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APPLICATION OF LINEAR PROGRAMMING TECHNIQUES IN DECISION MAKING IN NIGERIAN INDUSTRIES FOR SUSTAINABILITY

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Abstract

This study aimed at demonstrating the efficacy of linear programming as a problem-solving and decision-making techniques in industries for sustainability in Nigeria. Related literatures were appraised on the models of sustainable development and decision making. Applications of linear programming techniques for sustainable decision making was highlighted and demonstrated. Hence, it can be proposed that linear programming technique could be an effective tool to facilitate rational decision making in Nigerian industries, for increase productivity, job creation and economic sustainability. Therefore, it is recommended in this treatise that managers and captains of industries in Nigeria adopt this tool in decision making for effective and sustainable development.

Keywords: Application; Decision Making; Development; Linear Programming; Sustainability

JEL Classification: C4.

1. INTRODUCTION

From the Colonial Development Plan (1958-68) to National Development Plan, Nigeria has comparatively experienced long years of development planning. Mid-term development plans and national rolling plans have also been articulated. Other strategic plans like the National Economic Empowerment and Development Strategy; and the Structural Adjustment Programme are all efforts towards attaining developmental goals. However, most these towards developments seem to lack effective implementation. Thus, Nigeria aspiration to become among the top 20 world economies in 2020 seems to be faltering away. The intention of most development plans in Nigeria was to advance the living standard of its citizens. Unfortunately, most of these laudable dreams have not been realised due to ineffective implementations.

Nations around the world have gathered in 2015 at the United Nations to agree on some important goals to protect the earth, eradicate poverty and ensure prosperity for all in an effort to set a new form of sustainable development agenda. The year 2030 was set for the attainment of the specific targets of each goal. It is therefore worrisome that Nigeria has not witnessed substantial evidence in terms of realization of her version 2020 talk less of the United Nations' sustainable development goals (Nneji, 2013). A sensory look at the 17 UN sustainable development goals reflects that the nation is quiet far from the target. For instance, the rate of poverty is very high in Nigeria. Primary health care and functional education are not easy to find. Drinkable water and affordable energy are inadequate. Economic prosperity is not an attribute under recessing economy like Nigeria's. More than that, the Nigerian industries seem to lack innovative approaches towards sustainable goal attainment.

The place of industries in ensuring sustainable development in any society is very vital. Industries add value to human lives. Almost all processed foods that are consumed by humans are produced in industries. Home and other appliances use by humans today are manufactured in the industries. Industries are major poverty eradication component of any nation, since they provide more than 53% of employment generation, across the globe (Kiz, 2010). As various industries compete for customers, they improve human health and indeed the overall prosperity of a nation.

Interestingly, sustainability of any industry hinges on critical decision-making by managers and their team. Simply defined, decision is a choice or judgment (Whyte, 2011). The decision of the manager or management team can make or mar an industry. Hence, decision making is very crucial for any organization. Whyte (2011) has defined decision making as a process of selecting choices from a pool of several feasible options. The choice and values of the decision maker is very crucial to making decision. As a matter of fact, decision-making is a difficult problem-solving activity. Hence, there is a need for a decision-maker to be innovative, creative, knowledgeable and objective.

Objectivity is synonymous to rationality. An objective decision maker does not allow emotions or personal prejudices toward influencing his choice. Kiz (2010) observed that an important means to arrive at an objective and quality outcome in management is by employing mathematical models such as linear programming. Linear programming involves calculating the least and highest values of a linear expression over a region of feasible solutions and satisfying a group of constraints presented in the form of inequalities. In practice, the restrictions determine the set of achievable solution while the quality that is minimized or maximized is denoted by the objective function.

The main aim of linear programming is to yield the best result that is void of bias or personal prejudice. It is therefore a concern when most mangers in Nigerian ignore the utilisation of linear programming model in most of their decision-making processes (Nneji, 2013). The consequence of avoiding optimization techniques, such as linear programming within Nigerian industries is

noticeable from the number moribund industries in Nigeria today. Poverty and hunger occasioned by unemployment and underemployment have burgeoned exponentially. This is happening in an era when the desire to attain sustainable development goals is high. Hence the need for action is indeed ubiquitous.

2. OBJECTIVE OF THE STUDY

The main objective of this paper is to reflect on how linear programming could be to improve decision making for sustainability in Nigerian industries.

3. LITERATURE REVIEW

The sections below form the literature review of this paper.

3.1. CONCEPT OF SUSTAINABLE DEVELOPMENT

Before discussing sustainable development, it is expedient for one to first of all define the concept of development. According to Lofchie (1971) development encompasses the political sphere, which portrays the improvement of civil authorities in their bid to represent and respond to the various welfare of mankind within a pluralistic society. Lofchie (1971) maintained that from a societal perspective, development embodies the eradication or minimisation of inequities, and expansion of a popular government services such as health, education, welfare etc. Furthermore, Lofchie (1981) observed that the fiscal sphere development should include continuous improvements of the material condition of life, such as diversification of agriculture, advancement of industrial activities and general increase in level of self-reliance. Nneji (2013) added that development entails achieving specific goals or needs through a systematic use of scientific and technical knowledge. According to Nneji when someone or something grows or changes and becomes more advanced, we say that development has taken place.

Sustainable Development includes all plans for attaining human development objectives while at the same time ensuring that the capability of natural systems to offer the natural means is sustained, while ensuring that no damage is done to the eco-system, on which the economy and society are dependent on. The desirable intents of sustainable development are to attain a situation where living conditions and consumption of resource meet human needs continually without doing any harm to the functionality and sustainability of the natural systems. As the concept of sustainable development accelerates, it has turned to centre more on fiscal growth, social growth and ecological sustenance for future generations. It has been proposed that *"the word 'sustainability' ought to be observed as (homeostasis) that is, man's principal aim of human-ecosystem equilibrium, while 'sustainable development' denotes to the universal method and spatial procedures that guide us to the finish point of sustainability"*. According to Banjo (2004) to attain sustainable development is to attain a status where economic and social transformation is maintained and kept in existence. Banjo explained that

these must be founded on complex cultural and ecological factors and their interactions. Hookes (2010) opined that sustainable development involves a mechanism for holding a leeway of the theoretical or practical aspects of an intervention, a design, discovery or concept.

Any development that takes care of the needs of the current generation without undermining the survival of generations after them to attain their personal needs can be regarded as sustainable development. Sustainable development consists two main principles namely, the perception of needs and the knowledge of limitations. Lask (2011) observed that sustainable development as used today focuses more on the goal of socially inclusive and environmentally sustainable economic growth. This is an improvement above the former intergenerational framework, which sustainable development was known for. Furthermore, sustainable development encourages wide public contribution in decision making as a basic requirement for achieving it. No doubt widened consultations will aid better decisions, especially when the inputs are analysed using objective optimization techniques such as the linear programming.

The Millennium pronouncement identified treaties and principles on sustainable development, under the ideologies of United Nations Charter. These include economic development, societal improvement and environmental protection. Hence, in wide terms sustainable development can be defined as a system development and approach to growth, which produce social capital, and manage natural resources for the well-being of their own and future generations. Issues associated with bigger issues of human development such as education, land, public health development, and standard of living form major components of sustainable development as applied by United Nations. The 17 sustainable goals of the United Nations (UN) as adopted by nations of the world (2015) are in Table 1 below.

Table 1. *UN Sustainable development goals*

No	Goal
1	No poverty
2	Zero hunger
3	Good health and well being
4	Quality education
5	Gender equality
6	Clean water and sanitation
7	Affordable and clean energy
8	Decent work and economic growth
9	Industry innovation and infrastructure
10	Inequalities
11	Sustainable cities and communities
12	Responsible consumption and production
13	Climate action
14	Life below water
15	Life on land
16	Peace justice and strong institution
17	Partnership for the goals

Source: Authors compilation from the UN (2015) report.

Just like the universal, integrated and transformative 2030 Agenda, the General Assembly of United Nations expects that every member country implements and achieves the "17 sustainable development goals from the year 2016 to 2030". The obtainability of quality water, air, food, shelter and other vital human desires are also the ecological base for sustainable development. Integral elements for a sustainable development include innovation, creativity, ingenuity and research. Even though sustainable development could lead to a diminution in resource consumption, it can also improve the quality of life for people. In business and industries, utilization of natural, human and other available resources efficiently, can be a major widely accepted index for commercial sustainability. The second index for commercial sustainability is the relationship amid an industry's extra value and its social impact. Thus, industries occupy a crucial position in any nation's strive towards sustainable development.

3.2. THE CONCEPT OF DECISION MAKING

The concept, decision making according to Whyte (2011) is a choice or judgment. Whyte further defined decision-making as a cognitive activity giving rise to certainty or a course of action amongst many options. However, Umar (2007) is of the view that all processes of identifying and selecting from a pool of options that stem from the knowledge and choices of a decision-maker constitute decision making. Decision-making, as a problem-solving action, ends when a convincing solution is attained. Since decision making is built on tacit or explicit knowledge, it can be considered as rational or irrational action. The exploration of a fixed set of options, that is well-defined in position of evaluative principle, makes up a crucial part of decision-making. The challenge could be to organize most of these options in relation to how striking they present themselves to the decision-maker(s), most especially when all the principle is considered concurrently. Hence, finding the finest choice or to decide virtually on total preference of each choice when all the criteria are considered simultaneously, is major another challenge.

Mang (2007) noted that if specialists in business or any field should utilise their knowledge in a particular filed to make well-articulated decision, then logical decision making is unavoidable. Mang (2007) differentiated between problematic exploration and decision making. He argued that traditionally, analysis of problem can be carried out in the first place to enable the data collected in that procedure to be used for effective decision-making. Problem analyses consider what the outcomes should be as opposed to the actual result. It is only the nonconformity from set standards that give rise to problems. Another characteristic of problem analysis is that a precise identification and description of problems are required. Moreover, problems result from a change from a distinctive feature. Mang (2007) added that a distinction can always be made between what has or has not been affected by a given cause. Some of the causes of difficulties can be taken from pertinent changes noticed after examining a problem.

From another angle, decision making requires that objectives must be established before anything else. Also required, is the proper classification and placement of objectives, in order of preference. Alternative actions must be analysed and evaluated against all other options. The option that achieves all the goals is the temporal decision. The temporal decision is then appraised against other alternative ones. Decisive steps and more steps (actions) are prompted to avoid undesirable magnitudes of problems. This will ensure that problem analyses and decision making is not run all over again. Decision making involves steps that yield decision model which could be used to establish an optimum plan. Broadly speaking, decision-making techniques entail both individual decision-making techniques and group decision-making techniques.

Group decision making technique includes consensus decision-making, Voting-based methods (majority, plurality and range voting), Delphi method, Democratic or Participative decision-making and Decision engineering. Individual decision making consist of Decisional balance sheet, Simple prioritization, Satisfying, Closeness to a leader or an expert; just following orders, Anti-authoritarianism, Flipism, Automated decision support and Decision support systems. Leon Mann (cited in Aka, 2009) propounded a decision-making process called GOFER to enhance decision making. GOFER represents an abbreviation of five decision-making steps:

1. **G**oals: Survey values and objectives.
2. **O**ptions: Consider a wide range of alternative actions.
3. **F**acts: Search for information.
4. **E**ffects: Weigh the positive and negative consequences of the options.
5. **R**eview: Plan how to implement the options.

Kristina Guo (cited in Sendal, 2008) has propounded the DECIDE as the ideal decision-making model with six components, namely

1. **D**efine the problem
2. **E**stablish and **list** all the criteria (constraints)
3. **C**onsider and **gather** all the alternatives
4. **I**dentify the best alternative
5. **D**evelop and implement an action plan
6. **E**valuate and monitor the solution and scrutinise feedback when the need arises.

Both the steps of GOFER and DECIDE mentioned above, are components of linear programming techniques advocated in this study for sustainable decision making in Nigerian industries.

4. RESEARCH METHODOLOGY

The research methodology of the paper is discussed below:

Application of Linear Programming Technique in Industries Towards Profit Maximization and Sustainability

For instance, using the case of O-A Industries Limited (code name used for ethical reasons), that has the intention to maximization profits for two products. The first product brings in a profit of N150 per unit, and the end product yields a profit of N2.00 per unit. Surveys and other business sources have shown the following constraints:

1. The combined production level must not be above 1200 units monthly.
2. The demand for product B is no more than half the demand for product A.
3. The production level of product A is less than or equal to 600 units plus trice the production level of product B.

5. RESULT

If one allowed the number of units of product A to be x and the number of units of product B to be y, the objective function (for the combined profit) is given as:

$$P = 1.5x + 2y \quad (1)$$

The three constraints translate into the following linear inequalities:

i. $x + y \leq 1200$

ii. $y \leq \frac{1}{2}x$ OR $-x + 2y \leq 0$

iii. $x \leq 3y + 600$ OR $x - 3y \leq 600$

Since neither x nor y can be negative, one also has the two additional constraints of $x \geq 0$ and $y \geq 0$. These are called non-negativity constraints because the manufacturer would normally utilize all available resources; the three inequalities can be translated to equations as follows;

i. $x + y \leq 1200 \rightarrow x + y = 1200$ (2)

ii. $-x + 2y \leq 0 \rightarrow -x + 2y = 0$ (3)

iii. $x - 3y \leq 600 \rightarrow x - 3y = 600$ (4)

Using equations (2), (3) and (4) the graph in figure 1 is obtained:

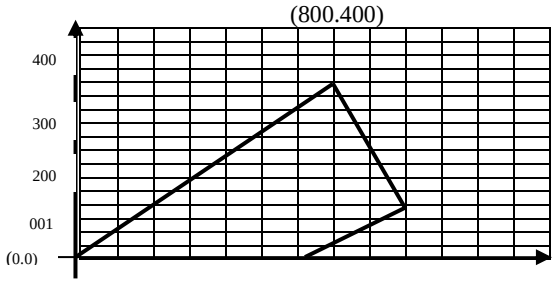

Figure 1. *Graph of number of units (x and y) of the two products (A and B)*

The graph displays the region determined by the constraints. To locate the maximum profit, there is a need to test the value of P at the vertices of the region.

Table 2. *Values of P at the vertices of the bounded region in the graph*

Corner	**X (N1.5)**	**Y (N2)**	**P(1.5x +2y) (N)**
0:0	1.5 (0)	2 (0)	0
800 : 400	1.5(800)	2(400)	2000-***Maximum profit***
1050: 150	1.5 (1050)	2 (150)	1875
600: 0	1.5(600)	2(0)	900

Source: Authors' Fieldwork

From Table 1 above, the combinations of products A and B gave four options. The first option (0, 0) gave a P value of 0. The second option (800: 400) gave a P value of 2000. The third option (1050: 150) yielded a P value 1875 while the fourth option (600: 0) gave a P value of 900. Therefore, the maximum profit is N2000, and it occurs at that point when the production for the month consists of 800 units of products **A** and 400 units of products **B**.

Hence, linear programming techniques could be valuable decision-making technique for sustainability in Nigerian industries as reflected in O-A Industries Ltd. It can lead optimal solutions to problems of productivity as propounded by Hookes (2010) and others.

6. IMPLICATIONS FOR SUSTAINABLE DEVELOPMENT

From the application of linear programming technique illustrated above, it is clear that linear programming can aid effective decision-making for sustainability in Nigerian industries. No doubt a manager in the above example

could have made wrong combinations in the production of products A and B. However, the right and most rewarding combination was determined mathematically through linear programming. It is certain that when profit increases, job creation will increase due to demand for product and subsequent need for additional hands (workers) to meet up with the positive change in demand and supply. Yashe (2009) opined that unemployment is associated with so many societal problems such as crimes, hunger, and poverty and, in extreme cases, death. Whyte (2011) submits therefore that it is important for any responsive government, manager or leader to adopt realistic measures towards solving sustainability challenges in their nation or organisation. Since corruption has almost destroyed all efforts to revive the nation's ailing industries that have shut down in various sectors, it is imperative to initiate a turnaround strategy to change the status quo. This, therefore, necessitates the adoption of mathematical models, such as linear programming, for optimal decision making to revive the Nigerian industries towards economic sustainability.

7. CONCLUSIONS AND RECOMMENDATIONS

In conclusion, there can be no surer way of implementing and achieving the sustainable development goals than saving the nation's ailing and moribund industries from total collapse. Since mangers and heads of industries in Nigeria are faced with daily challenges to choose between competing alternatives, decision making process becomes more technical. These technicalities are heightening when managers are confronted with numerous constraints. However, this sustainability challenge can be resolve through the utilisation of linear programming techniques.

Based on the above analysis, the following recommendations are proposed:

1. Managers and heads of industries and indeed other branches of the Nigerian economy should embrace the utilization of linear programming techniques in their various decision-making processes.
2. Manufacturers and business owner should consider the used of appropriate mathematical decision-making model in their day to day operations.
3. Mathematical modelling techniques such as linear programming should be included in all management and business administration course in various tertiary institutions' curriculum in Nigeria.

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