

# SYSTEMS APPROACH TO FARM MECHANIZATION IN NIGERIA

by

Uche Anazodo  
Agricultural Engineering Department  
University of Nigeria Nsukka

## Summary

The concept, objectives and factors that enhance agricultural mechanization are reviewed from relevant literature. Various impediments that usually frustrate mechanization schemes in traditional tropical agriculture are briefly discussed. Some fundamental questions are then raised which the author argues can best be studied by a multidisciplinary team using the systems approach in evaluating the appropriate levels of mechanization suitable for Nigerian agricultural systems. Attention is focused on the nature of data needed for the development of acceptable mathematical models of the real systems. Solution by linear programming aided by a computer is advocated.

## Introduction

Despite the great achievements of the Green Revolution and other world, regional or national strategic plans for the attainment of a reasonable degree of self-sufficiency in agricultural production in developing countries, our food supplies are still pathetically inadequate in terms of both quantity and quality. In Nigeria, for instance, the government experts predict that at the present rate of growth in agricultural produce, the country will not be able to feed her population in the next decade (1). This sad picture in a paradox which typifies hunger and miseries. In the midst of an apparently untapped bountiful natural and human resources.

## Factors For Accelerated Food Production

For an effective increase in agricultural output, the important input factors are:

- a) According to the agricultural sector of the economy its right priority in the broad development plans of the nation's economy.
- b) A sound agricultural education policy including an effective extension service
- c) A cautious transformation of the present conservatism of farmers to responsive attitudes towards modernisation in agriculture
- d) Development and distribution of high yielding varieties of food crops
- e) Efficient agricultural processing facilities.
- f) Adequate storage and marketing facilities.
- g) Liberal but well operated agricultural credit institutions.
- h) Availability of accurate agro-meteorological data for better weather forecasts
- i) A more pragmatic approach to land settlement and land development
- j) Better control of the nation's water resources, either in the form of irrigation schemes, soil

conservation works, water conservation farming, or land drainage schemes.

- k) An appropriate level of mechanization.

Although the order of priorities in the above list will vary from place to place, yet mechanization is deliberately mentioned last in order to emphasize that mechanization is impracticable unless the other inputs are not limiting factors.

## Mechanization Objectives

The word mechanization in many minds connotes tractors and similar power machinery. A broader definition of the term is, however, that which encompasses the use of hand and animal operated tools and implements, as well as motorized equipments to reduce human effort, improve the timeliness and quality of various farm operations, thereby increasing yields, quality of product, and overall efficiency (2). The objectives of mechanization may then include the following:

- a) To reduce drudgery from farm work.
- b) To increase the agricultural output per man-hour.
- c) To improve timeliness of operations.
- d) To reduce spoilage, waste and other losses of products.
- e) To preserve and properly process farm products and food supplies
- f) To maximize yields by improved agricultural operations.
- g) To enable the production of more or additional food products.
- h) To improve water supplies and water control systems.
- i) To reclaim land abandoned because of primitive operations or inadequate power
- j) To develop new land for agriculture by clearing of obstructions or by draining, levelling or other reclamation operations.
- k) To create a greater measure of well-being for farm families.

## Aids to Progress in Mechanization

There are certain pre-requisites for an effective farm power and machinery in traditional farm systems. Some of these factors that aid agricultural mechanization may include:

- (a) A growing desire by farmers for better machinery and tools
- (b) A government sympathetic to mechanization developments.
- (c) Education, Research, and extension programs.
- (d) Establishment of agricultural mechanization

training centers.

- (e) Adequate transportation facilities from farm to market.
- (f) Development of food storages, processing facilities, and distribution organizations
- (g) Advancement of industrial production.
- (h) Development of suitable machines for small farms.

It is not suggested here that all these favourable conditions must exist in Nigeria before mechanization, can take off. Instead the purpose for enumerating them is to assist one in evaluating how feasible any particular mechanization project is in any particular environment. Indeed some of these aids already exist in Nigeria. For instance, the growing desire of farmers in Nigeria (as well as those in some other African countries) to exchange their primitive tools for modified versions of them and some entirely modern new ones has been reported in a documentary field study undertaken by Michigan State University. (2) Also the concern of the Federal and State governments about increased agricultural production has been demonstrated by the establishments of the Agricultural Credit Bank, the several food production companies, and the different agricultural development authorities and agencies. Nor are the generality of the Nigerian public ignorant of the need for mechanization judging from the several agro-business enterprises mushrooming in quite a good number of places in the country. It appears that all that is needed in Nigeria for mechanization to succeed is a well co-ordinated and systematic action programme capable of exploiting the current disposition of Nigerians towards scientific and cultural advancement.

### Impediments

Notwithstanding the above narrated recent progress towards accelerated food production in Nigeria, certain bottlenecks still exist in the mechanization of Nigerian agriculture. The more important impediments may be listed as follows:

- (a) Unemployment problem: Since most machines developed in the technologically advanced countries are labour saving, indiscriminate introduction of them will lead to a good number of our farm workers being made more redundant than they already are with grave social, political and economic consequences.
- (b) Fragmented holdings which may be un-economic for machinery application. The operating cost per hour of a machine is higher in small farm units than in larger ones since the machine can only be used for only few hours each year in the smaller farms.
- (c) Cultural practices of a great majority of our farmers are not very conducive for mechanization. To derive the advantages of mechanization-timeliness of operation, ease of

work, increased output per man-hour etc. our farmers should be made more familiar with the potential benefits of improved crop varieties, increased use of fertilizers, increased water availability and proper rotation of crops.

- (d) Adjustment problems exist as farm implements usually have to be adjusted to local conditions of soil. Climate, crop varieties, topography, dimensions of farm units, forms of packing, and systems of marketing. .
- (e) Equipment management which demands adequate after-sale service, repair and maintenance facilities.

The other more general problems facing the furtherance of agricultural mechanization in developing countries are discussed in greater detail elsewhere (2 - 8).

### Fundamental Questions

The foregoing review of the objectives of agricultural mechanization and those factors favouring or hindering it raises some fundamental questions such as: What appropriate levels of mechanization are needed in Nigeria? Are we planning for a selective, Gradual, and progressive mechanization, or do we aim at a complete mechanization at a stroke? Do we go out for a complete substitution of our more familiar but probably inefficient hand tools with the latest designs in imported tillage, Seeding, weeding, harvesting and processing equipments? What are the scopes for improving our traditional hand tools? What are the comparative effectiveness of large, medium, and small powered tractors; the conventional horticultural tractors, and the Japanese-type walking tractors in the particular realities in which our farmers live and operate? Have we sufficiently identified the social, technical, economic and resources problems that may impede a successful introduction of farm power and machinery in Nigeria? Are these impediments quantifiable? How limiting are they as input factors in a mechanization program?

For reasonable answers to questions similar to those posed above, the logical approach is that fashionably described as the systems approach.

### The Systems Concept

Essentially the systems concept is that of expressing the overall interactions of a group of items rather than focusing attention on the operation of each component elements in turn. A system itself may be defined as either a regularly interacting or independent group of items forming a unified whole or an organised set of doctrines, ideas, or principles usually intended to explain the arrangement or working of a systematic whole. The explicit motivation of any system study is to generate information so that a decision can be made. The systems approach has successfully been applied to

various aspects of agricultural production and mechanization in North America and Europe (9, 10, 11,) and most probably in other developed countries like Japan and the Soviet Union. In Nigeria, the first attempt in undertaking studies involving systems approach to farm mechanization were initiated at the International Institute of Tropical Agriculture (IITA) Ibadan (12). There were two aspects of this work: the formulation of mathematical models of existing systems and examination of their behaviour with varying mechanization inputs; and the establishment of model farms where the behaviour of selected systems can be studied.

### Goals

The purpose of the present study is to evaluate the optimal levels of mechanization suitable for small farms in Nigeria. For this the previously posed fundamental questions may be introduced in our system of goals as follows:

- (a) What is the desired (or optimal) level of production consistent with maximal availability of productive land, capital, and market resources?
- (b) Does the farmer achieve the optimal level of production under his existing level of mechanization?
- (c) Can he do so by more intensive land utilization (double, triple cropping if realistic) ?
- (d) Can he reach the optima level of production by cultivating more land?
- (e) If it is possible to amalgamate individual farms, is the production increased to the optimal level?
- (f) Does an improved management skill (that is to say, scientific allocation of his land and crops, better use of his existing labour force and tools, better system of operation) enable the farmer to achieve the estimated desirable level of production?
- (g) Is the farmer able to perform at optimal level of production by any combinations of the above improvement schemes?
- (h) Determine what level of machinery introduction that will enable him achieve the desired level of production.
  - (i) What powered system (that is hand-, animal-, and engine- power) is most effective in achieving the optimal levels of production?
  - (j) Evaluate the effectiveness and level of irrigation technology which will raise crop production to the desired amount.

### The Model

The model is to be formulated with respect to a point in time, that is to say, the period over which the data is collected. The model is thus a static one which is however suitable for 'other periods of time once the relevant data are used.

Its objective function is a combination of the ten main goals outlined previously, and it is constructed in such a way that alternative functions may be tested. Since the major objective of the project is to

increase production of various food products by introducing farm machinery, each crop and each farming operation is allowed to constitute an individual activity in the model. Some of the common crop combinations could each be considered as a separate activity. The objective function and the group of activity-variables form the first and second major components of a mathematical model of a real system. The third component is the system of inequality-equations which generally describe the restrictions that are to be imposed on all the activity variables in the model. Usually the number of real activities can never be greater than the number of restrictions. Thus more than one constraining inequality- equation may be applied to any single activity variable.

In formulating these three main components of the model, certain preliminary investigations must be successfully conducted. The following should serve as guidelines in collecting information for building an acceptable model:

- (a) Identify and analyze farming methods now followed and the types of tools and equipments now used.
- (b) Identify the factors or conditions favouring and hindering various forms of mechanization proposals.
- (c) Make an economic appraisal of the problems inherent in selective mechanization in the areas to be studied.
- (d) Identify specific agricultural engineering problems requiring immediate attention and suggest related research.
- (e) Develop a set of generalizations as the basis for planning selective mechanization.

### Data Collection

It is necessary to collect data on the environments in which the analysis will be undertaken. These data are of two types, namely, quantitative data based on observations and measurements which describe organizational, financial, procedural, physical, and operational relationships and flows in the system; and qualitative data based on questionnaire, authoritative publications and expert opinions which describe these relationships and flows. A survey of all the tractors, implements, and hand methods currently in use will generate such quantitative information as their drawbar performance, tractive efficiency, field capacity, field efficiency, actual life, operating costs and labour performance. All these, including other relevant performance parameters and crop yields, will help to determine the input-output coefficients in the mathematical model. It is important to give a systematic description of all implements and powered systems, possibly with diagrams and photographs. All non-quantifiable impediments in their use (for instance lack of repair and maintenance facilities) must clearly be pointed out.

Adequate knowledge of all other relevant restraining conditions for improving existing farming

methods or for introducing new powered system and associated equipments will be obtained from a well organised questionnaire. Recorded answers to such questions as listed below may be collected:

- (a) Why plant at the time you do?
- (b) Why not earlier?
- (c) Why not later?
- (d) Can you expand your cultivated land?
- (e) Reasons for (d)
- (f) Are you willing to change your system of cropping if you are advised that it is in your best interest? Give reasons.
- (g) Have you any objections to someone else re-organizing your labour inputs. if you are advised that it is in your best interest ?
- (h) Are you ready to work more hours?
- (i) Can you allow any member of your family to engage in other employments or training program?
- (j) Will you agree to hire paid labour if you are advised that it will increase your production ?
- (k) Are you willing to combine your farm business with your neighbours ?
- (l) Reasons for (k).
- (m) Will you change your answer to (k) if you happen to lose your leadership in a combined or amalgamated farm?
- (n) Will you agree to sell a piece of land to someone else if you are advised that you are better without it ?
- (p) Have you any objections to allowing your land to be cultivated on loan by someone else?
- (q) Will you change your answers to (n) and/or (p) if that someone is:
  - (i) The Federal Government
  - (ii) the State Government,
  - (iii) the local government.
  - (iv) Co-operative farmers society, or
  - (v) somebody not from your Immediate neighborhood?
- (r) Will you be willing to try new varieties of crops.
- (s) will you be Willing to apply new fertilizers ?
- (t) Are you ready to buy/hire alone or jointly any machines If you are assured that the extra cost of doing so will be completely balanced by Increased production ?
- (u) If credits are available for buying or hiring new machines can you accept such If you are
  - (i) Requested to sell your 'surplus' produce to a government agency at her own fixed price?
  - (ii) Pay higher taxes?
  - (iii) Open a savings account in your nearest bank 'or increase your present savings?
  - (iv) Supply some of your 'surplus' family labour for unpaid/underpaid government or community projects?
  - (v) Enter into an agreement to repay the credits in a government stipulated time or face certain penalties including auctioneering of some of your personal or landed property.

Furthermore it is essential to collect classified data on storage, processing, distribution and marketing

facilities in each area to be studied. Other important facts to be assembled from authoritative publications include: impact of agronomy innovations; potential of extending fertilizer use; cost and benefits of irrigation and conservation schemes; capacity of the Nigerian economy to absorb any displaced labour from mechanized farms; general and specific agro- climatological advantages and limitations; topological situations; soil management and local diseases and pests. Yet another group of important data for the development of an effective model of a farm system are those derived from research experiments. Useful criteria on soil-machine interaction for areas under study should be established. These may include: the comparative assessment of various tillage machines on types of soil of relevant interest; influence of soil moisture, Suction, physical strength on growth and yield of tropical crops; the compacting and structural effects of motorized-power systems on agricultural soils. However, valuable engineering research data as those just mentioned may take a long period of time to gather. Thus initially our model may be based on classified engineering data alone, while it is hoped that the result of this preliminary model analysis will help to emphasize areas where urgent engineering research is needed. Information from well conducted engineering research may then help to establish new optimal levels for agricultural production.

#### Methods of Solution

The next logical step after collecting these vital data is their analysis, from which certain guidelines, principles, critical factors, input and output coefficients may be established in the model. At this stage certain modifications may be made on the model to reflect all the relevant information gathered from the real system.

There are several mathematical techniques for solving a model such as the one just described. These include: the simple gross margin analysis and complete budgeting technique, linear programming, and the rather more complex dynamic programming method. It may also be possible to Incorporate some of the critical path method (CPW) and the Problem evaluation and review technique (PERT). Mention has also been made by some knowledgeable individuals of the possible suitability of the method of dimensional analysis in solving real systems as complex as the one we are attempting to simulate. Each method has his advantages and disadvantages. However the linear programming technique appears to be more suitable here. Its computation may be aided by computer, using the Fortran language. The deductions from the model(s) must aim at answering all the ten goals previously listed, in addition to making other remarks and suggestions necessary for formulating and implementing an effective policy on agricultural mechanization in Nigeria and similar tropical

countries.

### Staff Structure

It is clear that the procedure described in this paper can best be carried out successfully by a multi-disciplinary team. Government officials, agricultural extension workers, agriculturists, agricultural engineers, economists and farmers all have some contributions to make in the suggested model study. The project can be launched at a local or national level.

At the local level, a university lecturer in agricultural engineering assisted by one junior research fellow in agricultural engineering and three field assistants can undertake a study of any selected area. Consultations with university lecturers in farm management, economics, vocational agricultural education and rural education; and also with nearby government farm mechanization officers will be made. Enough fund for paying the salaries of the research and field assistants, for travels and other minor expenses is all that is financially required. Additionally, the encouragement of government and local authorities in supplying up-to-date information as may become necessary will enhance the study.

At the national level, the project outlined in this paper may best be undertaken by the proposed National Institute of Agricultural Mechanization (NIAM) (5) with two possible branches—one in the North and the other in the South.

### Conclusion

In conclusion, the author strongly believes that successful mechanization of agriculture in Nigeria will continue to be a day-dream unless thoughts and 'blue-prints' similar to those expressed in this paper form the basis of any mechanization scheme in Nigeria.

### REFERENCES

1. Essien Effiong, guidelines on "Third Development Plan: Part 1" Daily Times, August 27, 1973.
2. Kline C. K. and others. Agricultural mechanization in Equatorial Africa Michigan State University, 1969 (Documentation).
3. McColly H. F. A proposal for agricultural mechanization in the developing countries of Southeast Asia. Journal. Agricultural Mechanization in Southeast Asia. Spring 1971. (Article).
4. Farm Machinery Industrial Research Corp. The Status quo and problems of farm mechanization in the developing countries. (Article) in the same journal as reference. 3
5. FAO, Rome. Agricultural Research in West Africa. (Country Report) 1973.
6. Kolawole M. I. Economic aspects of tractor contracting operations in Western Nigeria. J. Agric. Engng. Res. (1972) 17. 289-294 (Article).
7. Chancellor W. J Social and Institutional factors in mechanization of Agriculture in Thailand and Malaysia by Tractor Hire Services. International conference on Tropical and Subtropical Agriculture, Michigan. U.S.A. 1972 (Article).
8. Tsuchiya Keizo. Economics of Farm Mechanization in Japan. (Article) in same Journal as reference 7
9. Dent and Anderson. Systems analysis in Agricultural Management. (Book).
10. Link D. A. Activity Network Techniques as applied to a farm machinery selection problem. TASAE Vol. 110. No.3, pp. 310-317 (Article)
11. Liang Tung, Bio-production equipment systems selection: A separable Programming approach. J. Agric. Engng. Res. (1971) 16 (3) 269-279 Article.
12. Lalor W. F. and Anazodo Uche. Systems, Research in Mechanization. Farm Systems Program. IITA (1972 Report).