-cost feed formulation, an appropriate environment needs to be created to optimize the benefit of computerization or automation.

For the proper functioning of the new system, the recommendation for sustenance are:

(i) Control should be exercised over timeliness and reliability of data.

(ii) Management should periodically review the status of the system. The authority, role willing the organization and scope of authority of the senior officer in charge of the system need to be defined and made clear to system users.

iii) Mechanisms should be established to ensure that all equipments and software are in good operating conditions at all times with a minimum of down time.

iv) The effect of any computer application will be determined in part, by its effect on the place of individual in the organization.

A move towards automation may lead to fears on the part of some staff that their jobs may be lost or downgraded as functions are assumed by the computer. The management have to carry along the staff on the computerization exercise so as to remove their fears of loosing their jobs to automation. Automation, often, infact, creates new information related to jobs. The need to re-channel human resources should be seized as an opportunity and interpreted as such by management to the organization's staff. The organization should train the staff on computer training that directly related to their needs and operator skills.

5.4 **Suggestions for further studies**

i) Computerization of fish feed effect on fish type

ii) Computerization of fish commercial activities in NIFFR, New-Bussa, Niger State.

iii) Computer analysis of Data for the substitution of machinery for labour in fish feed formulation.

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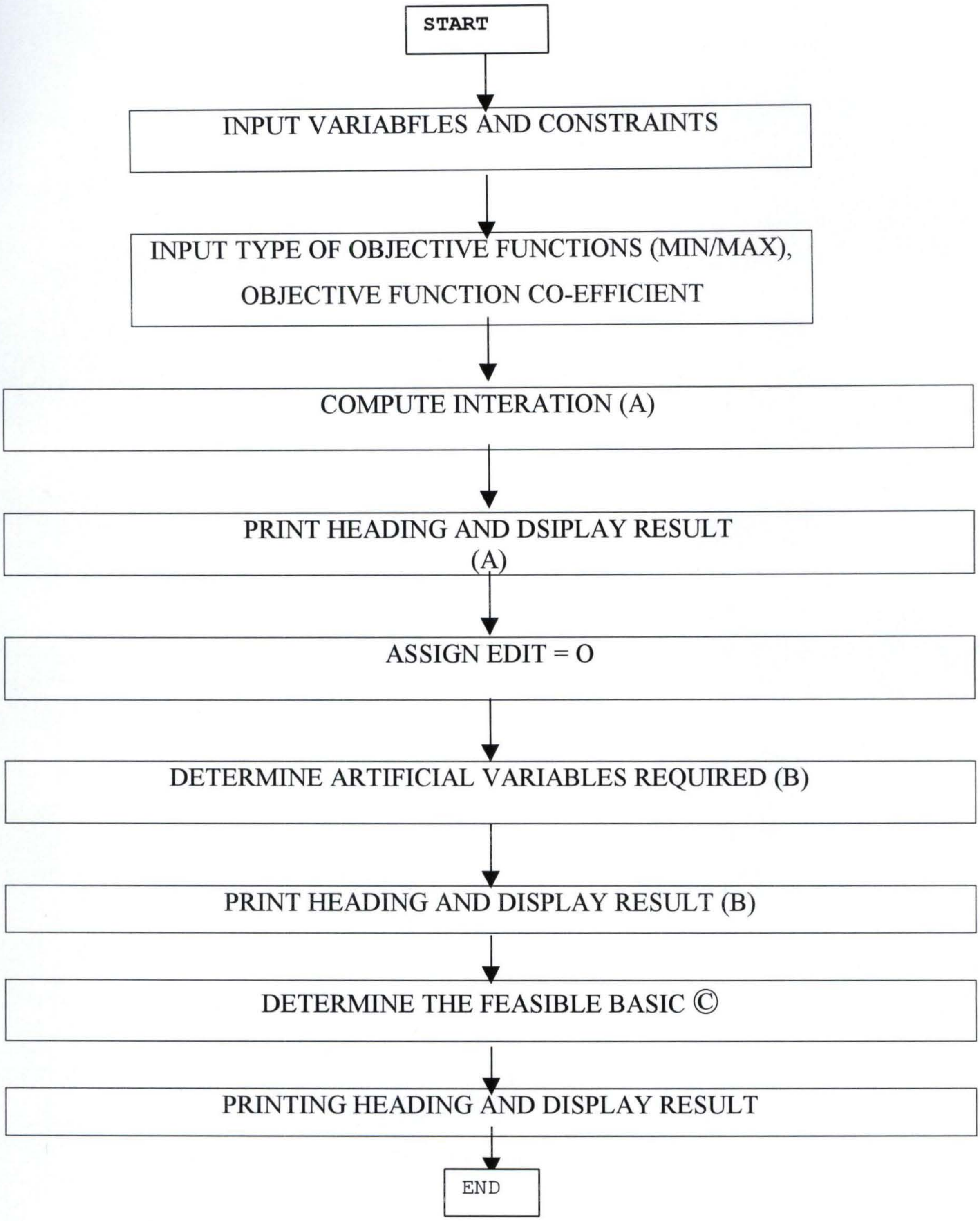
# BLOCK CHART


START
INPUT VARIABFLES AND CONSTRAINTS
INPUT TYPE OF OBJECTIVE FUNCTIONS (MIN/MAX),
OBJECTIVE FUNCTION CO-EFFICIENT
COMPUTE INTERATION (A)
PRINT HEADING AND DSIPLAY RESULT
(A)
ASSIGN EDIT = O
DETERMINE ARTIFICIAL VARIABLES REQUIRED (B)
PRINT HEADING AND DISPLAY RESULT (B)
DETERMINE THE FEASIBLE BASIC ©
PRINTING HEADING AND DISPLAY RESULT
END

Rows as Input

| TYPE | X 1 | X 2 | X 3 | X 4 | X 5 | X 6 | X 7 | X 8 | X 9 | X 10 | X 11 | X 12 | X 13 | X 14 | R.H.S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -Z | 20.0000 | 35.0000 | 120.0000 | 10.0000 | 5.0000 | 5.0000 | 5.0000 | 5.0000 | 10.0000 | 25.0000 | 300.0000 | 250.0000 | 15.0000 | 20.0000 | 0.0000 |
| G | 10.0000 | 42.0000 | 65.0000 | 89.2000 | 12.8000 | 28.8000 | 25.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2000 | 32.0000 |
| L | 10.0000 | 42.0000 | 65.0000 | 89.2000 | 12.8000 | 28.8000 | 25.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2000 | 40.0000 |
| G | 3432.0000 | 2700.0000 | 2860.0000 | 3080.0000 | 2860.0000 | 3491.0000 | 3450.0000 | 0.0000 | 1716.0000 | 8170.0000 | 8200.0000 | 0.0000 | 0.0000 | 3400.0000 | 2618.0000 |
| L | 3.6000 | 3.5000 | 9.6000 | 1.3000 | 13.7000 | 14.1000 | 10.5000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.0000 |
| L | 2.3000 | 6.5000 | 0.7000 | 1.0000 | 11.1000 | 14.0700 | 10.5200 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0800 | 6.0000 |
| G | 0.2500 | 2.8000 | 4.7200 | 6.3300 | 0.5200 | 0.7200 | 1.7800 | 0.0000 | 2.2000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.6300 |
| G | 0.1700 | 0.5900 | 1.7500 | 0.8800 | 0.2000 | 0.7300 | 0.4400 | 0.0000 | 0.5800 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3000 |
| G | 0.3900 | 1.2100 | 0.3100 | 2.1200 | 0.3300 | 0.8000 | 0.6800 | 0.0000 | 0.7300 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.7400 |
| L | 0.0300 | 0.2000 | 5.1900 | 0.2900 | 0.0300 | 0.5200 | 9.0600 | 37.6200 | 37.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.5000 |
| G | 0.2800 | 0.6000 | 2.8800 | 0.2400 | 0.2700 | 0.7000 | 0.5000 | 0.0700 | 15.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.5000 |
| L | 0.2800 | 0.6000 | 2.8800 | 0.2400 | 0.2700 | 0.7000 | 0.5000 | 0.0700 | 15.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.7000 |

ARTIFICIAL VARIABLES REQUIRED
X 26

PRIMAL FEASIBLE TABLEAU

| BASIC | X 1 | X 2 | X 3 | X 4 | X 5 | X 6 | X 7 | X 8 | X 9 | X 10 | X 11 | X 12 | X 13 | X 14 | X 15 | X 16 | X 17 | X 18 | X 19 | X 20 | X 21 | X 22 | X 23 | X 24 | X 25 | X 26 | R.H.S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -Z | 20.0000 | 35.0000 | 120.0000 | 10.0000 | 5.0000 | 5.0000 | 5.0000 | 5.0000 | 10.0000 | 25.0000 | 300.0000 | 250.0000 | 15.0000 | 20.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| X 15 | 3422.0000 | 2658.0000 | 2795.0000 | 2990.8000 | 2847.2000 | 3462.2000 | 3425.0000 | 0.0000 | 1716.0000 | 8170.0000 | 8200.0000 | 0.0000 | 0.0000 | 3399.8000 | 1.0000 | 0.0000 | -1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2586.0000 |
| X 16 | 10.0000 | 42.0000 | 65.0000 | 89.2000 | 12.8000 | 28.8000 | 25.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 40.0000 |
| X 26 | 3432.0000 | 2700.0000 | 2860.0000 | 3080.0000 | 2860.0000 | 3491.0000 | 3450.0000 | 0.0000 | 1716.0000 | 8170.0000 | 8200.0000 | 0.0000 | 0.0000 | 3400.0000 | 0.0000 | 0.0000 | -1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 2618.0000 |
| X 18 | 3.6000 | 3.5000 | 9.6000 | 1.3000 | 13.7000 | 14.1000 | 10.5000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.0000 |
| X 19 | 2.3000 | 6.5000 | 0.7000 | 1.0000 | 11.1000 | 14.0700 | 10.5200 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0800 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| X 20 | 3431.7500 | 2697.2000 | 2855.2800 | 3073.6699 | 2859.4800 | 3490.2800 | 3448.2200 | 0.0000 | 1713.8000 | 8170.0000 | 8200.0000 | 0.0000 | 0.0000 | 3400.0000 | 0.0000 | 0.0000 | -1.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2616.3701 |
| X 21 | 3431.8301 | 2699.4099 | 2858.2500 | 3079.1201 | 2859.8000 | 3490.2700 | 3449.5601 | 0.0000 | 1715.4200 | 8170.0000 | 8200.0000 | 0.0000 | 0.0000 | 3400.0000 | 0.0000 | 0.0000 | -1.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2617.7000 |
| X 22 | 3431.6101 | 2698.7900 | 2859.6899 | 3077.8799 | 2859.6699 | 3490.2000 | 3449.3201 | 0.0000 | 1715.2700 | 8170.0000 | 8200.0000 | 0.0000 | 0.0000 | 3400.0000 | 0.0000 | 0.0000 | -1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2617.2600 |
| X 23 | 0.0300 | 0.2000 | 5.1900 | 0.2900 | 0.0300 | 0.5200 | 9.0600 | 37.6200 | 37.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 1.5000 |
| X 24 | 3431.7200 | 2699.3999 | 2857.1201 | 3079.7600 | 2859.7300 | 3490.3000 | 3449.5000 | -0.0700 | 1701.0000 | 8170.0000 | 8200.0000 | 0.0000 | 0.0000 | 3400.0000 | 0.0000 | 0.0000 | -1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 2617.5000 |
| X 25 | 0.2800 | 0.6000 | 2.8800 | 0.2400 | 0.2700 | 0.7000 | 0.5000 | 0.0700 | 15.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.7000 |
| X 0 | 3432.0000 | 2700.0000 | 2860.0000 | 3080.0000 | 2860.0000 | 3491.0000 | 3450.0000 | 0.0000 | 1716.0000 | 8170.0000 | 8200.0000 | 0.0000 | 0.0000 | 3400.0000 | 0.0000 | 0.0000 | -1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2618.0000 |

PIVOT = 8200 NEW BASIC VAR. X 11 IN PLACE OF X 15

ITERATION No 1

| BASIC | X 1 | X 2 | X 3 | X 4 | X 5 | X 6 | X 7 | X 8 | X 9 | X 10 | X 11 | X 12 | X 13 | X 14 | X 15 | X 16 | X 17 | X 18 | X 19 | X 20 | X 21 | X 22 | X 23 | X 24 | X 25 | X 26 | R.H.S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -Z | -105.1951 | -62.2439 | 17.7439 | -99.4195 | -99.1658 | -121.6659 | -120.3049 | 5.0000 | -52.7805 | -273.9024 | 0.0000 | 250.0000 | 15.0000 | -104.3829 | -0.0366 | 0.0000 | 0.0366 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -94.6098 |
| X 11 | 0.4173 | 0.3241 | 0.3409 | 0.3647 | 0.3472 | 0.4222 | 0.4177 | 0.0000 | 0.2093 | 0.9963 | 1.0000 | 0.0000 | 0.0000 | 0.4146 | 0.0001 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3154 |
| X 16 | 10.0000 | 42.0000 | 65.0000 | 89.2000 | 12.8000 | 28.8000 | 25.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 40.0000 |
| X 26 | 10.0001 | 42.0001 | 65.0000 | 89.2001 | 12.8001 | 28.8000 | 25.0001 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2000 | -1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 32.0000 |
| X 18 | 3.6000 | 3.5000 | 9.6000 | 1.3000 | 13.7000 | 14.1000 | 10.5000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.0000 |
| X 19 | 2.3000 | 6.5000 | 0.7000 | 1.0000 | 11.1000 | 14.0700 | 10.5200 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0800 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.0000 |
| X 20 | 9.7501 | 39.2000 | 60.2800 | 82.8700 | 12.2801 | 28.0800 | 23.2201 | 0.0000 | -2.1999 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2000 | -1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 30.3701 |
| X 21 | 9.8302 | 41.4100 | 63.2500 | 88.3202 | 12.6002 | 28.0700 | 24.5601 | 0.0000 | -0.5799 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2000 | -1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 31.7000 |
| X 22 | 9.6102 | 40.7901 | 64.6899 | 87.0799 | 12.4700 | 27.9999 | 24.3202 | 0.0000 | -0.7299 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2000 | -1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 31.2600 |
| X 23 | 0.0300 | 0.2000 | 5.1900 | 0.2900 | 0.0300 | 0.5200 | 9.0600 | 37.6200 | 37.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 1.5000 |
| X 24 | 9.7201 | 41.4000 | 62.1201 | 88.9601 | 12.5301 | 28.1000 | 24.5001 | -0.0700 | -15.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2000 | -1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 31.5000 |
| X 25 | 0.2800 | 0.6000 | 2.8800 | 0.2400 | 0.2700 | 0.7000 | 0.5000 | 0.0700 | 15.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.7000 |
| X 0 | 10.0001 | 42.0001 | 65.0000 | 89.2001 | 12.8001 | 28.8000 | 25.0001 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2000 | -1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 32.0000 |

PIVOT = 88.96008 NEW BASIC VAR. X 4 IN PLACE OF X 24

ITERATION No 2

| BASIC | X 1 | X 2 | X 3 | X 4 | X 5 | X 6 | X 7 | X 8 | X 9 | X 10 | X 11 | X 12 | X 13 | X 14 | X 15 | X 16 | X 17 | X 18 | X 19 | X 20 | X 21 | X 22 | X 23 | X 24 | X 25 | X 26 | R.H.S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -Z | -94.3322 | -15.9763 | 87.1677 | 0.0000 | -85.1625 | -90.2620 | -92.9242 | 4.9218 | -69.5441 | -273.9025 | 0.0000 | 250.0000 | 15.0000 | -104.1594 | -1.1542 | 0.0000 | 0.0366 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.1176 | 0.0000 | 0.0000 | -59.4061 |
| X 11 | 0.3775 | 0.1544 | 0.0862 | 0.0000 | 0.2958 | 0.3070 | 0.3172 | 0.0003 | 0.2708 | 0.9963 | 1.0000 | 0.0000 | 0.0000 | 0.4138 | 0.0042 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0041 | 0.0000 | 0.0000 | 0.1862 |
| X 16 | 0.2537 | 0.4884 | 2.7124 | 0.0000 | 0.2361 | 0.6242 | 0.4338 | 0.0702 | 15.0404 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0005 | 1.0027 | 1.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -1.0027 | 0.0000 | 0.0000 | 8.4150 |
| X 26 | 0.2538 | 0.4884 | 2.7123 | 0.0000 | 0.2362 | 0.6241 | 0.4339 | 0.0702 | 15.0405 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0005 | 0.0027 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -1.0027 | 0.0000 | 1.0000 | 0.4150 |
| X 18 | 3.4580 | 2.8950 | 8.6922 | 0.0000 | 13.5169 | 13.6894 | 10.1420 | 0.0010 | 0.2192 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0029 | 0.0146 | 0.0000 | -0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0146 | 0.0000 | 0.0000 | 4.5397 |
| X 19 | 2.1907 | 6.0346 | 0.0017 | 0.0000 | 10.9591 | 13.7541 | 10.2446 | 0.0008 | 0.1686 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0778 | 0.0112 | 0.0000 | -0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0112 | 0.0000 | 0.0000 | 5.6459 |
| X 20 | 0.6955 | 0.6342 | 2.4126 | 0.0000 | 0.6078 | 1.9037 | 0.3972 | 0.0652 | 11.7732 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0137 | -0.0685 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | -0.9315 | 0.0000 | 0.0000 | 1.0266 |
| X 21 | 0.1800 | 0.3078 | 1.5767 | 0.0000 | 0.1602 | 0.1721 | 0.2363 | 0.0695 | 14.3121 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0014 | -0.0072 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | -0.9928 | 0.0000 | 0.0000 | 0.4265 |
| X 22 | 0.0956 | 0.2651 | 3.8827 | 0.0000 | 0.2048 | 0.4938 | 0.3379 | 0.0685 | 13.9530 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0042 | -0.0211 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | -0.9789 | 0.0000 | 0.0000 | 0.4257 |
| X 23 | -0.0017 | 0.0650 | 4.9875 | 0.0000 | -0.0108 | 0.4284 | 8.9801 | 37.6202 | 37.0489 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0007 | 0.0033 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | -0.0033 | 0.0000 | 0.0000 | 1.3973 |
| X 4 | 0.1093 | 0.4654 | 0.6983 | 1.0000 | 0.1409 | 0.3159 | 0.2754 | -0.0008 | -0.1686 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0022 | -0.0112 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0112 | 0.0000 | 0.0000 | 0.3541 |
| X 25 | 0.2538 | 0.4883 | 2.7124 | 0.0000 | 0.2362 | 0.6242 | 0.4339 | 0.0702 | 15.0405 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0005 | 0.0027 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0027 | 1.0000 | 0.0000 | 0.6150 |
| X 0 | 0.2538 | 0.4884 | 2.7123 | 0.0000 | 0.2362 | 0.6241 | 0.4339 | 0.0702 | 15.0405 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0005 | 0.0027 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -1.0027 | 0.0000 | 0.0000 | 0.4150 |

PIVOT = 15.04047 NEW BASIC VAR. X 9 IN PLACE OF X 26

ITERATION No 3

| BASIC | X 1 | X 2 | X 3 | X 4 | X 5 | X 6 | X 7 | X 8 | X 9 | X 10 | X 11 | X 12 | X 13 | X 14 | X 15 | X 16 | X 17 | X 18 | X 19 | X 20 | X 21 | X 22 | X 23 | X 24 | X 25 | R.H.S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -Z | -93.1587 | -13.7180 | 99.7089 | 0.0000 | -84.0703 | -87.3761 | -90.9179 | 5.2463 | 0.0000 | -273.9025 | 0.0000 | 250.0000 | 15.0000 | -104.1619 | -1.1417 | 0.0000 | 0.0366 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -3.5187 | 0.0000 | -57.4872 |
| X 11 | 0.3729 | 0.1456 | 0.0373 | 0.0000 | 0.2916 | 0.2958 | 0.3094 | -0.0010 | 0.0000 | 0.9963 | 1.0000 | 0.0000 | 0.0000 | 0.4138 | 0.0042 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0140 | 0.0000 | 0.1787 |
| X 16 | -0.0001 | -0.0001 | 0.0001 | 0.0000 | -0.0001 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 1.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 8.0000 |
| X 9 | 0.0169 | 0.0325 | 0.1803 | 0.0000 | 0.0157 | 0.0415 | 0.0288 | 0.0047 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0002 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0667 | 0.0000 | 0.0276 |
| X 18 | 3.4543 | 2.8879 | 8.6527 | 0.0000 | 13.5135 | 13.6803 | 10.1356 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0029 | 0.0146 | 0.0000 | -0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 4.5336 |
| X 19 | 2.1879 | 6.0291 | -0.0287 | 0.0000 | 10.9565 | 13.7471 | 10.2397 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0778 | 0.0112 | 0.0000 | -0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 5.6413 |
| X 20 | 0.4968 | 0.2519 | 0.2895 | 0.0000 | 0.4229 | 1.4151 | 0.0576 | 0.0103 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0141 | -0.0706 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | -0.1467 | 0.0000 | 0.7017 |
| X 21 | -0.0615 | -0.1570 | -1.0042 | 0.0000 | -0.0646 | -0.4218 | -0.1766 | 0.0027 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0020 | -0.0098 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | -0.0387 | 0.0000 | 0.0316 |
| X 22 | -0.1399 | -0.1880 | 1.3665 | 0.0000 | -0.0144 | -0.0852 | -0.0647 | 0.0034 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0047 | -0.0236 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | -0.0487 | 0.0000 | 0.0407 |
| X 23 | -0.6269 | -1.1381 | -1.6937 | 0.0000 | -0.5927 | -1.1090 | 7.9113 | 37.4473 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0007 | -0.0034 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 2.4667 | 0.0000 | 0.3750 |
| X 4 | 0.1121 | 0.4709 | 0.7287 | 1.0000 | 0.1435 | 0.3229 | 0.2803 | -0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0022 | -0.0112 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3587 |
| X 25 | -0.0000 | -0.0001 | 0.0001 | 0.0000 | -0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 1.0000 | 0.2000 |

PIVOT = .9963416 NEW BASIC VAR. X 10 IN PLACE OF X 11

ITERATION No 4

| BASIC | X 1 | X 2 | X 3 | X 4 | X 5 | X 6 | X 7 | X 8 | X 9 | X 10 | X 11 | X 12 | X 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -Z | 9.3535 | 26.3130 | 109.9728 | 0.0000 | -3.9087 | -6.0652 | -5.8552 | 4.9778 | 0.0000 | 0.0000 | 274.9082 | 250.0000 | 15.0000 |
| X 10 | 0.3743 | 0.1462 | 0.0375 | 0.0000 | 0.2927 | 0.2969 | 0.3106 | -0.0010 | 0.0000 | 1.0000 | 1.0037 | 0.0000 | 0.0000 |
| X 16 | -0.0001 | -0.0001 | 0.0001 | 0.0000 | -0.0001 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 |
| X 9 | 0.0169 | 0.0325 | 0.1803 | 0.0000 | 0.0157 | 0.0415 | 0.0288 | 0.0047 | 1.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 |
| X 18 | 3.4543 | 2.8879 | 8.6527 | 0.0000 | 13.5135 | 13.6803 | 10.1356 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 |
| X 19 | 2.1879 | 6.0291 | -0.0287 | 0.0000 | 10.9565 | 13.7471 | 10.2397 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 |
| X 20 | 0.4968 | 0.2519 | 0.2895 | 0.0000 | 0.4229 | 1.4151 | 0.0576 | 0.0103 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| X 21 | -0.0615 | -0.1570 | -1.0042 | 0.0000 | -0.0646 | -0.4218 | -0.1766 | 0.0027 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| X 22 | -0.1399 | -0.1880 | 1.3665 | 0.0000 | -0.0144 | -0.0852 | -0.0647 | 0.0034 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| X 23 | -0.6269 | -1.1381 | -1.6937 | 0.0000 | -0.5927 | -1.1090 | 7.9113 | 37.4473 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| X 4 | 0.1121 | 0.4709 | 0.7287 | 1.0000 | 0.1435 | 0.3229 | 0.2803 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| X 25 | -0.0000 | -0.0001 | 0.0001 | 0.0000 | -0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 |

| BASIC | X 14 | X 15 | X 16 | X 17 | X 18 | X 19 | X 20 | X 21 | X 22 | X 23 | X 24 | X 25 | R.H.S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -Z | 9.5950 | 0.0056 | 0.0000 | 0.0031 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3166 | 0.0000 | -8.3484 |
| X 10 | 0.4153 | 0.0042 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0140 | 0.0000 | 0.1794 |
| X 16 | 0.0000 | 1.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 8.0000 |
| X 9 | -0.0000 | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0667 | 0.0000 | 0.0000 | 0.0276 |
| X 18 | -0.0029 | 0.0146 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 4.5336 |
| X 19 | 0.0778 | 0.0112 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 5.6413 |
| X 20 | 0.0141 | -0.0706 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | -0.1467 | 0.0000 | 0.7017 |
| X 21 | 0.0020 | -0.0098 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | -0.0387 | 0.0000 | 0.0316 |
| X 22 | 0.0047 | -0.0236 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | -0.0487 | 0.0000 | 0.0407 |
| X 23 | 0.0007 | -0.0034 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 2.4667 | 0.0000 | 0.3750 |
| X 4 | 0.0022 | -0.0112 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3587 |
| X 25 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 1.0000 | 0.2000 |

PIVOT = 13.68027 NEW BASIC VAR. X 6 IN PLACE OF X 18

ITERATION No 5

| BASIC | X 1 | X 2 | X 3 | X 4 | X 5 | X 6 | X 7 | X 8 | X 9 | X 10 | X 11 | X 12 | X 13 | X 14 | X 15 | X 16 | X 17 | X 18 | X 19 | X 20 | X 21 | X 22 | X 23 | X 24 | X 25 | R.H.S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -Z | 10.8850 | 27.5933 | 113.8091 | 0.0000 | 2.0826 | 0.0000 | -1.3615 | 4.9778 | 0.0000 | 0.0000 | 274.9082 | 250.0000 | 15.0000 | 9.5937 | 0.0121 | 0.0000 | 0.0031 | 0.4434 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3166 | 0.0000 | -6.3384 |
| X 10 | 0.2993 | 0.0835 | -0.1503 | 0.0000 | -0.0006 | 0.0000 | 0.0906 | -0.0010 | 0.0000 | 1.0000 | 1.0037 | 0.0000 | 0.0000 | 0.4154 | 0.0039 | 0.0000 | -0.0001 | -0.0217 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0140 | 0.0000 | 0.0810 |
| X 16 | -0.0001 | -0.0001 | 0.0001 | 0.0000 | -0.0002 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 1.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 8.0000 |
| X 9 | 0.0064 | 0.0237 | 0.1541 | 0.0000 | -0.0253 | 0.0000 | -0.0019 | 0.0047 | 1.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0001 | 0.0000 | 0.0000 | -0.0030 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0667 | 0.0000 | 0.0138 |
| X 6 | 0.2525 | 0.2111 | 0.6325 | 0.0000 | 0.9878 | 1.0000 | 0.7409 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | -0.0002 | 0.0011 | 0.0000 | 0.0000 | 0.0731 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.3314 |
| X 19 | -1.2832 | 3.1271 | -8.7237 | 0.0000 | -2.6230 | 0.0000 | 0.0545 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0807 | -0.0034 | 0.0000 | -0.0000 | -1.0049 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0855 |
| X 20 | 0.1395 | -0.0468 | -0.6056 | 0.0000 | -0.9750 | 0.0000 | -0.9909 | 0.0103 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0144 | -0.0721 | 0.0000 | -0.0000 | -0.1034 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | -0.1467 | 0.0000 | 0.2327 |
| X 21 | 0.0450 | -0.0679 | -0.7374 | 0.0000 | 0.3521 | 0.0000 | 0.1359 | 0.0027 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0019 | -0.0093 | 0.0000 | -0.0000 | 0.0308 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | -0.0387 | 0.0000 | 0.1714 |
| X 22 | -0.1184 | -0.1700 | 1.4204 | 0.0000 | 0.0698 | 0.0000 | -0.0015 | 0.0034 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0047 | -0.0235 | 0.0000 | -0.0000 | 0.0062 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | -0.0487 | 0.0000 | 0.0690 |
| X 23 | -0.3469 | -0.9039 | -0.9922 | 0.0000 | 0.5028 | 0.0000 | 8.7330 | 37.4473 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0004 | -0.0022 | 0.0000 | -0.0000 | 0.0811 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 2.4667 | 0.0000 | 0.7425 |
| X 4 | 0.0306 | 0.4027 | 0.5245 | 1.0000 | -0.1754 | 0.0000 | 0.0411 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0023 | -0.0116 | 0.0000 | -0.0000 | -0.0236 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2517 |
| X 25 | -0.0000 | -0.0001 | 0.0001 | 0.0000 | -0.0001 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 1.0000 | 0.2000 |

PIVOT = 8.732986 NEW BASIC VAR. X 7 IN PLACE OF X 23

ITERATION No 6

| BASIC | X 1 | X 2 | X 3 | X 4 | X 5 | X 6 | X 7 | X 8 | X 9 | X 10 | X 11 | X 12 | X 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -Z | 10.8309 | 27.4524 | 113.6544 | 0.0000 | 2.1609 | 0.0000 | 0.0000 | 10.8159 | 0.0000 | 0.0000 | 274.9082 | 250.0000 | 15.0000 |
| X 10 | 0.3029 | 0.0929 | -0.1400 | 0.0000 | -0.0058 | 0.0000 | 0.0000 | -0.3895 | 0.0000 | 1.0000 | 1.0037 | 0.0000 | 0.0000 |
| X 16 | -0.0001 | -0.0001 | 0.0000 | 0.0000 | -0.0002 | 0.0000 | 0.0000 | 0.0005 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 |
| X 9 | 0.0063 | 0.0235 | 0.1539 | 0.0000 | -0.0252 | 0.0000 | 0.0000 | 0.0128 | 1.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 |
| X 6 | 0.2819 | 0.2878 | 0.7167 | 0.0000 | 0.9451 | 1.0000 | 0.0000 | -3.1770 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 |
| X 19 | -1.2811 | 3.1328 | -8.7175 | 0.0000 | -2.6261 | 0.0000 | 0.0000 | -0.2339 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| X 20 | 0.1001 | -0.1494 | -0.7182 | 0.0000 | -0.9179 | 0.0000 | 0.0000 | 4.2592 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| X 21 | 0.0504 | -0.0538 | -0.7220 | 0.0000 | 0.3443 | 0.0000 | 0.0000 | -0.5801 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| X 22 | -0.1184 | -0.1702 | 1.4202 | 0.0000 | 0.0699 | 0.0000 | 0.0000 | 0.0099 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| X 7 | -0.0397 | -0.1035 | -0.1136 | 0.0000 | 0.0576 | 0.0000 | 1.0000 | 4.2880 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| X 4 | 0.0322 | 0.4069 | 0.5292 | 1.0000 | -0.1778 | 0.0000 | 0.0000 | -0.1761 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| X 25 | -0.0000 | -0.0001 | 0.0001 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0002 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 |

| BASIC | X 14 | X 15 | X 16 | X 17 | X 18 | X 19 | X 20 | X 21 | X 22 | X 23 | X 24 | X 25 | R.H.S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -Z | 9.5937 | 0.0117 | 0.0000 | 0.0031 | 0.4560 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1559 | 0.7012 | 0.0000 | -6.2227 |
| X 10 | 0.4154 | -0.0039 | 0.0000 | -0.0001 | -0.0225 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0104 | -0.0116 | 0.0000 | 0.0733 |
| X 16 | 0.0000 | 1.0000 | 1.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 8.0000 |
| X 9 | -0.0000 | 0.0001 | 0.0000 | 0.0000 | -0.0030 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | -0.0661 | 0.0000 | 0.0140 |
| X 6 | -0.0003 | 0.0013 | 0.0000 | 0.0000 | 0.0662 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0848 | -0.2093 | 0.0000 | 0.2684 |
| X 19 | 0.0807 | -0.0034 | 0.0000 | -0.0000 | -1.0054 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0062 | -0.0154 | 0.0000 | 1.0808 |
| X 20 | 0.0145 | -0.0723 | 0.0000 | -0.0000 | -0.0942 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.1135 | 0.1332 | 0.0000 | 0.3170 |
| X 21 | 0.0019 | -0.0093 | 0.0000 | -0.0000 | 0.0296 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | -0.0156 | -0.0771 | 0.0000 | 0.1598 |
| X 22 | 0.0047 | -0.0235 | 0.0000 | -0.0000 | 0.0062 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0002 | -0.0482 | 0.0000 | 0.0691 |
| X 7 | 0.0001 | -0.0003 | 0.0000 | -0.0000 | 0.0093 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1145 | 0.2825 | 0.0000 | 0.0850 |
| X 4 | 0.0023 | -0.0115 | 0.0000 | -0.0000 | -0.0240 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0047 | -0.0116 | 0.0000 | 0.2483 |
| X 25 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 1.0000 | 0.2000 |

```
DECLARE SUB rationalize (col!)
DECLARE SUB swaprows (r!)
' Standard Linear Programming Problem

' ns=number of slack variables
' nv=number of original variables
' ne=number of original equations i.e rows
' nr=number of rows of tableau
' nc=number of columns of tableau
CLS
INPUT "enter number of variables: "; nv
INPUT "enter number of equations: "; ne
DIM SHARED nr, nc AS INTEGER
nr = ne + 1
ns = ne
nc = ns + nv + 2

DIM SHARED table(nr, nc)
DIM SHARED X(nv)
DIM consts(nr - 1)    'array of constants in the rightmost column

FOR i = 1 TO nr
FOR j = 1 TO nc
table(i, j) = 0
NEXT j: NEXT i

' input of values of table

' first the variables
FOR i = 1 TO ne
FOR j = 1 TO nv
PRINT "Enter variable X("; j; ")= ";
INPUT table(i, j)
NEXT j
INPUT "<= "; table(i, nc)
NEXT i

' then the objective function
PRINT "Input coefficients of variables in the objective function:"
FOR i = 1 TO nv
PRINT "Coefficient of X("; i; ")= ";
INPUT table(nr, i)
table(nr, i) = -table(nr, i)
NEXT i

' then the P column
table(nr, nc - 1) = 1

FOR i = 1 TO nr - 1
FOR j = nv + 1 TO nc - 1
table(i, j) = 0
NEXT j
NEXT i

FOR i = 1 TO nr - 1
table(i, nv + i) = 1
NEXT i

CLS

' this is the initial tableau
PRINT "This is the initial tableau"
PRINT
FOR i = 1 TO nr
```

```
RINT USING "#####"; table(i, j);
NEXT j
PRINT
NEXT i

s$ = INPUT$(1)

 Step seven (check)
 t = 0
 R i = 1 TO nc
  ((table(nr, i) <> ABS(table(nr, i))) AND (table(nr, i) <> 0)) THEN opt = 1
 XT i

 O WHILE (opt <> 0)

 Step 2
 D-row largest negative value i.e. row nr

 rgestDcol = 1
  i = 1 TO nc - 1
  (table(nr, i) <> ABS(table(nr, i))) THEN              'must be negative
      IF (ABS(table(nr, i)) > ABS(table(nr, largestDcol)) AND (ABS(table(nr, i)) <> 0)) THE
  IF
 T i

 NT largestDcol

 tep three (all according to note)
  i = 1 TO nr - 1
  ts(i) = table(i, nc)
   i

  = 1 TO nr - 1
  s(i) = consts(i) / ABS(table(i, largestDcol))
   i

  p four
  Constrow = 1
   = 1 TO nr - 1
  nsts(i) < consts(leastConstrow) THEN leastConstrow = i

  leastConstrow

  ngrow = leastConstrow
  ngCol = largestDcol

  five
  le(enteringrow, enteringCol)
   1 TO nc
  nteringrow, i) = table(enteringrow, i) / j

  s (enteringrow)

   1 TO nr
   1 TO nc
  SING "####.##"; table(i, j);
```

```
' Step six
rationalize (enteringCol)


PRINT "rationalized"
FOR i = 1 TO nr
FOR j = 1 TO nc
PRINT USING "####.##"; table(i, j);
NEXT j
PRINT
NEXT i

s$ = INPUT$(1)

' Step seven (check)
opt = 0
FOR i = 1 TO nc
IF ((table(nr, i) <> ABS(table(nr, i))) AND (table(nr, i) <> 0)) THEN opt = 1
NEXT i

LOOP

'Else the optimum value has been reached, evaluate and print
FOR i = 1 TO nv
FOR j = 1 TO nr - 1
IF table(j, i) = 1 THEN X(i) = table(j, nc)
NEXT j
NEXT i

FOR i = 1 TO nv
PRINT X(i)
NEXT i


SUB rationalize (col)
FOR i = 2 TO nr
k = table(i, col)
FOR j = 1 TO nc
table(i, j) = table(i, j) - (k * table(1, j))
NEXT j
NEXT i
END SUB

SUB swaprows (r)
DIM temp(nc)

FOR i = 1 TO nc
temp(i) = table(r, i)
NEXT i

FOR i = r - 1 TO 1 STEP -1
FOR j = 1 TO nc
table(i + 1, j) = table(i, j)
NEXT j
NEXT i

FOR i = 1 TO nc
table(1, i) = temp(i)
NEXT i
END SUB
```

```
CLARE SUB procphase ()
CLARE SUB procpivot ()
CLARE SUB procpivotrow ()
CLARE SUB procpivotcolumn ()
LARE SUB prociterate ()
LARE SUB procequalities ()
LARE SUB proctransform ()
LARE SUB procartificial ()
CLARE SUB procslacks ()
CLARE SUB procmatrix ()
CLARE SUB procprint ()
CLARE SUB procinput ()
TION BASE 0

 SHARED a(11, 21), b(21), c(11), status(21), type$(11)
M SHARED a(30, 30), b(30), c(30), status(30), type$(30)
 SHARED iteration, l, e, g, phase, a1, cmax, i0

 SHARED n, m, i, j, i1, j1, type1$, z$, edit, p
 SHARED coeff, test, ratio, col, best

ration = 0
 0
 0
 0
se = 0
= 0
x = 0
= 0

NT "This Software solves a Linear Programming Problem"
NT
NT

NT "Involving >=, =, and <= constraints for any system of equations"
NT
NT

NT "Press any key to input varibales and constraints"
NT
NT

= INPUT$(1)

cinput
cprint
 = 0
cmatrix
cprint
citerate

 procartificial
0, n + i0) = -1
0, 0) = n + m + 1
0, n + m + 1) = 1
```

```
tatus(n + m + 1) = 1
'OR j = 1 TO n + m
a(m + 1, j) = a(m + 1, j) + a(i0, j)
'EXT j
(m + 1) = c(m + 1) + c(i0)

ID SUB

SUB procequalities
FOR i = m - e + 1 TO m
FOR j = 1 TO n
a(m + 1, j) = a(m + 1, j) + a(i, j)
NEXT j
c(m + 1) = c(m + 1) + c(i)
(i, n + i) = 1
(i, 0) = n + i
tatus(n + i) = 1
EXT i

ID SUB

JB procinput
NPUT "Number of main variables: ", n
NPUT "Number of constraints: ", m
RINT
OR i = 1 TO m
RINT
RINT "input type of constraint i="; STR$(i)
RINT "i.e. input L, E, G for <=, =, >=: ";
NPUT type1$
F type1$ = "L" THEN l = l + 1: type$(i - e) = "L"
F type1$ = "G" THEN g = g + 1: type$(i - e) = "G"
F type1$ = "E" THEN e = e + 1: type$(m - e + 1) = "E"
RINT "input a(i,j) & c(i) for constraint i="; STR$(i)

OR j = 1 TO n
RINT "a("; STR$(i); ","; STR$(j); ")=";
F type1$ = "E" THEN INPUT a(m - e + 1, j)
F type1$ <> "E" THEN INPUT a(i - e, j)
EXT j

RINT "c("; STR$(i); ")=";
F type1$ = "E" THEN INPUT c(m - e + 1)
F type1$ <> "E" THEN INPUT c(i - e)
F type1$ = "G" AND c(i - e) >= cmax THEN cmax = c(i - e): i0 = i - e
EXT i

NPUT "type of objective function (enter MAX or MIN): ", z$
RINT "Now input the objective function coeffs b(j)"

OR j = 1 TO n
RINT "b("; STR$(j); ")=";
NPUT b(j)
F z$ = "MIN" THEN a(0, j) = b(j)
F z$ = "MAX" THEN a(0, j) = -b(j)
EXT j
```

```
OR j = 1 TO n
(i1, j) = a(i1, j) / p
NEXT j
(i1) = c(i1) / p
OR i = 0 TO m + phase
1 = a(i, j1)
OR j = 1 TO n
F i <> i1 THEN a(i, j) = a(i, j) - col * a(i1, j)
NEXT j
IF i <> i1 THEN c(i) = c(i) - col * c(i1)
NEXT i
iteration = iteration + 1

ND SUB

JB procpivotcolumn
st = 0
eff = 0
 = 0
R j = 1 TO n
 phase = 0 AND a(0, j) < -1E-08 THEN coeff = -a(0, j)
 phase = 1 AND a(m + 1, j) > 1E-08 THEN coeff = a(m + 1, j)
 coeff > best THEN best = coeff: j1 = j
XT j
atus(j1) = 1

D SUB

B procpivotrow
tio = 1E+11
st = 1E+11
 = 0
R i = 1 TO m
 a(i, j1) > 1E-08 THEN test = c(i) / a(i, j1)
 test < ratio THEN ratio = test: i1 = i
XT i
atus(a(i1, 0)) = 0

D SUB

3 procprint
INT
 edit = 0 THEN PRINT "BASIC"; ELSE PRINT "TYPE";
R j = 1 TO n
INT TAB(10 * j); "X"; STR$(j);
XT j
INT TAB(10 * (n + 1)); "R.H.S"
INT
R i = 0 TO m + phase
R j = 0 TO n
 z$ = "MAX" AND i = 0 AND j = 0 THEN PRINT "Z";
 z$ = "MIN" AND i = 0 AND j = 0 THEN PRINT "-Z";
 edit = 0 AND i > 0 AND j = 0 THEN PRINT "X"; STR$(a(i, 0));
 edit = 1 AND i > 0 AND j = 0 THEN PRINT type$(i);
 j > 0 THEN PRINT TAB(10 * j); a(i, j);
XT j
INT TAB((n + 1) * 10); c(i)
```

```
edit = 1
PRINT
PRINT "Rows as Input"

END SUB

SUB prociterate
DO
procpivotcolumn
IF j1 = 0 AND phase = 1 THEN PRINT "NO FEASIBLE BASIS": END
IF j1 = 0 AND phase = 0 THEN EXIT SUB
procpivotrow
IF i1 = 0 THEN PRINT "UNBOUNDED SOLUTION": END
p = a(i1, j1)
PRINT "PIVOT ="; p; "  NEW BASIC VAR. X"; STR$(j1);
PRINT " IN PLACE OF X"; STR$(a(i1, 0))
procpivot
IF phase = 1 THEN procphase
PRINT
PRINT "ITERATION No  "; STR$(iteration)
procprint

LOOP

END SUB

SUB procmatrix
IF g > 0 THEN procartificial
FOR i = 1 TO m - e
IF type$(i) = "L" THEN procslacks
IF type$(i) = "G" AND i <> i0 THEN proctransform
NEXT i
IF e > 0 THEN procequalities
IF e + g > 0 THEN phase = 1
IF g > 0 THEN a1 = 1
a1 = a1 + e
PRINT
IF a1 > 0 THEN PRINT "ARTIFICIAL VARIABLES REQUIRED"
IF e > 0 THEN FOR i = m - e + 1 TO m: PRINT "X"; STR$(n + 1): NEXT i
IF g > 0 THEN PRINT "X"; STR$(n + m + 1)
IF g > 0 THEN n = n + m + 1 ELSE n = n + m
PRINT
PRINT "PRIMAL FEASIBLE TABLEAU"

END SUB

SUB procphase
phase = 0
FOR i = n - a1 + 1 TO n
IF status(i) = 1 THEN phase = 1
NEXT i
IF phase = 0 THEN n = n - a1

END SUB

SUB procpivot
a(i1, 0) = j1
```

```
FOR j = 1 TO n
PRINT "b("; STR$(j); ")=";
INPUT b(j)
IF z$ = "MIN" THEN a(0, j) = b(j)
IF z$ = "MAX" THEN a(0, j) = -b(j)
NEXT j

edit = 1
PRINT
PRINT "Rows as Input"

END SUB

SUB prociterate
DO
procpivotcolumn
IF j1 = 0 AND phase = 1 THEN PRINT "NO FEASIBLE BASIS": END
IF j1 = 0 AND phase = 0 THEN EXIT SUB
procpivotrow
IF i1 = 0 THEN PRINT "UNBOUNDED SOLUTION": END
p = a(i1, j1)
PRINT "PIVOT ="; p; "  NEW BASIC VAR. X"; STR$(j1);
PRINT " IN PLACE OF X"; STR$(a(i1, 0))
procpivot
IF phase = 1 THEN procphase
PRINT
PRINT "ITERATION No  "; STR$(iteration)
procprint

LOOP

END SUB

SUB procmatrix
IF g > 0 THEN procartificial
FOR i = 1 TO m - e
IF type$(i) = "L" THEN procslacks
IF type$(i) = "G" AND i <> i0 THEN proctransform
NEXT i
IF e > 0 THEN procequalities
IF e + g > 0 THEN phase = 1
IF g > 0 THEN a1 = 1
a1 = a1 + e
PRINT
IF a1 > 0 THEN PRINT "ARTIFICIAL VARIABLES REQUIRED"
IF e > 0 THEN FOR i = m - e + 1 TO m: PRINT "X"; STR$(n + 1): NEXT i
IF g > 0 THEN PRINT "X"; STR$(n + m + 1)
IF g > 0 THEN n = n + m + 1 ELSE n = n + m
PRINT
PRINT "PRIMAL FEASIBLE TABLEAU"

END SUB
```

Table 1: Specification of raw materials used in computerized linear programming for formulation of least - cost ration for *C. gariepinus*

| | | INGREDIENT LEVELS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw materials | Cost (N/kg) | Crude protein (%) | Energy ME (LCal/kg) | Ether Extract (%) | Crude Fibre (%) | Lysine (%) | Methionine (%) | Methionine + cystine | Calcium (%) | Phosphorus (%) |
| Yellow maize | 20.00 | 10.0 | 3432 | 3.6 | 2.3 | 0.25 | 0.17 | 0.39 | 0.03 | 0.28 |
| Soybean meals | 35.00 | 42.0 | 2700 | 3.5 | 6.5 | 2.8 | 0.59 | 1.21 | 0.20 | 0.60 |
| Fish meal | 120.00 | 65.0 | 2860 | 9.6 | 0.7 | 4.72 | 1.75 | 0.31 | 5.19 | 2.88 |
| Blood meal | 10.00 | 89.2 | 3080 | 1.3 | 1.0 | 6.33 | 0.88 | 2.12 | 0.29 | 0.24 |
| Rice bran | 5.00 | 12.8 | 2860 | 13.7 | 11.1 | 0.52 | 0.20 | 0.33 | 0.03 | 0.27 |
| Water fern | 5.00 | 28.8 | 3491 | 14.1 | 14.07 | 0.72 | 0.73 | 0.80 | 0.52 | 0.70 |
| Duckweed | 5.00 | 25.0 | 3450 | 10.5 | 10.52 | 1.78 | 0.44 | 0.68 | 9.06 | 0.50 |
| Oyster shell | 5.00 | - | - | - | - | - | - | - | 37.62 | 0.07 |
| Bone meal | 10.00 | - | 1716 | - | - | 1.20 | 0.58 | 0.73 | 37 | 15 |
| Vegetable oil | 25.00 | - | 8170 | | | | | | | |
| Cod liver oil | 300.00 | - | 8200 | | | | | | | |
| vit-min-mix | 250.00 | - | - | | | | | | | |
| Salt | 15.00 | - | - | | | | | | | |
| Starch | 20.00 | 0.2 | 3400 | - | 0.08 | | | | | |

1US$ = N85.00

Table 2: Constraints imposed on the selection of feedstuffs by computerized linear programming for *C. gariepinus*

| | Constraints (%) | |
|---|---|---|
| **Feedstuffs** | **Minimum** | **Maximum** |
| Yellow maize | 10 | 30 |
| Soybean meal | 4 | 69 |
| Fish meal | 10 | 35 |
| Water fern meal | 3 | 30 |
| Duck weed meal | 3 | 50 |
| Blood meal | 1 | 20 |
| Rice bran | 3 | 15 |
| Oyster shell | 0.5 | 5 |
| Bone meal | 1 | 5 |
| Vegetable oil | 1 | 10 |
| Cod liver oil | 1 | 5 |
| Vit-min-mix | 1 | 2 |
| Salt | 0.5 | 1.5 |
| Starch | 0.1 | 1 |

Table 3: Least-cost formulation restrictions on nutrients for *C. gariepinus* fingerlings.

| | Restriction (%) | |
|---|---|---|
| Nutrients | Minimum | Maximum |
| Protein (%) | 32 | 40 |
| Lipid (%) | - | 5 |
| Metabolizable energy(Kcal/g) | 2618 | - |
| Fibre (%) | - | 6 |
| Methionine | 0.30 | - |
| Lysine | 1.63 | - |
| Calcium | - | 1.5 |
| Phosphorus | 0.5 | 0.7 |
| Met. + cyst. | 0.74 | - |