PLANNING AND CONTROL MODEL FOR THE CONSTRUCTION OF A LARGE IRRIGATION PROJECT

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A thesis submitted to the Postgraduate School, Ahmadu Bello University, in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE(CONSTRUCTION MANAGEMENT)

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Ahmadu Bello University, Zaria

October, 1984

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We certify that we have read this thesis and in our opinion it confirms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science (Construction Management).

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DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented in any previous application for a higher degree. All quotations are indicated and the sources of informations are specifically acknowledged by means of references.

Ahmed Sambo, Abdulhameed

Date, October, 1984

ACKNOWLEDGEMENT

Thanks be to the Almighty Allah, the Most Gracious, the Most Merciful, that gave me the chance to undertake this course. He gave me guidance and the right teachers that groomed me for this course.

I am therefore indebt and grateful to my principal supervisor Professor Tim O. Mosaku, Head of Department of Building and Dean of the Faculty of Environmental Design, who though logged with administrative and academic duties found time to guide me through this thesis. May the Almighty God reward him, Amen.

My thanks goes to Dr. E.T. Jolayemi, who guided me through the quantitative analysis and drilled me through the computer works. To him I find no words adequate to thank him. I can only say, a dedicated teacher per exellence. So also Alhaji Aminu Bambale, my co-supervisor who through his reading my scripts and discussions offered useful advices and corrections. To him I am highly indebt.

This thesis wouldn't have being a reality without the cooperation and understanding of my employers, Messers Impresit Bakolori(Nigeria), Ltd, who missed my services for over a year to enable me undertake this course. To them I am grateful for the rare help in utilizing their data for my research and the financial help.

My stay to undergo this course would not have being a reality, if not for the understanding of my father, M. S. Sambo Abdulhameed and Alhaji Ahmed Rufai Haruna, who shouldered the finances of my postgraduate studies. To them I say, "May the Almighty Allah reward you adequately, Amen."

My thanks also goes to the many numerous persons, too many to be mentioned all, for the assistance to see me through this course, among who special mention should be made of:-

Ibrahim L. H. Abdullahi, Mohammed Bature, Rilwanu Sambo, Abdulhammeed, Abdulkadir Balarabe, Dalhatu Balarabe, Capt, Ibrahim Abdulhameed, Shehu Ibrahim, Alhaji Ibrahim Iro, Alhaji Abubakar Sadauki, Alhaji Hassan Waziri, Alhaji Rilwanu Halilu, Ibrahim Umar, Sani Ahmed, Mohammed Rilwanu, Shehu Balarabe etc.

My thanks goes to my wife, Aishatu, who joined me in wedlock just as I was about to start my research, her understanding, carring and cooperative behaviour, I will long to cherish.

Lastly, I am very grateful to Mallam Abdullahi Bello of the Postgraduate School, who inspite of the short notice and other constraints helped in typing the thesis.

DEDICATION

This thesis is dedicated to my father M. Salisu Sambo, Abdulhameed who shouldered the financing of my Postgraduate studies, and who was my first teacher.

So also to my late mother Habibatu S. Sambo who could not live long enough to see the maturing of her son and appreciate her labour and to those who aspire to learn.

ABSTRACT

The planning and control of large projects have being of great concern to the Nigerian public in recent times, moreso with the current ambitious modernization of structural facilities for economic purposes, Irrigation inclusive,

A review of current planning and control techniques in the construction industry was carried out using litreature review and a case study of live Irrigation project construction.

The progress reports from the live irrigation project formed the basis of study.

Utilizing Multiple Regression Analysis a Statistical model is peresented that took into consideration the most important production variables and time for the purpose of planning and control of large Irrigation project construction. The models were found also to be applicable to other projects with relative ease.

QUOTATION

In the Name of Allah the Most Gracious, the Most Merciful.

(1) (God) Most Gracious!

(2) It is He Who has Taught the Quran.

(3) He has created Man:

(4) He has taught him speech (And intelligence)

(5) The Sun and the Moon Follow courses (exactly) computed.

(6) And the herbs and the trees Both (alike) bow in adoration.

Quran, Sura LV

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CHAPTER ONE

INTRODUCTION

1.1. HISTORICAL BACKGROUND

Food is one of the essential requirements for human survival. It weilds such importance that human beings utilized it for social, economic and political advantages. The processes of producing food are many. Agriculture forms the backbone of food production. In the branch of agriculture, Irrigation plays a very vital role.

Irrigation is an old art, as old as the civilization. But mordern irrigation is considered as a science for human survival. Egypt considered itself to have the oldest dam for irrigation which dates back to 5000 years. Such countries as China, India, Iraq, Syria and Italy have had hundreds of thousands of years of experience in Irrigation.(1)

In Nigeria, modern irrigation is new to the farmers, though irrigation itself is not new to them. Irrigation cultivation was developed early in the Northern States by rural farmers as a result of unfavourable conditions of low rainfall and long period of draught. Crops such as sugarcane, rice and various vegetables are grown on seasonally flooded riverine or fadama land in the vicinities of Kano, Zaria, Sokoto and Bida.

The hand scoop for watering the onion crops in the drier parts of Oyo and Ilorin represents a rudimentary form of irrigation. But a more improved method of shadoof irrigation

is used in Kano and Zaria regions to water dry season crops Onions, Carrots and other vegetable crops.

The first survey of irrigation potential in Nigeria was carried out in the North during the second decade of twentieth century. The study resulted in the impounding of flood waters from Sokoto and Rima River valleys in order to develop irrigation for some plots of lands by 1918. The Kwara Project was the first attempt to irrigate a large area by building a protection dyke for Kware area and by supplying irrigation water supply through a canal from Shella stream. In 1940 this project was also destroyed by floods. The reasons for their failure of these attempts have been described to be the inadequate technical knowledge and inputs.(2)

Considering the development potentials of the area for irrigated agriculture, the Irrigation Division was set up in the then Northern Ministry of Agriculture in 1949. During 1950s the division concentrated on small scale rice projects in the Niger valley (Mokwa Area) and some in Sokoto Province. Later on, some small irrigation schemes like Wurno project were developed which involved pumping from rivers.

During the first National Development Plan (1962-1968) the Food and Agricultural Organisation of the United Nations (FAO) was requested to make an intensive study of the countrys agricultural potentials and to draw up a scheme of priority for development. In the final report the F.A.O. recommended that:-

"There is a varst potential for improvement of agriculture in Nigeria. Full realisation of this potential can result only from a long range programme since it will depend upon the development of surface and ground water resources for irrigation---------."(2)

In yet another effort, the Federal Government of Nigeria, requested assistance from the United Nations Special Fund (Now UNDP) in a project to appraise the soil and water resources of Sokoto - Rima Basin and to formulate an agricultural development plan for the area. F.A.O. was appointed to undertake the survey. While submitting a plan for the Sokoto Rima Basin Development the F.A.O. in the Final Report of 1969 also observed that:-

"Expirience in the development of irrigated agriculture in the North West State is limited. The irrigation wing of Ministry of Agriculture was started in 1949 and up to 1960, concentrated its activities on investigation, design and construction of small rice schemes in the former Niger and Ilorin Provinces. The irrigation projects during 1962/68 period were of a pioneering nature and were restricted to relatively small pilot projects. In 1967/68 the total area under small irrigation schemes in Northern Nigeria was less than 14000 acres of which some 1,000 acres only were in the former province of Sokoto. It is therefore essential to build up experience in intensive double cropping irrigation development(2)----------".

Based on such recommendations by the F.A.O., the Federal Government of Nigeria has reiterated a comittment to irrigation development as reflected in the statement contained in the second and third National Development Plans that:-(2)

"Full exploitation of the agricultural potential of the country is only possible if its water resources are developed for irrigation which will not only permit multiple cropping but also to ensure sufficient water during the growing season of the crops".

To reflect its priorities, the Federal Government of Nigeria has given the following statements on the agricultural sector objectives as contained in the Guidelines to the Fourth National Development Plan (1981 - 85). :

(a) Increase production of food and other raw materials to meet the needs of growing population and rising industrial production; a basic objective in this respect is the attainment of self sufficiency in food in about five years.

(b) Increased production of livestock and fish to meet domestic needs and create a surplus for exports;

(c) Increased production and diversifying the country's foreign exchange earnings in this respect a target of seven years is being set for the rivival of our cash crops.

The disastrous consequencies of 1973-1974 draught in the northern parts of the country became an eye opener to realise the need for the development of irrigated agriculture.

The draught infact served as a catalytic agent for development water resources by the government. (2)

In a nut shell, from the late sixties to date Nigeria's Agricultural policy has seen a dramatic change.

The cnanges were necessitated by the following:- (2)

(1) The need for increase output of food to moderate increase in cost of living.

(2) The need to contain work demand by workers.

(3) To bolster dependent capital accumulation.

(4) The need to diversify the national economy to run away from the monoeconomy syndrome. Thus Oil.

At the core of this diversification is the need to increase agricultural output through the introduction of new technology supported by infrastructural and intensive management. (3)

By utilizing water resources for modern irrigation the federal government intends to achieve the following:-

(1) Generate foreign exchange earnings by reducing the importation of food stuffs (Sugar, Wheat, Rice, Meat and Tomatoe preserves are major examples)

(2) Generate foreign exchange earnings by increasing the export of other agricultural products (groundnuts, cotton, and onions are good examples).

(3) To ensure returns on capital which, by exceeding 10% per annum, are exeptionaly for investment in Agriculture.

(4) Open up great possibilities for subsequent investments in industry and Trade with all the agro-allied industries that will process the agricultural product (sugar refinery, canning factory, wheat and rice mills, cattle ranch) as well as transport and marketing.

(5) The modern farming, and the parallel industrial and processing operations together with all the connected services and distributions will ensure good employment opportunities for many thousands of people in a densely populated region where there are few other opportunities for economic and social development. This type of development, by creating sound job opportunities spread over the region represents a good way of checking the undesirable drift of young people to the cities and overcrowding of the urban areas.

(6) In addition to giving water and electricity supplies to the rural populations, the dam also ensures steady water supply to urban centres.(4)

Having realised the importance that irrigation can play in Nigerias development efforts and having realised the enourmous task involved in trying to achieve these goals, a special structural organisation separate from that of the civil service was required. So, the federal Government started having the idea of river basin development as a tool of agricultural transformation as early as 1970. In 1973, the Sokoto Rima and Chad Basin Development Authorities were established and both became operational in 1974. Subsequently, nine other authorities were set up in 1976. Now each state has its own development basin Authority.

All River Basin Development Authorities are parastatals of the Ministry of Agriculture, Rural Development and Water Resources.

They were established by the Federal Government decree of 1973 Number 22 and continued in being by decree number 25 of 1976. The Federal Government modified and increased the scope of RBDAS activities and powers by decree number 87 of 1979, which was further ammended by Act number 7 of 1981 which supercedes all previous decree in respect of the River Basin Development Authorities.

The Acts provides the authorities with following functions:-

(1) To undertake comprehensive development of both surface and underground water resources for multipurpose use;

(2) To undertake schemes for the control of floods and erosion and for watershed management including afforestation.

(3) To construct and maintain dams, dykes, polder, wells, boreholes, irrigation and drainage systems and other works necessary for the achievement of the authority's function under this section.

(4) To provide water from reservoirs and lakes under the control of the authority for irrigation purposes to farmers and recognized associations as well as for urban water supply schemes for a fee to be determined by the authority, with the approval of the commissioner;

(5) The control of pollution in rivers, lakes, lagoons and creeks in the Authority's area in accordance with nationally laid down standards;

(6) To re-settle persons affected by the works and schemes specified in this section or under special resettlement schemes.

(7) To develop fisheries, and improve navigation on the rivers, lakes, reservoirs, lagoons and creeks in the Authority's Area.

(8) To undertake the mechanised clearing and cultivation of land for the production of crops and livestock and for forestry in areas both inside and outside irrigation projects for a fee to be determined by the Authority with the approval of the commissioner.

(9) To undertake the large scale multiplication of improved seeds, livestock and tree seedlings for distribution to farmers and for afforestation scheme;

(10) To process crops, livestock products and fish produced by farmers in the Authority's area in partnership with state agencies and any other person.

(11) To assist the state and local governments in the implementation of the following rural development work in the authority's area:

(a) The construction of small dams, wells and boreholes for rural water supply schemes and for feeder roads for the evacuation of farm produce.

(b) The provison of power of rural electrification schemes from suitable irrigation dams and other types of power stations under the control of authority's concerned.

(c) The establishment of agro-service centres.

(d) The establishment of grazing reserves and

(e) The training of staff for the running and maintainence of rural development schemes and for general extension work at the village level.(5)

1.2. SCOPE OF IRRIGATION PROJECTS IN NIGERIA

As we have seen in our historical background of Irrigation Projects in Nigeria, its development was in two folds, that of the rural communities done by traditional methods and the involvement of Government in developing irrigation using modern methods.

Modern Irrigation method is now the predominant method of agriculture in the extreme Northern parts of Nigeria and is spreading down wards to other parts.

This modern method could be defined as the application of controlled water probably from a reservoir to the soil for any number of the following reasons:-

(a) To add measured water to the soil to supply the moisture essentiall for plant growth. Without water, plants cannot absorb their nutrients from the soil. If this happens, the plants will die, and consequently they will not produce any seeds, tubes or fruits and we ourselves will also die with the plants. Put in a simple language, there are no trees in the deserts primarily because there is no water.

(b) To provide crop insuarance against short duration draughts. This is common in Southern parts of the country but more so in the north where we have long duration of draughts. Hence there is the more justification to site most of our dams in the north. There is also the problem of desert encroachment that must be stopped.

(c) To cool the soil and atmosphere, thereby making more favourable environment for plant growth. Mainly here in the north, we have the very dry spells during the dry season characterized by the north - south bound - dust ladden harmattan winds that do more harm than good to crops. It is very dry and ofcourse aid evapotranspiration. Irrigation

Irrigation cools not only the soil but also the atmosphere making it easier for plants to respire and transpire.

(d) To wash out or dilute salts in soils. We know that sodium salts and others abounds in the soil. These effect the plant, that in turn affects some crops. While some crops tolerate high acidity e.g. rice, maize, others like wheat and sugarcane don't.

(e) To reduce the hazards of soil piping., This could be very dangerous to both seeds and crops.

(f) To soften tillage pans. This is important for agricultural machines, e.g. ridges, disc, ploughs etc. It may not be easy to till a hard soil.

Irrigation water is supplied to supplement water available from the following four sources, none of which should be ignored when irrigation water requirements are estimated:-

(1) Precipitation: This is one of the reasons why a metrological station is very important in calculating the volume of water to add to the soil. During the rainy season, irrigation water supplements the rain water.

(2) Atmospheric water other than precipitation. Fogs, Clauds, and especially dews are other factors which not only affect evapotranspiration but could add some extra moisture to the ground. Dews collecting to flows have been used to grow some crops. High humudity obviously causes a drop in evapotranspiration, and thereby less demand for water by plants.

(3) Flood water.

(4) Ground water. Water may rise by capillarity. If the water table is high. If it is too high, it might become very dangerous to crops.

Modern Irrigation may be accomplished in four different ways:-

(1) By flooding
(2) By means of forrows
(3) By applying water underneath the land surface through sub-irrigation thereby causing the water table to rise.
(4) By sprinkler of different types. These four systems could be grouped under major systems of surface and sprinkler irrigations.(1)

Depending upon the engineering studies carried out, an irrigation project may comprise of one or a combination of the stated methods. The lasting consideration in designing and constructing irrigation project are the economy, reliability

and the social standards of the operators of the project.

The size of an irrigation project that can be considered as large is relative. However, for the purpose of our study and indeed currently in Nigeria up till the end of 1986, the following are considered as the parameters of size of irrigation projects:

TABLE 1

SIZE OF IRRIGATION PROJECTS IN NIGERIA

	IRRIGATION PROJECTS	SIZE
1.	Less than 10,000(Ha)	Small
2.	10,000 - 20,000(Ha)	Medium
3.	Greater than 20,000(Ha)	Large

Source: Adapted and processed from tables of Irrigation Projects in Nigeria 1975 - 86, from Arzika Mohammeds paper.(2)

The provision of facilities for mordern irrigation is very complex. Immagine, a land as big as 20,000 hectares prepared to be irrigated from a single reservoir.

How does the water from the reservoir reach every plot in the land?

This demands construction of many auxilliary structures that will enable the water to reach its destination and serve its purposes economically and without herm to anybody or anything.

In describing these structures, many type of terminologies are used, however, since our main consideration is the large irrigation project, the author seeks your indulgence to utilize the terms best known to him having worked with the contractors of Bakolori Irrigation Project for about four years.

A large irrigation project may comprise of the following facilities:-

(a) A DAM: This may be made up of either concrete, earth or a combination of both.

(b) RESERVOIR: The dam usually is constructed to retain the water to be utilized for irrigation. The water retained its quantity and the area it occupies is known as the reservoir.

(c) THE SUPPLY CANAL: Water from the reservoir is carried to the fertile plains by the supply canal to reach the main irrigation area.

(d) SURFACE IRRIGATION: The canal metwork consists of main canals, generally concrete lined, dividing into secondary canals, from which tertiary canals branch off, each serving an irrigation unit.

These units are further divided into plots to be irrigated by field ditches.

All surface irrigated fields are completely levelled to ensure that water can slowly reach the whole field.

SPRINKLER IRRIGATION: The sprinkler system is used where soils have medium to high permeability. The irrigation water is drawn from nearby canals by gravity and then the water is pumped into a network of buried pipes by means of electric pumps. Lateral movable pipes which are fitted with sprinklers are then connected to the buried pipes.

ROADS AND BRIDGES: Roads and bridges of different categories are constructed to ease up communication and transportation problems within and outside the project area.

ELECTRICITY SUPPLY: Power supply necessary for the functioning of all pumping stations, services, and Residential houses and helmets.

SERVICES CENTRES: To provide assistance to farmers.

HOUSING: Residential complex to accomodate personnel to operate and to maintain the project.

RESETTLEMENT: The creation of such project must require some resettlement schemes, proper organisation to resettle people is necessary.

DRAINS: Tertiary drains in surface irrigation collect over used water and empty them into secondary drains to main drains into a natural drain or into the drainage station,

EXPERIMENTAL IRRIGATION FARM: Before lauching such project, an experimental irrigation farm is necessary to test the irrigation techniques, assess irrigation parameters and experiment cultivation techniques and new crops to the area.(4)

CANAL STRUCTURES: Intake, field ditches, headworks, checks, Measuring flume, outlet box, turn out, tailescope and Aggreggate protection are structures made on canals to control and regulate the flow of water within the various canals and to protect the canals from erosion.(1)

DRAIN STRUCTURES: Drain drops and aggregate protection to control and regulate flow of water and to protect the drain from damages.(1)

SYPHON: A turnel constructed of reinforced concrete to convey water accross natural water logged depression.

PIPE BRIDGE: A pipe usually used to convey water for irrigation over a very deep depression in natural ground elevation,

From the above discriptions so far, it is inevitable that a whole lot of human and material resources are required for establishing a large irrigation project. Above it all is the marshalling of these resources by an entity to provide the infrastructures needed for such a project to become a reality.

The construction of a large irrigation project is therefore an ennormous and a challenging task. Its realisation by a contractor is one thing. How effectively its realised is another thing. How effectively it is realised depends on the managerial competence and capability of the contractor incharge of the project.

The complexity of constructing a large irrigation project demands the utilization of human resources with diverse qualities. From the characteristics of a large irrigation project, one sees that in its construction we need earthmoving equipments for earthmoving works like dams, reservoir, canals, drains, land levelling etc. Concrete equipment for the construction of Dam Spill Way, canals and canal structures, drain structures etc. Bush clearing and land levelling equipments for bush clearing and land levelling works of all irrigation lands. Pipe laying and testing equipment for sprinkler works. Trenching machines for excavating trenches, canals and drains of uniform sizes.

A very big workshop to maintain all equipment and plants so as to ensure contunuinity in executing the job.

A reliable quary supply for the provision of all agreggates required for the various constructions. A reliable services (power, water, security, communication etc) system. Very strong and reliable personnel who are disciplined and dedicated to the execution of the job. A strong and motivating management and good leadership to see the job through.

1.3. REASONS FOR THE RESEARCH

Until now we have known the historical background, scope and complexity of large irrigation projects in Nigeria. In these we realised the emmense effort the Nigerian Government has put in human and Material resources inorder to modernize irrigation in Nigeria. We had also realised the reasons behind this ambitious programme. For this ambitions to be realised, objectively and realistically there must exist construction managers who can manage the construction of these projects very well. This has been one area that Nigeria is lacking. One of the reasons advanced for the failure of the Nigerian Construction Manager is his inability to plan and control projects so as to curtail escalating cost of contracts.(6) His (Construction Manager) problem stem from his lack of understanding the techniques of short-term planning and control and the lack of willingness to adopt or research for new methods to improve his present standards.

1.4. AIM OF THE RESEARCH

The aim of this research therefore is to try and look at the current techniques used in Nigeria's Construction industry for planning and control with a view of formulating a model based on means of production through a very vigorous analysis of production variables that could be used for the construction of a large irrigation project and with relative ease be applied to other constructions.

1.5. OBJECTIVES OF THE RESEARCH

(1) To review planning and control techniques in construction industry.

(2) To analyse one year, monthly progress reports of the construction of a large irrigation project.

(3) To identify the most important production variables.

(4) Formulate a statistical Model based on the data studied to be used for planning and control of irrigation projects.

(5) To propose further areas of research in line with the above.

1.6. METHODOLOGY

The research was carried out, first by reviewing the planning and control system in the construction industry.

A case study is taken of the Bakolori Dam, Irrigation Project. The case study entailed using one year monthly progress report of the construction work of the project.

Assisted by clarifications through verbal interview from key personnels of the project, the monthly progress reports were subjected to study to identify the behavioural pattern of production throughout the year and what were responsible for the productions to be as they were.

After the study, all constraints in utilizing the data were identified. Assumptions were then advanced for utilizing the data in order to arrive at a realistic statistical model.

Based on earlier analysis and assumptions, the data was subjected to statistical analysis using the Ahmadu Bello University Computer Centre facilities.

The best model from the computer printout was then extracted based on the two mostly used criteria of R square and Residual Analysis.

The model is then interpreted and conclusions drawn. Suggestions on areas of further research are then given.

CHAPTER TWO

LITERATURE REVIEW

2.1. PLANNING

Management, have five essential functions in any entity:-

(1) Planning
(2) Organizing
(3) Staffing
(4) Leading
(5) Controlling.(7)

Out of these managerial functions, planning is considered the most basic of them all because:-

(a) It involves selecting from among alternatives future course of action.

(b) It determines how the four other functions of the manager will be implemented. Thus, a manager organizes, staffs, leads and controls inorder to assure the attainment of goals according to plans.

Generally, planning is a process. A process that involves making and evaluating each of a set of interelated decisions before action is required. In a situation in which it is believed that unless action is taken a desired future state is not likely to occur, and that, if appropriate action is taken, the likelyhood of a favourable outcome can be increased.(8)

It is the design of a desired future and effective ways of bringing it about. It is considered to be a special decision making process. It is special because:-

(1) Planning is something we do in advance of taking action, that is it is an anticipatory decision making. It is a process of deciding what to do, how to do it, when to do it and who to do it. It bridge the gap from where we are to where we want to go. It makes it possible for things to occur which would not have otherwise happen. Although the exact future can seldom be predicted and factors beyond control may interfere with the best laid plans, unless there is planning, events are left to chance.

(2) Planning is required when the future state that we desire involves a set of independent decisions. A set of decisions forms a system. If the effect of each decision in the set on the relevant outcome depends on at least one other decision in the set. The set of decisions that requires planning have the following characteristics:-

(a) They are too large to handle at once. Therefore planning must be divided into stages or phases that are performed either sequencially by one decision-making body, or simultaneously by different bodies, or by some combination of sequential and simultaneous efforts.

(b) The set of necessary decisions cannot be subdivided into independent subsets. Hence planning problem cannot be broken down into independent sub-planning problems. The sub-planning problems must be interelated. This means that decision made early in the planning process must be taken into account when making decisions later on, in the process and the earlier decisions must be reviewed in the light of the decisions made subsequent to them. This is why planning must be carried out before action is required.

These two properties of planning make clear why planning is not an act but a process, a process that has no natural conclusion or end point. It is a process that (it is to be hoped) approaches a "Solution", but it never quite gets there for two reasons:-

i) There is no limit to the amount of reviewing of previous decision that is possible. The fact that action is eventually required, however, make it necessary to settle for what has at some point in time.

ii) Both the system being planned for and its environment change during the planning process, and it is therefore never quite possible to take all such changes into account. The need to contineously update and "maintain" a plan derives in part from this fact.

(3) Planning is a process that is directed toward producing one or more future states which are desired and which are not expected to occur unless something is done. Planning is concerned with reducing the frequency of failure to exploit opportunities. Planning always has both a pessimistic and optimistic components. The pessimism lies in the belief that unless something is done a desired future state is not likely to occur. The optimism lies in the belief that something can be done to increase the chance that the desired state will occur.

The main reason for undertaking any sort of planning is to facilitate the accomplishment of enterprise purpose and objectives. It is to be noted that plans alone cannot make an entity, action is required. The entity must operate. Plans can, however, focus attention on purposes. Without plans, action must become merely random activity, producing nothing but chaos.

Planning is a function of all managers, although the planning will vary with their authority and with the nature of policies and plans outlined by their superiors.

The efficiency of plan is measured by the amount it contributes to purpose and objectives as offset by costs and other unsought consequences required to formulate and operate it. Since plans are courses of future action, they are varied and are classified as purposes or missions, objectives, strategies, policies, rules, proceedures, program and budgets.(7)

Plans are undertaken to perform certain functions in any set-up. These functions are:-(7,9)

1) To offset undertainty and change.
2) To focus attention on objectives.
3) To gain economical operation
4) To facilitate control
5) To allocate contractual responsibilities and provide for clear lines of communication.
6) To coordinate contributions from various groups.
7) To resolve delay and change order disputes on a predefined, quantifiable and equitable basis.

2.2. CONTROL

Having set standards (plans), Management can then proceed to act by setting up organizational structure, staff the structure, provide leadership and control the performance of resources inorder to achieve the desired objectives.

Control, therefore, to a great extent is the function that closes the loop in the system of managing. Control can be defined as the matching of performance of the resources inorder to achieve the desired objectives.

Control, therefore, to a great extent is the function that closes the loop in the system of managing. Control can be defined as the matching of performance with necessary or required conditions to obtain a purpose or objectives.(10) It is concerned not only with events directly related to the accomplishment of major purposes but also with maintaining the organization in a condition in which it can function adequately to achieve these major purposes. Therefore, it implies measurement of accomplishment of events against the standard of plans and the correction of deviation to ensure attainment of objectives according to plans. Once these plans become operational, control is necessary to measure progress, to uncover deviations from plans and to indicate corrective action.

In order to apply management control, there must be plans. This is so because control must be based on plans. There is way that managers can determine whether their organizational unit is accomplishing what is desired and expected unless they first know what is exptected.

Control are the reverse side of the coin of planning. Managers plan, then plans become the standards by which desired actions are measured.(7, 10, 11).

2.2.1. TYPES OF CONTROL

(1) PRE-CONTROL: When controlling effort takes place ~~priort~~ prior to the act. Its concerned with avoiding or preventing undesired things from occuring, and frequently this means eliminating, removing the possibility of or in some way preventing an undesired act from taking place.

(2) CURRENT CONTROL: It is concerned with the adjustment of performance still taking place inorder to achieve objective or standards. Current control, is likelier to consist in a person or machine making its own adjustments than to have some outside influence become involved with control, as usually occurs with precontrol.

(3) POST CONTROL: or evaluation, occur when there is effort to check on whether events did come out as desired. For example, the business concern balances its books at the end of the year to see whether it made profit desired. The higher officers in the army make inspection trips every few weeks or months to see whether military units are being maintained at a desired level of performance. This is checking after the fact, which means that information may be gathered regarding where people stand, but may not permit any corrective action to take place in regard to the performance completed.

It only provides for opportunity to evaluate and adjust the parameters of the system for future operations. Such changes might include re-alocating a plant, changing work flows in a government office, changing the size of an area covered by a charity derive etc.

Before control could effectively be taken, an organization must have a very sound organisational structure with clean cut responsibilities for - [12]:

(1) PRODUCT DEFINITION: Define or direct the definition of products to be developed in terms of hardware, soft-ware and services including standard for performance, quality, reliability and maintainability.

(2) TASKS AND FUND CONTROL: Assign tasks and allocate funds to all groups performing the said tasks and for procurring hardware and services for the organisation.

(3) MAKE OR BUY DECISIONS: Coordinate analyses of company capabilities, capacities and efficiencies and make final decisions on whether the company supplies or buys hardware and services for the organisation. Participate in the selection of major sources.

(4) SCHEDULING: Develop a master organisational schedule and coordinate schedule requirements with affected company organisations, associates subcontractors and customers.

(5) ORGANISATIONAL STATUS: Establish status reporting system and contineously monitor organisational expenditures, schedules, task completion, cost to complete and deliveries.

(6) IDENTIFICATION AND SOLUTION OF PROBLEM: Identify problems significant to organisational success and initiate action to solve them.

(7) ORGANISATIONAL CHANGE CONTROL: Approve and exercise control over all organizational changes including design changes.

(8) ASSOCIATE OR SUB CONTRACTOR CONTROL: Have control of major subcontractors involved in the team arrangements.

(9) CUSTOMER AND PUBLIC RELATION: Serve as the outside contact for the organisation.

(10) MARKET POTENTIALS: Maintain awareness of customer attitudes, customer desires and any other factors which could affect the organisation. Develop plans for a logical follow up action, potential or new applications or new versions of the organisational hardware or services.

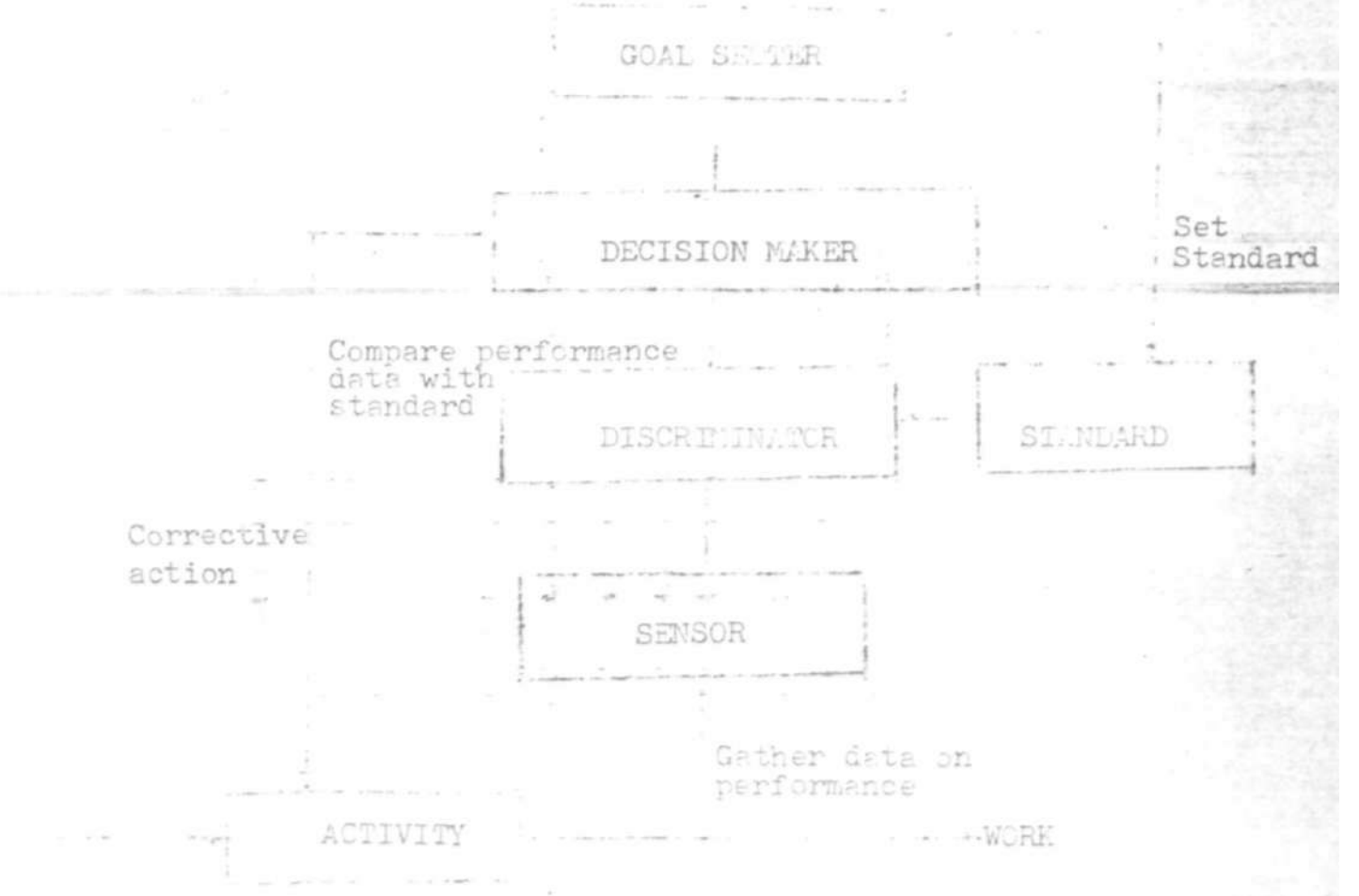
These bases for establishing control may not be applicable to all organizations, but to a large extent they form the backbone of applying control in majority of organizations. Having establish the bases of applying control, the process of installing and maintaining it are:- (7, 10, 11)

(1) Establish standards
(2) Gathering data on performance
(3) Measure performance against the standards
(4) Taking corrective action if performance does not match the standard properly.

These phases are carried out by a sensor, discriminator, and decision maker. There is a major alternative in any control process, ~~that is a major alternative in any control process,~~ that's instead of taking corrective action one adjusts the standards. The control process could be likened with a cycle of activities as is shown on figure 2.2.1.

FIG. 2.2.1

THE BASIC CONTROL CYCLE



Source: Litterer, J.A.. The Analysis of Organization, New York, John Wiley and Sons. Inc., (1965)

Having identified types, where, what and when managers have to control, we now look on how they control. Managers may correct deviation by:-

(1) Redrawing their plans.

(2) Modifying their goals

(3) By exercising their organising function, through reassignment or clarrification of duties.

(4) By additional staffing

(5) By better selection of training of subordinates

(6) By ultimate restaffing - firing

(7) Through better direction and leading

(8) Giving full explanation of jobs

(9) By more effective leadership

If controls are to work, they must be specifically tailored. They must be tailored:-

(1) To plans and position

(2) To individual managers and their personalities

(3) To the need for efficiency and effectiveness

2.3 PLANNING AND CONTROL IN THE CONSTRUCTION INDUSTRY

Once a decision has been made to proceeed with a revenue generating project the two factors which are often most critical in the owners strategy are:-

(1) To keep the engineering phase as short as possible (Engineering phase is defined as the set of activities from the time the owner/promoter decides to proceed to start up the commercial production of the facility).

(2) To devise and install a management system which is not only capable of planning, procurring and controlling the input required from the various groups, but is also compatible with the present day legal system so that contractual responsibilities are adequately defined, allocated and monitored in the course of the project.

In order to achieve these, many stages of development will have to be undergone right from its inception uptill the handing over and the commencement of operation. Many publications have produced an idea of the stages of development of realizing a project. (9, 12, 14, 15, 19, 20).

However, the one found to be most compatible with most projects is that advanced by Hackney(14):-

(1) Research and Development:

- new products are created
- special feutures of producing these products are developed.
- Better ways for making existing products are developed.

(2) Project Definition:

- practical plan for the project is drawnup and optimised, thereby establishing products, market, raw materials, and key engineering design features.

- It includes determination of plant capacity, raw material sources and quality, marketing and distribution methods, plant location process or production flow sheets, plant layouts in plan and elevation.

- List of equipment with size and type specified, specification for Key construction materials and site development requirements.

(3) Economic Decision:

- A "Separation Phase", usually marked by an appropriation request in which project value is given a formal, critical appraisal before moving on to the succeeding increasingly expensive project stages.

- A more reliable definition of earlier factors considered in stages one and two. In this phase they are well established in order to erase possibility in abandoning the project having committed so much resources.

(4) Engineering Design:

- Project design is completed, detailed drawings, bills of material and specifications are prepared fully defining the project for procurement and construction.

(5) Procurement and Construction:

- This is the phase in which individual components of the facility are purchased and installed in place, ready for operation.

(6) Initial Operation:

- Operators are trained.
- The first product made, bringing the plant up to design capacity product quality and efficiency.

These stages of development of project realisation are given to contractors/consultants by the client/promoter under contractual agreements, either independently, in combinations or all the stages are given to one contractor. The execution of these stages of project development fall under different types of contractual agreements either to different contractors or to a single contractor. The essence is that there must be a legal backing for the realisation of the project.

For a contractor to realise the execution of part/all the stages of this project. He must provide a sound organizational structure with good management.

Good planning and control form part of the requirements of good management. It is necessary to plan and control project with respect to time and accomplishment for successful execution of part/all project stages. Thus, a contractor employed to construct a project must plan and control his

resources, not only to get profit but also for the project to be completed within schedule and with minimum resources possible.

Planning is the determination of the individual operations which must be performed in order to carry out a project, and the establishment of sequential relationships between them.(14)

In the construction industry, this "subject", Planning, is divided into pre-tender, precontract and short-term planning.(16)

(1) PRE-TENDER PLANNING:

This planning is carried out to allow the estimator to arrive at an estimate of the cost based on the proposed methods of working an estimate required to carry out the work. It is usually in an outline form to consider only phasing of the main operation since much information is not at that time available. This pre-tender planning can be likened to the one proposed by Hackney as, The tabulation of Key dates.(14)

Pre-planning state fixes the direction and determines the success of any construction project. In preparing pre-planning the following must be adhered to(17):-

(1) Have the project head in the planning at the very start. Dont present him later the finished plan and say, "Follow this".

(2) Break the job down into components.

(3) Prepare a construction plan with the intention of reffering to it constantly; don't file it in the drawer to be forgotten.

(4) Take advantages of new tools that have demostrated they will save time, money or confusion.

With these guidelines the following could be realized:-

(a) Recipt dates of key controlling equipment, materials etc:-

(b) The appropriate time to be on site.

(c) A reasonably accurate estimate.

(2) PRE-CONTRACT PLANNING

This planning is carried out when the contract has been won and the project is considered more fully. Planning at this stage includes the overall programme, labour, schedule, plant schedule, material schedules etc. The overall programme should not break the operation down excessively or it will become unrealistic. In order to prepare pre-contract planning some basis of calculations are needed of the productive hours, from operational records of past contracts and from work study synthesis. This pre-contract planning can be likened with the master schedule proposed by Hackney.(14)

(3) SHORT TERM PLANNING

This sort of planning is done on site in greater detail and the programme at this stage is broken down much further. It covers a period of four to six weeks or may cover a stage of work. Sometimes it is done at interval of four weeks. The purpose is to ensure that work proceeds in accordance with the overall programme. For this to take place, the overall programme must be converted into a working schedule and must be updated regularly, whilst a review is simultaneously made of all requirements by checking schedules.

It is usually planned after the monthly planning meeting. In this way accounts can be taken of any alterations or variations which are necessary. The basis of calculation must be the operational records from previous contracts.

These are the three basic types of planning that a contractor will undertake to ensure a sucessful and realistic execution of his contract. However, depending upon the size of the project/contract, planning may continue beyond these three types to include[16]:-

(a) WEEKLY PLANNING

This programme ensures that the monthly programme is effectively carried out. It is used as a basis for operational instructions for communicating the plan to the trades foremen, gangers, and operatives and to help in coordinating the requirements of different sites. It is

prepared after the weekly site meeting at which gangsters and foremen are present, together with others who will be involved in the following weeks work. The operational records are the basis for calculation.

(b) DAILY PLANNING

(c) HOURLY PLANNING

Planning, scheduling and Programming have quite given much problem to the managers of the construction. We had already defined planning.

SCHEDULING/PROGRAMMING IN THE CONSTRUCTION INDUSTRY:

Programming was the word used before but on its use indiscriminately by all fields of endeavour, scheduling has taken its place. "It is the development of time requirements for each operations and the relating of each to calendar time".(14)

Any plan for starting actual construction on a project should facilitate the construction by establishing (19):-

(1) The time for delivering materials.

(2) The types, quantities and duration of equipment needs.

(3) The classification and numbers of labourers needed and the periods during which they will be needed.

(4) The extent to which financial aid, if any, will be needed.

(5) The time required to complete the project.

The purpose of any plan in any project execution is to (20):

(a) Create a feasible frame work and method statement for the execution of the works that provides the basis upon which the works will be performed.

(b) To allow the project manager enough time to handle unexpected problems and monitor progress rather than constantly fighting to keep up with planning requirements as works proceeds.

(c) To anticipate and resolve many difficulties before a start is made on site.

(d) Advices the planned completion date.

(e) Advices the sub-contractors of their start and finish date.

(f) Enables the contractor to anticipate resource need, i.e. critical dates and quantities of:- Labour, Plant and Material.

The production of the plan for the execution of any project must undergo processes inorder to appraise rationally the completed plan before any part is executed. The planning process may be analysed[20]:-

(1) Job - Analysis:

Available document must be studied so as to be able to appraise the whole work. This job analysis involves the preparation of a detailed schedule of quantities and resources required for the execution of the operations and works involved in the project.

(2) Plan Production:

We prepare a detailed plan on how all the jobs are going to be performed from the analysis carried out. This will involve appraising the resources requirements for the completion of each operation.

(3) Intergrate into programme:

It is necessary to combine the resource needs and the time scale of each activity into an intergrated programme. There are numerous methods given for graphical representation of programmes/schedules - :(9, 14, 15, 16, 18,19,21,22,23,25,27)

(1) Flow Charts
(2) Bar Charts
(3) Network Analysis(PERT, CPM, ARROW DIAGRAM, LINE OF BALANCE ETC).

For each of the listed methods are advantages and disadvantages. For clearity on each of the methods the references listed can serve as materials for digestion.

A contractor who discovers after a progject is finished that he has lost money may not have an opportunity to raise the price on the next project, especially if his losses were so great that he cannot finance another project. He may lose money because of one or more reasons, such as (19):

(1) Low bid
(2) Insufficient Knowledge of job conditions.
(3) Increase in the cost of materials and labour
(4) Adverse weather condition
(5) Improper selection of construction equipment
(6) Inefficient management and supervision

Therefore, for a manager to be efficient and successful, he must establish a structural organization that can facilitate the control of these factors. This structural organization is derived from the plan (standards) of the entity. The plan provides the avenue for control to take place.

Control in the construction industry therefore, "Is the comparing at a regular intervals, the actual achievement with the plans and then taking necessary corrective action to bring things back into schedule."(16)

Control must be carried out to make planning effective, as without control planning looses much of its value. Control must be applied contineously to update the plan and to enable

recomsideration of work ahead in the light of what has already taken place. Controlling techniques in project development irrespect of the phase of execution group themselves into those related to[14]:

(1) Capital Cost: Estimating and controlling the money invested.

(2) Time: planning, schedulling and monitoring for smooth progress toward early completion.

(3) Value: predetermined and controlling income as related to investment, operating cost and risks.

These techniques are made effective by having:-

(a) Proceedures: Establishing the mechanics of estimating and control for each of the advancing project stages.

(b) Organization: marshalling coorporate and outside resources for effective project execution.

In the present day of big construction projects, there is little chance for second guessing. The rewards of success or failure are great. A control system that is sensitive and responsive are required. These systems must indicate promptly and clearly any deviation from good performance and make it possible to take effective, timely corrective action. Good control can substantially improve the chances of success. Out of all the groups of control, the most influencial is "Time"

control whose elements are planning, scheduling and Reporting progress.

When planning and scheduling are completed and are put into action, control is necessary to measure performance and uncover deviations so as to be able to send in corrective measures into the system inorder to achieve the desired goals.

Management control is a collective responsibility within any organization even to a lesser person as the foreman in the construction industry. Top managers exert control in their projects through the feedback they receive from the plans they enforced on a project. They have to do this, because as managers, they do not handle people, but they motivate, guide and organize people to do their work. Their only tool of controlling is either the spoken, written words and the language of numbers or a combination of the tools.(28) Therefore, at specific intervals, usually monthly, weekly, quarterly, reports should be submitted by the project manager to the headquarters office showing the actual progress on each activity during the appropriate time interval or through the effective date of the report so that if progress on one or more activities or on the entire progress is behind schedule, such information will be known early enough to take corrective action.

These progress reports provide managers with the way the system is operating. It is only through it that the managers derive information about the way the system is operating, so

that the discrepancy between actual performance and the disirable level of performance can be assessed.

When this discrepancy has been determined, the controller decides whether to take action or not. If the discrepancy is too large to tolerate, the controller reacts and the system responds to his command in a suitable way. The controller is therefore, that component in the system that has the ability deliberately to adjust or change the systems performance.(11)

There are different ways progress reports are presented to managers to facilitate control.(12,14,16,18,19,27,28)

It should however, remain to the knowledge of the reader that, progress reports depend by their nature to a large extent to:-

(1) Nature and extent of projects.

(2) Demand on the nature and the type of the progremme to be employed in the contact by the conditions of contact.

(3) Nature and proceedures in the country the contact is to be executed.

(4) The aims, structure and to a large extent on what management are looking for in their project organization.

These progress reports produced have various functions to the management.(18, 28, 29):

(1) It gives the exact picture of where, when and how the project is going by highlighting deficiencies and thereby giving avenue for where to direct corrective action.

(2) It enhances coordination organizational, monitoring, planning and controlling activities and makes them easy to undertake.

(3) When a company has many projects at a time, it helps in managing them.

(4) It helps management in evaluating project managers performance under different conditions and hence they can be able to select the best manager for a particular type of project with particular conditions.

(5) It serves as a historical record for organizations thereby enhancing better management and chances of winning new projects.

(6) It helps in research programmes.

(7) It breeds efficiency, productivity and healthy competition among project managers.

For effective management function such as planning and control to take place in the construction industry, there must be[9]:

(a) A realistic estimation of the productivity of crews and adoptation of a representative f value for job - management efficiency factor (caution for values of $f > 0.5$)

(b) Sufficient time buffers between similar trades; this infact, is to simulate actual field conditions which indicate delay in start up of new operations.

(c) A sound project structural organisation with clear cut responsibilities.

(d) A reporting system in line with project structural organization.

These are the basis under which effective planning and controll can take place. Here lies the crux of the problem.

CHAPTER THREE

CASE STUDY

We had in the last two chapters known the historical background of irrigation development in Nigeria and how modern irrigation came to be introduced into the Nigerian agricultural scene and why. We had also realised the complexities involved both in terms of planning and execution. We had also seen how construction companies plan and execute their projects, we had also realised one of their area of deficiency - planning and control.

We are now going to consider production data of a construction company for one year with a view to analysing it so as to come up with a model. The company in mind is Impresit Bakolori (Nigeria) Ltd. The contractors of the Bakolori Dam, Irrigation Project.

3.1. THE BAKOLORI IRRIGATION PROJECT

The Bakolori Dam, Irrigation Project is situated at Talatan Mafara, Sokoto State, along Zaria - Sokoto Road.

The Bakolori Project as it is commonly known, is the first stage of the F.A.O. master plan for the development of the land and water resources of the Sokoto - Rima river basin. In June, 1975 part of the project was awarded for design and construction to Impresit Bakolori, (Nigeria) Ltd., and in June, 1977 the rest of the contract was awarded to the same firm to complete. The project comprises the storage dam on the Sokoto River, Irrigation and drainage canals, flood protection dikes, pumping stations for Sprinkler Irrigation,

protection dikes, pumping stations for sprinkler irrigation, hydro and diesel power stations, transmission lines, road network, and residential and Service centres.(4) see table 3.1 for scope of the project.

3.1.1. THE CONTRACTORS

Impresit Bakolori(Nigeria) Limited(30) was incorporated in 1975 for the studies, design, construction and eventually management of irrigation projects and the development of Agriculture in Nigeria.

It has a fixed assests worth US$100 million and an annual turnover of approximately US$200 million. The company is 60% owned by the Federal Government of Nigeria and the reminder by its technical partners. Impresit of Milan, one of the worlds largest companies in Civil Engineering. To construct the Bakolori Project, Impresit Bakolori, mobilized over 5,000 people, organized shipping from Europe and road transport from Apapa for the thousands of items required to implement such a large construction programme among others.

Impresit Bakolori developed a multisectoral organization which is the most efficient means for the rapid and sound implementation of large irrigation schemes such as Bakolori, where conception, design, construction and operation are superimposed on condition and support each other. Impresit Bakolori(Nigeria) Ltd., has a special feature of public and Private ownership. Public ownership gives it maximum sensitivity to public interest as is indispensable for projects involving

social questions on a large scale, and private ownership gives it the technology and managerial qualities of industry.

Impresit Bakolori like any other main contractor utilized the sub-contractors for some highly specialized jobs.

It completed the project in a duration of about eight years (from 1975 to 1983).(30)

The multisectoral organization concept of impresit Bakolori demanded the creation of two divisions at project levels to accomplish the projects objectives and goals. (see appendix A and B). They were the production division and the services divisions. These were further divided into sectors. The production sectors comprised of the following:-

(1) EARTHMOVING SECTOR

This sector was responsible for the construction of the following structures:-

(a) Secondary/Tertiary Canals and Roads type

(b) Embarkments using materials from drain

(c) Drain.

(d) Roads and Canals in Sprinkler Areas.

(e) Flood dykes

(f) Sub-base and base for Roads.

It utilized heavy duty engineering machinery and majority of its direct labour were operators.

(2) RAHCO (TRENCHING MACHINE) SECTOR

This sector performed the following functions:-

(a) Trench excavation for sprinkler lines

(b) Drains excavation

(c) Secondary and Tertiary Canals excavation

(d) Canal lining.

This sector had principal producing machine as the trenching machine with the trade name RAHCO.

(3) CONCRETE (STRUCTURES) SECTOR

This production sector was responsible for the following functions:-

(a) Construction of drainage, pumping (stations) and power house.

(b) Construction of all structures on Canals and drains.

(c) Lining of upstream and Downstream of canals and drains structures.

(d) Electrical poles

(e) Sprinkler Anchorage blocks

(f) Culverts and Corrugated steel pipes

(g) Aggregate protection

(h) Gabbions and Reno mattresses

(i) Siphon

(4) SPRINKLER SECTOR

Was responsible for the pipe line construction and testing.

(5) LAND LEVELLING SECTOR.

It ensured the production of:-

(a) Bush clearing in sprinkler areas

(b) Levelling of all lands for surface irrigation

(c) Grading all levelled land for irrigation

The services division on the other hand had the following sectors:-

(1) ELECTROMECHANICAL SECTOR - was mainly for plant installation and testing.

(2) AUXILIARY PRODUCTION SECTOR - ensured the provision of all aggregates required for the job like stones, gravels, sand etc, Batching Plant and precast structures.

(3) MECHANICAL WORKSHOP SECTOR - was responsible for the site mobile maintainance and works shop maintainance of machinery and plant.

(4) MANAGEMENT - Is self explanatory

(5) TECHNICAL SERVICES SECTOR - for planning and cost control, Budgetting, Quantity Surveying, Land Surveying, technical designs and drawings, etc.

(6) ADMINISTRATIVE SERVICES SECTOR - Provided the administration of personnel, welfare and stores.

(7) RESIDENTIAL SERVICES SECTOR - Responsible for providing accommodation, supermarket, club, swimming pool, clinic, cinema house, mess, playingrounds, sanitation etc.

(8) SUNDRY SERVICES SECTOR - Responsible for transport services, Roads and site maintainance, provision of security and plant erection and dismantling.

(9) OPERATION AND MAINTAINANCE - Is self explanatory.

With this type of sectoral organization there was a clear cut definition of responsibility in the organizational structure. Each of this sector was headed by a person known as the sectional manager. All these sectoral managers had unit heads under them and the unit had subordinates. The section managers were answerable to the project manager who inturn is answerable to the management. All these sectors presented daily operation reports to the planning office who inturn presented it to the project manager in a technical and logical way.

MRT Consulting Engineers(Nig) Ltd., were responsible for checking the contractors design, supervising construction and valuing the works in accordance with the contract. Inevitably on a contract of this size disputes arose and where they could not be settle by mutual agreement the engineer was empowered to give an independent ruling.(31)

3.2. NATURE AND TYPES OF DATA COLLECTED

For the purpose of our study, the type of data collected from the Bakolori Project included:-

(1) The monthly progress report for the year 1981 which contained:-

(a) The personnel strength at the end of each month per sector per trade against the estimated (see Appendix A)

(b) Climatic reports.

(c) Work progress against projected per sector per structure (see Appendix B)

(d) Machine efficiencies (see Appendix C)

(e) Certificates Approval

(f) Earned money against projected.

(2) Summary of verbal interview with Key Personnel at the project.

The data collected for 1981 was considered for this research because of the following reasons:

(1) Bakolori Project took about 8 years to complete and was executed under two separate contracts by the same contractor. The first three years took care mainly of the Dam construction and the last five years took care of the land reclaimation. Therefore, by considering the period of the dam construction alone does not give an adequate information on the performance of the sectors.

(2) 1979 and 1980 were not considered because, 1979 was considered to be partly occupied by mobilization exercise and in 1980 there was the famous "Bakolori Riots" spanning about three months (from February to April, intermittently) there by interrupting productions, hence the inadequacy of the data as true reflection of the situations.

(3) 1982 was not considered because there was no work for three good month (July - September) due to outstanding payments running to the tune of about ₦67,000,000 by the client to the contractor on the project.*

(4) 1983 and 84 were not considered partly because the author was out of the organization on study leave, hence, statistical modelling will be inaccurate due to lack of understanding of how the system operated. Partly due to the fact that many structures were completed at the time the author left.

(5) In 1981, all irrigation structures were under construction

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*Source: Impresit Bakolori(Nigeria) Ltd.
(from verbal interview with the Financial Controller).

and there was no disturbance at all, as such it was considered as the best representation of our system in operation.

One company was considered for the study because it is assumed that under normal circumstances, in any plan of project execution, inrespect of any technology utilized, the resources utilization follows a normal distribution. Therefore, in using statistical models to help and plan or control project execution, the methodology of arriving at the model and what it reveals is the most important. Secondly, there are two major heavy duty machine technology (considered necessary for this type of project) under utilization in the Nigeria's Construction I Industry, thus the Fiat Allis and Catepiller. Our study concerns mainly the Fiat Allis group.

3.3. DATA LIMITATIONS

The data collected from Impresit Bakolori could only allow sectoral modelling of productions, rather than "Structural" modelling per sectoral productions(see Appendix A, B, and C). This is because, the reporting system of the progress of job produced a monthly achieved work per structure per sectoral production while the personnel status produced total personnel per trade per sector of productions and not per structure produced per sector.

However, when a sectoral model is produced we can utilize the ratio of structural productions to the total

sectoral productions to know the quality to be produced for each structure.

Secondly, the land levelling reporting system did not have the reports on bush clearing for the greater part of the year. So the modelling will only be restricted to land levelling.

3.4. DATA ANALYSIS.

Having understood the scope of Bakolori project, its contractors and their management, we now analyse our data to identify production variables most suitable for our statistical modelling.

The first consideration in this regard is to study the behaviour of our sectoral productions and find what might have been responsible for their following such a pettern. Figures 3.4a to f shows the scatter diagram for the various sectoral productions. On observing the scatter diagram we identified where we have the maximum, minimum and the mean.

For us to be able to discover what were responsible for such patterns of production we have to rest our thoughts on how the system operated and the general factors of production among which are:-

Materials, Men, Machinery, Money and probably the clinate of the area.

Therefore in trying to find out the rationale for the production patterns we had to consider each month production with its corresponding manpower strength, available working days, machine efficiencies and climatic condition.

The following tables give us a clear picture of relationships between time, productions and the production factors:-

(a) Earthmoving Sector

Table 3.4.1

Table 3.4.a.1

Table 3.4.a.2

Table 3.4.a.3

(b) Rahco Sector

Table 3.4.1

Table 3.4.b

(c) Concrete Sector

Table 3.4.1

Table 3.4.c.1

Table 3.4.c.2

(d) Sprinkler Sector

Table 3.4.1

Table 3.4.d.1

Table 3.4.d.2

(e) Land Levelling Sector

Table 3.4.1.

Table 3.4.e.1

Table 3.4.e.2

On scrutinizing these set of tables the following observations were made:-

(1) The mean, minimum and maximum values could be read from the tables for each sector.

(2) Productions generally reduced from January and reached the minimum in August and then rose to the month of december.

(3) When productions were compared to the number of worked days per month, it was found that productions decreased with decreasing number of worked days and increased with increasing number of worked days.

(4) Looking at production with climatic conditions, it was observed that least productions took place when there was abundant rainfall and relatively high tempreatures.

(5) Juxta posing productions with mean machine efficiency, revealed that productions decreased with decreasing mean machine efficiency and increased with increasing mean machine efficiency.

(6) Productions when compared with personnel strength revealled that lowest number of personnels corresponded with lowest quantity of productions.

From the foregone observations we can confidently rest assured that our monthly productions from productive sectors are affected by the number of work days per month, by the climatic condition particularly rainfall, by machine efficiency and by personnel strength.

Therefore, we could if we desire develop from these analysis and equation that shows the relationship between monthly sectoral productions and the factors listed above, however, certain technicalities demands further proving within the system inorder to bring the most reliable and practicable relationship

BAKOLORI IRRIGATION PROJECT

TABLE 3.4.1. SUMMARY OF 1981 MONTHLY CLIMATIC CONDITIONS

MONTH	RAINFALL MM	TEMPREATURE °C		
		MINIMUM	MAXIMUM	MEAN
JANUARY	0	10	35	20.50
FEBRUARY	0	11	39	25.00
MARCH	TRACES	18	40	29.00
APRIL	38.50	17	42	29.00
MAY	48.00	20	41	30.50
JUNE	123.50	20	39	29.50
JULY	260.00	20	36	27.00
AUGUST	156.00	20	35	27.00
SEPTEMBER	153.00	19	37	28.00
OCTOBER	0	16	37	28.00
NOVEMBER	0	14	34	25.00
DECEMBER	0	11	35	22.50
TOTAL	779.00	196	450	321
MEAN	64.92	16.33	37.50	26.75
MINIMUM	0	10	34	20.50
MAXIMUM	260.00	20	42	30.50

SOURCE: IMPRESIT BAKOLORI (NIGERIA) LTD.

BAKOLORI IRRIGATION PROJECT 1981
EARTH MOVING PRODUCTIONS

TABLE 3.4.a.1., SUMMARY OF MONTHLY EARTHWORKS WORKED DAYS

MONTH	WORKED DAYS	PRODUCTIONS m^3
JANUARY	25	572,560
FEBRUARY	24	577,526
MARCH	26	592,539
APRIL	24	533,740
MAY	21	416,238
JUNE	25	490,880
JULY	21	399,210
AUGUST	14	177,254
SEPTEMBER	23	219,028
OCTOBER	23	423,152
NOVEMBER	24	455,516
DECEMBER	24	509,996
TOTAL	274	5,367,674
MEAN	22.83	447,303.91
MINIMUM	14	177,254
MAXIMUM	26	592,539

SOURCE: IMPRESIT BAKOLORI (NIGERIA) LTD.

BAKOLORI IRRIGATION PROJECT 1981
EARTHMOVING PRODUCTIONS

TABLE 3.4.a.2., SUMMARY OF MONTHLY PRODUCTIONS/ PERSONNEL STRENGTH

MONTH	PRODUCTIONS m3	DIRECT LABOUR Nos	MANAGERS Nos
JANUARY	572,560	264	45
FEBRUARY	577,526	264	45
MARCH	592,539	264	45
APRIL	533,740	264	45
MAY	416,238	264	45
JUNE	490,880	264	45
JULY	399,210	264	45
AUGUST	177,254	220	41
SEPTEMBER	219,028	220	41
OCTOBER	432,152	241	45
NOVEMBER	455,516	264	45
DECEMBER	509,996	264	45
TOTAL	5,367,674	3,057	532
MEAN	447,303.91	254.75	44.33
MAXIMUM	592,539	264	45
MINIMUM	177,254	220	41

NOTE:- (1) Managers comprised of supervisors, foremen, staff and sectional managers.

(2) Direct labour comprised of special skill, skilled and unskilled.

SOURCE: INTERSOIL BAKOLORI (NIGERIA) LTD.

BAKOLORI IRRIGATION PROJECT 1981
EARTHMOVING WORKS

TABLE 3.4.a.3., SUMMARY OF MONTHLY EARTHWORKS/ MEAN MACHINE EFFICIENCY

MONTH	PRODUCTIONS (m^3)	MEAN MACHINE EFFICIENCY %
JANUARY	572,560	46.61
FEBRUARY	577,526	47.71
MARCH	592,539	49.11
APRIL	533,740	49,25
MAY	416,238	45.86
JUNE	490,880	50.29
JULY	399,210	41.29
AUGUST	177,254	29.54
SEPTEMBER	219,028	32.82
OCTOBER	432,152	51.65
NOVEMBER	455,516	57.04
DECEMBER	509,996	57.90
TOTAL	5,367,674	559.07
MEAN	447,303.91	46.59
MINIMUM	177,254	29.54
MAXIMUM	592,539	57.90

SOURCE: IMPRESIT BAKOLORI (NIGERIA) LTD.

BAKOLORI IRRIGATION PROJECT 1981
RAHCO (TRENCHER) PRODUCTIONS

TABLE 3.4.b. SUMMARY OF MONTHLY RAHCO WORKS/ PERSONNEL STRENGTH

MONTH	WORKED DAYS	PRODUCTIONS		PERSONNEL STRENGTH	
		EXCAVATIONS m	LINING m^3	DIRECT	MANAGERS
JANUARY	25	32,863	1835	54	11
FEBRUARY	24	44,106	1856	54	11
MARCH	26	62,318	23	54	11
APRIL	24	28,491	191	54	11
MAY	25	33,811	49	54	11
JUNE	25	30,741	48	54	11
JULY	23	18,191	1756	41	8
AUGUST	20	20,958	391	41	8
SEPTEMBER	22	19,065	1874	58	9
OCTOBER	23	59,424	221	58	11
NOVEMBER	24	59,837	393	58	11
DECEMBER	24	47,251	29	54	11
TOTAL	285	457,056	8512	654	124
MEAN	23.75	38,088	709.33	54.50	10.35
MINIMUM	20	18,191	23	41	8
MAXIMUM	26	59,837	1874	58	11

NOTE: (1) Direct labour comprised of special skill, skilled, and unskilled.

(2) Managers comprised of supervisors, foremen staff and sectional Managers.

SOURCE: IMPRESIT BAKOLORI (NIGERIA) LTD.

BAKOLORI IRRIGATION PROJECT 1981
CONCRETE PRODUCTIONS

TABLE 3.4.c.1., SUMMARY OF MONTHLY CONCRETE WORKS/ WORKED DAYS

MONTH	NO. OF WORKED DAYS	CONCRETE USED (m3)	PRECAST STRUCTURE (Nos)	CORRUGATED STELL PIPES (m)	AGGREGATE PROTECTION (m3)	GABBIONS m3
JANUARY	25	4,067	7	375	792	1,473
FEBRUARY	24	3,914	0	371	1,205	1,143
MARCH	26	1,987	5	551	0	1,382
APRIL	24	2,346	18	485	495	1,173
MAY	25	2,365	19	830	573	991
JUNE	26	2,983	0	521	243	969
JULY	23	4,205	0	296	0	572
AUGUST	21	2,503	3	174	0	702
SEPTEMBER	23	3,505	10	159	170	787
OCTOBER	23	2,150	0	405	57	1,028
NOVEMBER	24	2,500	2	579	87	1,035
DECEMBER	24	2,654	13	675	324	1,762
TOTAL	288	35,177	77	5,421	3,949	13,017
MEAN	24	2,931.42	6.42	451.75	329.08	1,084.75
MINIMUM	21	1,987	0	159	0	572
MAXIMUM	26	4,205	19	830	1,205	1,762

SOURCE: IMPRESIT BAKOLORI (NIGERIA) LTD.

BAKOLORI IRRIGATION PROJECT 1981
CONCRETE PRODUCTIONS

TABLE 3.4.c.2., SUMMARY OF MONTHLY MEAN MACHINE EFFICIENCY AND PERSONNEL STRENGTH

	MEAN * MACHINE EFFICIENCY %	PERSONNEL STRENGTH	
		DIRECT LABOUR (Nos)	MANAGERS (Nos)
JANUARY	44.75	693	89
FEBRUARY	46.50	693	89
MARCH	46.25	693	89
APRIL	46.25	693	89
MAY	48.75	693	89
JUNE	48.00	693	89
JULY	45.00	540	81
AUGUST	42.25	540	81
SEPTEMBER	40.50	693	89
OCTOBER	48.04	693	89
NOVEMBER	50.08	693	89
DECEMBER	48.92	693	89
TOTAL	555.29	8010	7052
MEAN	46.27	667.50	87.67
MINIMUM	40.50	540	81
MAXIMUM	50,08	693	89

* MACHINE EFFICIENCY DOES NOT INCLUDE AUTOMIXER.

BAKOLORI IRRIGATION PROJECT 1981
SPRINULER PRODUCTIONS

TABLE 3.4.d.1., SUMMARY OF MONTHLY SPRINULER PRODUCTIONS

	WORKED DAYS (Nos)	PIPE PLACING (m)	PIPE TESTING (m)	CONCRETE ANCHORAGE BLOCKS (m^3)
JANUARY	25	18,539	22,664	138
FEBRUARY	24	18,290	21,911	170
MARCH	26	21,423	23,753	225
APRIL	24	16,424	20,183	132
MAY	25	17,010	17,446	76
JUNE	25	17,301	19,452	111
JULY	23	12,235	6,067	104
AUGUST	24	9,961	8,705	81
SEPTEMBER	19	10,074	8,098	64
OCTOBER	23	15,126	16,338	72
NOVEMBER	24	18,122	11,540	213
DECEMBER	24	20,854	12,233	239
TOTAL	286	195,359	188,390	1625
MEAN	23.83	16,279.92	15,699.17	135.42
MINIMUM	19	9,961	6,067	64
MAXIMUM	26	21,423	23,753	239

SOURCE: IMPRESIT BAKOLORI (NIGERIA) LTD.

BAKOLORI IRRIGATION PROJECT 1981
SPRINULER PRODUCTIONS

TABLE 3.4.d.2., SUMMARY OF MONTHLY MACHINE EFFICIENCY AND PERSONNEL

	MEAN MACHINE EFFICIENCY %	PERSONNEL STRENGTH (Nos)	
		DIRECT LABOUR	MANAGERS
JANUARY	46.50	211	29
FEBRUARY	47.67	211	29
MARCH	47.83	211	29
APRIL	46.83	211	29
MAY	44.83	211	29
JUNE	45.33	211	29
JULY	39.00	160	19
AUGUST	34.50	160	19
SEPTEMBER	33.67	205	24
OCTOBER	52.79	225	29
NOVEMBER	56.83	211	29
DECEMBER	56.42	211	29
TOTAL	552.20	2438	323
MEAN	46.02	203.17	26.92
MINIMUM	33.67	160	19
MAXIMUM	56.83	225	29

NOTE: (1) Direct labour comprised of special skill, skilled, and unskilled.

(2) Managers comprised of supervisors, foremen, staff and sectional Managers.

SOURCE: IMPRESIT BAKOLORI (NIGERIA) LTD.

BAKOLORI IRRIGATION PROJECT 1981
LAND LEVELLING PRODUCTIONS

Table 3.4.e.1., SUMMARY OF MONTHLY LAND LEVELLING PRODUCTIONS

MONTH	WORKED DAYS (Nos)	PRODUCTIONS (HA)
JANUARY	25	184
FEBRUARY	24	179
MARCH	26	224
APRIL	24	186
MAY	23	179
JUNE	25	207
JULY	22	150
AUGUST	-	2
SEPTEMBER	23	52
OCTOBER	23	180
NOVEMBER	24	197
DECEMBER	24	2
TOTAL	263	1742
MEAN	21.92	145.17
MINIMUM	0	2
MAXIMUM	26	224

SOURCE: IMPRESIT BAKOLORI (NIGERIA) LTD.

BAKOLORI IRRICATION PROJECT 1981
LAND LEVELLING PRODUCTIONS

TABLE 3.4.e.2., SUMMARY OF MONTHLY PERSONNEL STRENGTH AND MACHINE EFFICIENCY

MONTH	MEAN MACHINE EFFICIENCY %	PERSONNEL STRENGTH (Nos)	
		DIRECT LABOUR	MANAGERS
JANUARY	49.15	141	22
FEBRUARY	51.40	141	22
MARCH	52.45	141	22
APRIL	53.15	141	22
MAY	47.40	141	22
JUNE	52.30	141	22
JULY	41.70	135	22
AUGUST	27.75	100	16
SEPTEMBER	35.65	137	22
OCTOBER	49.20	141	22
NOVEMBER	56.90	139	22
DECEMBER	58.20	141	22
TOTAL	572.25	1639	258
MEAN	47.69	136.58	21.50
MINIMUM	27.75	100	16
MAXIMUM	58.20	141	22

NOTE: (1) Direct labour comprised of special skill, skilled and unskilled.

(2) Managers comprised of supervisors, foremen, staff and sectional Managers.

SOURCE: IMPRESIT BAKOLORI (NIGERIA) LTD.

CHAPTER FOUR

DEVELOPMENT OF MODEL FOR A LARGE IRRIGATION PROJECT

A model is a convinient way of representing the total experience which we posses and their deducing from that experience whether we are in the presence of patterns and law and if so, of showing how such patterns and laws can be used to predict the future. Essentially, it is an attempt to extract from the richness of a real situation and to formulate a concept which can be manipulated and controlled. In doing so, one must try to understand the real situation and formulate in a hypothetical form the logical patterns of causes and effects which link together the controllable and uncontrollable variables. Models are not derived solely so that some aspects of affairs might be better described, they are derived so that some complex situation might be subject to prediction and control, that is, the model must first have some potential usefulness by knowing how well it predicts. The two major techniques used in model formulation are those of mathematics and statistics.(32)

In trying to achieve these objectives, we had considered in the preceeding chapters, the planning and control in the construction industry and how they came about, we did take a case study of an irrigation project, analysed its production data for one year and came out with relationships. In order to facilitate the construction of our statistical model, we now have to reinforce our situation with basic assumptions under which we hope to operate our model hence the constraints.(32)

4.1. BASIC ASSUMPTIONS

(1) There were sufficient fund to keep the project moving for one complete year which was considered to be the "Average Collection Period," of the project.* This assumption was considered to be very important because in a developing country like Nigeria, Clause 82 of the Federal Ministry of Works Conditions of Contract for Civil Engineering works concerning CERTIFICATES AND PAYMENT IS not respected.(33) Again this clause is rendered impotent within the same conditions of contract by clause 93, demanding the contractors to show adequate financial strength of executing the project by way of obtaining guarrantee from banks and insurance companies. The contractor under study is assumed to have had more than enough internally and externally as explained in chapter three.

(2) That most of the personnel go on holidays in the months of July, August and December, every year. This might probably be one of the reasons why there was a reduction of output within these months.*

(3) In planning irrigation project construction one year was taken as the cycle time under which all variables (production, labour, machinery and climate) showed their behavioural patterns per month. It is expected that because of seasonal variations, a year is complete period for this analysis.

(4) The most important variables that affect productivity in construction works of this nature are climate, machinery, direct labour and money.

(5) There were six working days per week with one shift of ten hours per day and an eight working hours per day for all categories of personnel (Managers and direct labour).* Note that this assumption gave an index for measuring the level of supervision and the strength of labour productivity.

(6) That in treating sectoral models, we assumed that the work of one sector did not interfere with that of another sector. Implying that there was a very good coordination system that allowed sectoral jobs to move on smoothly.

(7) That there was enough support by the government in all type of purchases regarding the project either within or outside the country. (Note that the second National Development Plan, tagged this project as one of the special projects)*(34)

(8) That machine efficiency[28] (SEE APPENDIX C) is considered as the most important index of measuring machine productivity. This is because machine efficiency is a function of utilization and Rainfall efficiences and machine availability. The relationship is best understood by the formula:-

$$\text{Machine efficiency} = \frac{\text{Machine Availability x 100}}{\text{Utilization Efficiency}}$$

Source: Impresit Bakolori(Nigeria) Ltd.
(Planning Office).

(9) Direct labour was the most valuable human resources used in executing the project and that there were adequate managerial guidance and leadership as effective as described in assumption number five. The direct labour here refers to special skill, skilled and unskilled. While managers refers to from supervisors and above.

(10) The total output observed in each sector has an appropriate unit of measurement and is total work done for each month.

(11) That there is a well established structural organization with well defined responsibilities that will facilitate execution of management functions and such organizational structure is in line with the concept of sectoral organization and projectitis (13, 30).

* Source: Impresit Bakolori (Nigeria) Ltd.
from verbal interview with the Financial controller.

4.2. VARIABLES IDENTIFICATION

From the analysis we have carried out in the preceeding chapter and the above assumptions, we are left with a bunch of variables that explained why our monthly sectoral productions were as they were. These explanatory variables can be scrutinized to determine the most important ones that contribute greatly in explaining our productions. The characteristics of utilizing our data gave us the latitude of utilizing multiple regression for our modelling[35,36,37,38,39]. Thus we are left from the above observations and analysis with the following:-

(1) A response variable as the total output (Y_i) per month per sector with the following predictor variables:-

(2) X1i, representing number of direct labour utilized per month to get the production Y_i per month.

(3) X2i, representing the measure of mean machine efficiency per month per sector that ensured the production Yi per month.

(4) (i) stands for observations from 1 - 12 which represents the number of months in a year.

Therefore from the above variable identification, our model now is to conform to finding the best fitting statistical relationship between productions per month on one hand and direct labour and mean machine efficiency on the other hand.

Because of the tidiousness and time consumption of multiple regression Analysis, Computer was employed for the analysis.

4.3. COMPUTER UTILISATION

The SPSS package of the Ahmadu Bello University Computer Centre was utilized to undertake the analysis of our variables under the multiple regression programme. All statistics of Regression Analysis (multiple) contained in the package of SPSS were called for our data.

The computer print outs were subjected to observations and analysis to determine the paramaters and realibity of our variables.

Finally the following models were extracted as the best representation and predictors of our situation.

4.4. BEST FITTING MODELS.

As we had identified in 4.2. All sectors are considered for analysis on the basis of manpower and machine efficiency. Therefore, we intend to present three sectoral production models in order to erase totology, since the methodology is the same. The sectors considered were Earthmoving, Sprinkler, and Land Levelling.

From the computer print outs of our multiple regression Analysis, using methods of R square and Residual analysis [35,36,37,38,39], the following models were extracted as best representation of our situation:-

4.4.1. EARTH MOVING WORKS

From the computer printout (the analysis of predictor variables)(see Appendix D). The following observations and deductions were made:-

(1) Direct labour alone could be used as a predictor variable for it explained 76.42% of the variability in the response variable.

(2) The predicted equation is:-

$$Yi = 6662.74\ X1i - 1250030.20 - (E1)$$

Where Yi is the predicted monthly earthmoving job in m^3.

X1i is the monthly number of direct labour used to get Yi

It showed that for every unit increase in X1, there would be a corresponding increase in Yi by 6662.74 m^3

The intercept (-1250030.20) shows that if personnel are available we will have a negative production equals to the intercept. This is practically impossible. However, it only tells us that we are loosing by that much when none of our personnel is working. Model E1 comfirms one thing, that it is the pperators that mainly constitute the direct labour force of this sector and because they operate the machines, they determine how effectively the machines are utilized. Hence the machine efficiency. In other words even if you have the machines and you do not have the operators, there would be no efficiency to measure from the

machine or the machines cannot produce.

(3) But when variables machine efficiency (X2i) was entered as a second variable into the regression analysis together with direct labour, the coefficient of determination, R square, rose to 0.79096. Which meant that a combination of direct labour and machine efficiency explains the variability of monthly production by about 79.10%. An increase of about 3% by adding the additional explanatory variable (machine efficiency).

This variable is retained in the regression equation simply because, "Though our model E1 showed that direct labour alone explained the major part of the variability in response variable (Yi), machine efficiency also is important for if the variable X1 showed that it is constituted of operators, the overall consideration is that they cannot produce on their own without the machines and hence the efficiency as a variable. Therefore machine efficiency must be an intergral part of the predictor variables."

(4) The predicted equation when X2i is included as a variable (predictor) is:-

$$Yi = 5229.80\ X1i + 3900.50\ X2i - 1066708.80 \quad (E2)$$

where Yi is the predicted monthly earthmoving job in m^3

X1i is the monthly number of direct labour used to get Yi

X2i is the monthly machine efficiency used to get Yi and "i" is the number of calendar month from 1 - 12.

(5) The best fitting model that best describe the relationship of predictor variables for earth moving job is:

$$Yi = 5229.80\ X1i + 3900.50\ X2i - 1066708.80$$

4.4.2. SPRINKLER WORKS

In trying to get the best fitting model for sprinkler works which mainly is made of pipe placing and testing a situation of maximum personnel strength is considered for both.

(1) PIPE PLACING (SEE APPENDIX E)

(a) When variable X1i was entered into the model, it showed that it could explain 46.92% of the variability in the response variable Yi.

(b) On entering the second explanatory variable X2i in the equation, it explained the variability in the response variable Y2 to 53.92% an increase of about 7%

(c) The explanatory variables X1i and X2i both had level of significance equals to 0.014 and 0.031 which showed that they are very important explanatory variables.

(d) The coefficients of X1i and X2i were 96.074 and 150.86 respectively.

(e) The equation had a constant whose value is nagative and is equal to - 11119.70.

(f) That the best fitting model for pipe placing work is:-

$$Yi = 96.07\ X1i + 150.86\ X2i - 11119.70$$

(2) PIPE TESTING (SEE APPENDIX F)

(a) When explanatory variable X1i was introdueed into the equation, it was able to explain 59.38% (Thus it is coefficient of determination (R square) was 0.59386) of the variability of the response variable Yi with a level of significance equals to 0.003.

(b) On entering the second explanatory variable X2i into the equation it was able to further explain the variability of the response variable Xi by 12.61%, thus it had a coefficient of determination equals to 0.71999 (R square value) and with a level of significance = 0.003.

(c) However, when we considered the possible interraction of the two explanatory variables into our equation, we found that this product of the explanatory variables could further explain the variability of our response variable by about 17.87%. Thus X1i X2i value of R square is equal to 0.89873 with a level of significance equals to 0.000.

(d) The coefficients of X1i, X2i and X1i X2i were-1198.73, -6869.06 and 35.28 respectively.

(e) That it had a constant equals to 241, 773.45.

(f) That the best fitting equation for the model is:-

$$Yi = -1198.72\ X1i - 6869.06X2i + 35X1i\ X2i + 241773.45$$

4.4.3. LAND LEVELLING WORKS (SEE APPENDIX G)

(a) On entering X1i into the equation its coefficient of determination was 0.35946 which implied it could explain the variability of the response variable by 35.95%. It had a level of significance equals to 0.039.

(b) On entering X2i as a second variable in the equation, it was also able to explain the variability of the response variable Yi by only 1.05% with a level of significance equals to 0.121. Thus like in the earthmoving works, due to practical reasons X2i cannot be dropped from the explanatory variables list.

(c) That the coefficients of the variables (predictor) X1i and X2i had the values 3.10 and 1.62 respectively, there coefficients had a level of significance equals to 0.281 and 0.646 respectively.

(d) The constant in the equation had a value equals to -355.67 with a level of significance in the equation equals to 0.221.

(e) The best fitting equation that best describe the land levelling job is:-

$$Yi = 3.10\ X1i + 1.62\ X2i - 355.67$$

We have now identified and extracted our models and justified the utilization of their parameters.

What is the meaning of these numbers and letters we had brought out? This we will now discuss.

CHAPTER FIVE

INTERPRETATION OF MODELS AND CONCLUSIONS

5.1. INTERPRETATION OF MODELS

The following give the meaning and application of our models.

Generally all the models are multiple regression (linear) models, with response variable Y_i (monthly productions per sector) and predictor variables X_{1i} (number of direct labour per month to be utilized), X_{2i} (machine efficiency in % per month) and in some cases X_{1i} X_{1i} (the possible interraction between direct labour and mean machine efficiency per month). They have a constant value C.

Secondly, that, monthly production values could be predicted if direct labour strength per month per sector and mean machine efficiency per month per sector are given.

5.1.1. EARTHMOVING WORKS

(i) If monthly mean machine efficiency is kept fixed, an increase in one direct per month will increase our production by 5,299.80 m^3 per month.

(ii) When direct labour is kept fixed, an increase in one unit of mean efficiency per month will increase production by 3,900.50 m^3 of earthmoving works per month.

(iii) When values of X_{1i} and X_{2i} are put at zero, it implies that direct labour and machines are idle, hence, the company will suffer a loss of production of 1,066, 708.80m^3 per month. This is the intercept (constant) value that is negative.

(iv) That in planning and controlling earthmoving works per month, management, has two variables to consider, thus direct labour and mean machine efficiency. Each with its economic implications. The question then the management should ponder on is EITHER, how much will it cost us to employ one direct labour for the earthmoving works for one month, thus keeping efficiency fixed, so as to get a monthly rise in production by 5,299.80m^3. Or, how much will it cost us to raise our machine efficiency by 1% per month per sector, keeping the number of our direct labour constant, so as to get our monthly production increased by 3,900.50m^3

5.1.2. SPRINKLER WORKS

(a) PIPE PLACING

(i) If we keep our mean machine efficiency fixed, an increase in one direct labour, will raise our monthly pipe laying production by 96.07m.

(ii) When direct labour is kept fixed, an increase in monthly mean machine efficiency by one percent will increase our pipe placing work by 150.85m per month.

(iii) When direct labour and machines are idle, the company will suffer a loss of production equals to 11,119.70m which is the constant value and is negetive.

For the sake of repetition, Appendix D,E,F and G can be used to interprete the rest of the sectors in line with the above interpretations for pipe testing and land levelling.

5.2. CONCLUSIONS

It is to be considered that in any modelling effort there is a choice. We can construct a simple model that may not completely duplicate reality, or we can build a highly sophisticated and complex model which can be accurate but which also requires a large amount of effort and resources to be developed and manipulated. Even if the most sophisticated model could be developed, there would still be some part of reality that could not be explained by the model. The number of factors in real life phenomenon is infinate. Thus we have to try to introduce the smallest number of variables (the principle of parismony) and at the same time achieve values that will satisfy the laws and principles of our technique- thus Multiple regression analysis. The following summarizes our findings:-

5.2.1. SUMMARY

(i) For the construction of a large irrigation project, there should be an organizational structure at the project level with multisectoral concept of organization. This multisectoral concept should further be expanded in each sector to have projectitis system. This will give wide latitude for well defined responsibilities - that will ensure a good reporting system which will facilitate a realistic planning and control of all operations.

(ii) A very conciese and yet revealling reporting system in the line with the concept of multisectoral organization and projectitis system should be evolved to facilitate indepth under standing of how the project operated within a given time by the management so that planning and control could effectively be carried out.

(iii) That in planning and controlling the construction works of a large irrigation projects, the most important variables that determine sectoral productions were direct labour and machine efficiency.

(iv) That planning and control should take place at interval of one month taking into consideration the number of direct labour available and mean machine efficiency.

(v) That in planning and controlling productions monthly which of the predictor variable should be higher in magnitude, machine efficiency or direct labour.

(vi) Multiple Regression Analysis could be used to model production because it can take into consideration many variables that affect productions and yet is tied to time

(vii) The model can be applied to other types of construction with relative ease because of the commonness of the variables and at the same time they are linked with time.

5.2.2. PROPOSALS FOR FURTHER RESEARCH

(i) There is the need for investigation into the forecasting methods used in the Nigeria's construction industry.

(ii) The need for study on organizational structure of large construction projects in Nigeria.

(iii) There is no research carried out in the reporting system used in the Nigeria's Construction Industry.

(iv) A comparative Analysis on either direct labour, machinery, or both with time in Nigeria's Construction Industry.

CHAPTER SIX

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BAKOLORI DAM IRRIGATION PROJECT

DESIGN DATA		
Reservoir		
Reservoir storage capacity	450 million	m^3
River flow in the 50% probability year	534 million	m^3
Estimated peak flood	3,750	m^3/sec
Lake level at maximum flood	338.30	m a.s.l.
Maximum lake operating level	334.00	m a.s.l.
Minimum lake operating level	320.00	m a.s.l.
Lake area at maximum flood	8,900	ha
Lake length along the river bed at maximum flood	19	km
Dam - concrete section		
Crest level	340.00	m a.s.l.
Crest length	356	m
Maximum height above foundations	48	m
Normal spillway blocks	6	
Normal spillway sill elevation	334.00	m a.s.l.
Emergency spillway block	1	
Emergency spillway sill elevation	338.40	m a.s.l.
Hydropower plant intake elevation	317.35	m a.s.l.
Bypass intake elevation	317.10	m a.s.l.
Bottom outlet elevation	313.00	m a.s.l.
Hydropower (two Kaplan turbines)	5,000	kW

DESIGN DATA		
Dam - earthfill section		
Crest level	341.20	m a.s.l.
Crest length (left and right bank wings	5,135	m
Maximum height above foundations	19	m
Irrigation area		
Gross area (including canals, drains, roads and rights of way)	35,930	ha
Net irrigation area (at full development)	30,000	ha
Supply canal	15	km
Design discharge of the supply canal	30	m^3/sec
Main canals	45	km
Net irrigation area under the awarded contract	23,200	ha
— surface irrigated 8,200 hectares		
— sprinkler irrigated 14,200 hectares		
Secondary canals	200	km
Tertiary canals	300	km
Field ditches	600	km
Buried pipelines	530	km
Aluminium laterals with sprinklers	800	km
Farms for sprinklers, filter and drainage	160	
Paved roads	150	km
Reinforced bridges across Sokoto and Rima rivers	3	
Pipe bridge across Sokoto river	1	
Houses and buildings	65,000	m^3

CONSTRUCTION DATA		
Excavation for dam foundations (rock and common material)	1,000,000	m^3
Embankment for earthfill dam impervious core, sand shoulders, filters, slope protection)	1,700,000	m^3
Concrete for dam and appurtenant structures	175,000	m
Excavation for canals, drains and roads	20,000,000	m
Embankments for canals, flood dikes and roads	10,000,000	m^3
Excavation for buried pipelines	1,900,000	m^3
Excavation for land levelling	5,000,000	m^3
Concrete for lining canals	120,000	m^3
Concrete for structures	100,000	m^3
Steel gates for canals	650	
Concrete gates for turnouts	1,150	
Takeoff hydrant risers for sprinkler irrigation	5,600	
Concrete poles for power lines	2,500	

IMPRESIT BAKOLORI (NIGERIA) LTD

BAKOLORI PROJECT

MONTH OF Dicembre 1981

APENDIX A

PERSONNEL NUMBER PER SECTIONS	EXPATRIATE PERSONNEL							LOCAL PERSONNEL						
	PART TIME	SUPERVISOR	FOREMAN	SECT.MANAG.	MANAGER	TOTAL MONTH		STAFF	SUPERVISOR	SPEC.SKILL	SKILLED	UNSKILLED	TOTAL MONTH	
EARTHMOVING SECTION		7	5			12		26	7	191	26	47	297	
RAMIC SECTION		6	1			7		2	2	32	1	21	58	
LEVELLING SECTION		6	1			7		10	5	103	9	29	156	
SPRINKLER SECTION		15	2			17		8	4	126	2	83	223	
STRUCTURES SECTION		40	8	1		49		23	17	460	31	202	733	
ELECTROMECH. SECTION		21	2			13		15	6	94	2	33	150	
AUXILIARY PRODUCTION		4	1			5		8	2	100	11	25	146	
MECHANICAL WORKSHOP		50	15			65		58	34	256	43	213	604	
MANAGEMENT		1			5	6		3		2			5	
TECHNICAL SERVICES		24	8	3		35		46	1	40	58	27	172	
ADMINISTRAT. SERVICES		5	4	2	1	12		76	6	30	45	374	533	
RESIDENTIAL SERVICES	3	4	3	3	1	16		43	3	75	31	180	334	
SUNDRY SERVICES			2			2		6	1	67	2	60	136	
OPERATION & MAINTENANCE		4	2			6		10	1	32	1	18	62	
TOTAL	3	187	54	8	7	261		338	89	1.608	262	1.312	3.609	
ESTIMATE						276							4.063	
Δ Total – Estimate						-15	- 5.4%						-454	-11.2%

EARTHMOVING	SEC.& TERT. CANALS & ROADS ...A.T.MORE...	CM	[illegible]	[illegible]	318.0
	EMBANK.FROM DRAINS	CM	-	4430	
	DRAINS EXC.TO WASTE	CM	-	6350	90.0
	SPRINK.AREAS ROADS & CANALS	CM	-	1470	
	FLOOD DYKES	CM	-	1960	
	OTHERS BY SCRAPERS	CM	-	2030	
	DRAINS EXC. BY EXCAVATORS...N.T.PRICE...	CM	420	1518	
	TOTAL EARTHMOVING (EXCAVATION)	CM	1186	43020	408.0
	VARIOUS	CM	-	2432	
	SUBBASE and BASE...M.C/5-12...(PRICE)...	CM	2%	5416	10.4
BAICO	TRENCH. EXCAVATION...M11/A	LM	503	21409	19.6
	DRAINS EXCAVATION...M.C/E...A.A.7...	LM	400	20385	20.7
	SEC.& TERT.CANALS EXC	LM	-	2517	17.8
	CANALS LINING	CM	-	24	-
CONCRETE	DRAINAGE STATIONS (STRUCT.)	CM	-	-	-
	" " (BUILD.)	CM	-	24	-
	PUMPING STATIONS (STRUCT.)M.C...G/Sec.	CM	8	451	4
	" " (BUILD.)	CM	-	10	
	MAIN CANAL STRUCTURES	CM	-	334	3
	STRUCTURES ON CAN.& DRAINS.DRAIN-16	CM	16	370	3
	LINING U/S & D/S THE STRUCT...PRICE	CM	14	1055	1.1
	OTHERS...ELECTRICAL LINE	CM	4	10	-
	VARIOUS	CM	-	2	-
	TOTAL OF CONCRETE	CM	42	2380	2.3
	SPRINKLER ANCHOR BLOCKS...SPRINKLER & GRIGHT	CM	32	1284	1
	PRECASTED STRUCTURES PLACING	NO	-	12	-
	CORRUGATED STEEL PIPES...PRICE Rif. SHEET	LM	20	1236	1.2
	AGGREGATE PROTECTION	CM	-	304	-
	GABIONS...DRAINAGE STATION GRIGHT	CM	92	176	0.2
SPRINK	PIPES PLACING...SPRINKLER	LM	781	20850	20.4
	PIPES TESTING...G/Sec...	LM	592	9933	21.0
L.L	BUSH CLEARING-SPR.AREAS	Ha	-	12	-
	LAND LEVELLING...L.C	Ha	2	16	-

&& LE QUANTITA' SOPRA INDICATE SONO COMPRENSIVE DI SFRIDI.

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BAKOLORI PROJECT

MONTH OF Decemb. 198 1

APENDIX C

EQUIPMENT OPERATION	MONTHLY										PROGRESSIVE									
	HOURS						%				HOURS						%			
	SHIFT	WORK	ST/BY	MAINT.	B/DOWN	RAIN	MEC. AV.	MET. AV.	UTILISAT.	EFFIC.	SHIFT	WORK	ST/BY	MAINT.	B/DOWN	RAIN	MEC. AV.	MET. AV.	UTILISAT.	EFFIC.
AUTO MIXER																				
745 LOADER																				
645 LOADER																				
AD20 DOZER																				
BD20 DOZER																				
BD14 DOZER																				
HD21 DOZER																				
150 GRADER																				
TRACT. SCRAPER																				
ELEV. SCRAPER																				
SOUTHWEST																				
RAYGO 410																				
DYNAPAC																				
300 W/TANK																				
300 TIPPER																				
SIMIT S 90																				
SIMIT SR70																				

APENDIX D

