SOME ECONOMIC ASPECTS OF STORING DURA IN THE SUDAN

by

Ahmed Salim Ahmed

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I. INTRODUCTION

The Sudan is the largest African country with an area of about one million square miles. It is inhabited by 12.6 million people (estimated June 30, 1963). Except for a few mountainous regions which are small in relation to the whole area, the country is a vast plain. The topography is well-suited for construction of irrigation systems and for mechanized agriculture. Although half the country is desert, semi-desert, or rivers, the Sudan has large areas of land not yet intensively used, capable of considerable future development.

The Gross Domestic Product (G.D.P.) in 1962/63 was Ls. (Pounds Sudanese) 403.0 million and per capita income was Ls. 32.0 (equivalent to about $90.00). The contribution of the agricultural sector was and is about 60 percent of the total G.D.P. (1, p. 16).

Agricultural output has grown fairly well since the late 1950's. Production grew by 29 percent (3.3 a year) over the period 1955/56 - 1962/63. The output of modern agriculture increased by 46 percent and that of the traditional agriculture apparently kept slightly ahead of population growth\(^1\) (Table 10).

The Sudanese economy depends heavily on a single crop, cotton, which is its most important export. It constitutes about 40 percent of the total national revenue and about 60 percent of the export trade. The

\(^1\)These figures, computed for the estimate of gross national product are based on current prices. As prices declined during the period, these figures underestimate the growth rate of agriculture if there are no offsetting errors.
heavy dependence on one crop with the price determined by the international market led to frequent undesirable fluctuations. This fact was realized at the formulation of the Sudan's Ten-Year Plan of Social and Economic Development where it was stated that "the base of the economy has to be strengthened before any sustained growth can take place. It is no less essential that the excessive reliance on a monoculture crop, cotton, has to be gradually reduced by the diversifying of the agricultural cropping pattern. This entails the development of various other crops besides cotton." (1, p. 23)

The general trend of the increase of the main crops of Sudan is in line with this objective of diversification. The period 1956 - 63 witnessed sizeable expansion in area, output, and yield for dura, groundnuts, and sesame. The largest increase in area under cultivation occurred for groundnuts; the increase amounted to about 200 percent. The second largest increase was in the area under sesame amounting to about 100 percent. Percentage-wise, the increase in area under dura was approximately equivalent to that under sesame (Table 11). The expansion of the area under cotton and the cotton cultivation continued because it is still the most rewarding crop (Table 12). The number of livestock (especially cattle, sheep, and camels) has increased appreciably (Table 13). The production of gum Arabic in which the Sudan has almost a world monopoly (86.5 percent of the world's production between 1957 and 1961) has also appreciably increased (Table 11).

Sorghum (Arabic dura) provides the staple food for the majority of the Sudanese. The surplus of dura is offered for sale in the external
market. The demand for export is mainly from two distinct groups of countries. The first group (Ethiopia, Saudi-Arabia, Somaliland, and Egypt) demand dura for human consumption and their demand is subject to fluctuations because it depends on whether these countries experience any shortage in food during any particular year; i.e., they purchase dura from Sudan to supplement their local production so as to meet their local needs. The fact that their local production is subject to fluctuations, too, ultimately leads to an unstable demand for the Sudanese dura by this group. The volume of dura purchased by this group of countries is influenced by their annual domestic output and the existing trade agreements between them and the Sudan, rather than by price changes. They prefer to spend their earnings of Sudanese currency on purchases of dura from the Sudan so as to spend their dollar and sterling earnings on the import of capital-goods. The consequence is that their demand for dura tends to have a low price elasticity.

The other side of the demand is mainly from Western European countries where dura is used for consumption as animal feed. The price that dura can bring in the latter market depends on competitive prices of other exporting countries that may resort in some years to the practice of dumping. So any policy for the promotion of the dura export trade should plan on reducing the cost of production and distribution of dura so as to compete in these markets.

The Sudan and the United States are net exporters of dura. With some effort toward the reduction of the cost of production and distribution of dura, the Sudan stands a good chance of competing with the United States.
A. Statement of the Problem

In a general manner the factors that lead to the reduction of the cost of production and distribution for the augmentation and stabilization of the dura surplus (marketable) will be considered in this study. Some suggestions have been made that the government, with the objective of stabilizing and augmenting the dura surplus, should take the following measures: removal of export and royalty duties, purchases of domestic surpluses by the government for the purpose of stabilizing domestic prices, reconsideration of the taxation system, reduction of railway freight rates, exploitation of new markets, and barter agreements, mechanization of the harvest operations, production of spare-parts and machinery, provision of adequate transport facilities, improvement of dura storage, and diversification of grain land production (2, p. 3 - 6).

More special emphasis will be given to price policies, certainty, and storage. Storage has become a more critical problem as a result of a continuous increase in production during the period 1956 - 1963, from approximately 65,000 tons to 1,250,000 tons. Added to this is the expected increase during the period 1966 - 1970 and given an increase in consumption, the surplus for export is estimated to be between 200,000 and 250,000 tons on the average every year. With lower production and distribution costs, our competitive position in external markets could be improved. Two other aspects of the storage problem are in the deterioration of quality and in the loss because of pests and climatic conditions. It is estimated that losses from these conditions is a minimum of 5 percent.
The construction of elevators for both bulk handling and scientific storage was considered to be the best remedy to cut down on distribution expenses and to save losses due to damage. Investigation was therefore conducted into the question of constructing two elevators -- one at Gedaref, the main production area, for export purposes and the other at Port Sudan. Study has shown that the Gedaref Elevator should be bigger than that of Port Sudan. The Gedaref Elevator could then serve both for storage and handling, while that at Port Sudan would be mainly concerned with handling as a regulator for export.

In view of the bumper arrivals during the limited harvest period of three to four months and considering the practical railway abilities, it was decided to make the elevator at Gedaref of 100,000 ton capacity. On considering movement of grain from Gedaref (and other minor areas) to Port Sudan, and comparing it with shipment, the Port Sudan elevator was constructed for 50,000 ton capacity only (3).

E. Objectives

This study is an attempt to identify and evaluate some of the factors which determine the level of dura production and distribution while focusing on the marketable surplus. Consideration will be given to the implications of the variables in the hands of the policy-makers for augmenting and stabilizing the surplus which is an important source of foreign exchange. The storage facilities are of prime importance in the cost of production and distribution of dura yet little research has been done pertaining to the cost of storage with the objective of planning
storage facilities. Factual data pertinent to the decision-making problem is needed. It is essential that location and storage capacity of different types of dura marketing be specified in order for government agencies to plan storage facilities in a manner consistent with the determined suitable criteria of efficiency and it is important to consider the cost of storage services at these different facilities.

C. Scope and Usefulness of the Study

The maximization of export proceeds is a subject of great concern to newly-developing countries. Foreign exchange is needed to import capital-goods for industrialization. Marketable agricultural surpluses must go up to finance the growing imports of capital goods necessary for developmental projects. Experience in less-developed countries shows that the role of governments in giving momentum to their respective economies has become vital. The policy-makers in these countries can employ different policy instruments for the realization of the ends-in-view. Due to the fact that decisions are generally made under highly dynamic conditions, some efficiency criteria are necessary for guiding such decisions.

In general, this study will discuss the factors that determine the size of the marketable surplus and the role of the marketable surplus in less-developed countries.

In particular, the augmentation and stabilization of the marketable the marketable dura surplus in the Sudan will be attempted with the objective of maximizing the net dura export proceeds.
With this view, the Sudanese Government can employ one or a combination of several measures. The study will be confined to a discussion of the probable outcome of price policies, certainty, and storage facilities on the level of the marketable dura surplus.

To study the possible outcomes of manipulating prices, a survey of some of the literature on the nature of the response of farmers to prices in less-developed countries will be undertaken. This will be followed by a broad conceptual analysis for providing a norm by which the degree of efficiency of resource use in the storage of dura may be measured.

In addition, we shall study the cost of production, present, potential markets for dura, the effect of prices manipulation in the efficient allocation of resources in the production of different commodities, the different types of uncertainties which influence the planning horizon of the producer, and the effects of storage facilities in the reduction of the rate of deterioration.

On the whole, the study might be considered as exploratory in nature. It is designed to "point-up" the central economic issues involved in the production and marketing of the dura surplus. It is hoped, however, that this study will provide a framework for further study.
The literature dealing with this subject can be divided into three major groups.

The first group is concerned with the nature of farmers' response to price in the less developed countries. Some writers maintain that farmers in these countries respond very little, or do not respond or respond perversely, to price changes. Others maintain that the response is positive.

Regarding this controversial subject, Falcon, (h), who maintains that the response is positive as illustrated by his empirical study in Pakistan, says:

Much of the apparent disagreement appears to be the result of not clearly distinguishing between cash and home-consumed crops, between land and non-land inputs, between production and marketing, and between the relative production of a given commodity and total production in the aggregate.

The second group is concerned with identifying, measuring and evaluating the factors which determine the level of marketable surplus of subsistence crops.

The Indian Society of Agricultural Economics (5, p. 26 - 11h) attempted to study the size of the marketable surplus, to identify the factors which influence it and to find means to augment its size.

The third group approach the question of marketable surplus in economic development, its role in the early stages of industrialization and in the process of sustained growth.

The three groups shall generally be discussed in turn.
A. Farmers' Response to Price Change in the Less Developed Countries

Some economists claim that farmers in less developed areas do not respond to price incentive. If this is true, it will have serious implications in the sense of the limitation it will impose in the use of the price of the agricultural commodity as an instrument in the augmentation of the size of the marketable surplus.

Mr. Raj Krishna (6) and Mr. W. F. Falcon (11) in their respective studies maintain that there is a positive price response in India and Pakistan for cotton and wheat. They suggest that price elasticity of output could be approximated by price elasticity of acreage. The elasticities are positive and higher in the case of cash crops (e.g., cotton) than in the case of food crops (e.g., wheat). Falcon emphasizes that "price response, as measured in the case of cotton, appears to be unquestionably positive and of a large magnitude" (11, p. 119). In the case of wheat, however, he points out that "wheat provides an excellent example of how price responsiveness can vary with the area chosen for study. In the rainfed lands of the Punjab, climatic restrictions were such that the number of cropping alternatives was very small and in this area no response to relative prices were noted. "On the other hand, in the irrigated region, a competition for land and water was noted between sugarcane and wheat. Here, the possibilities for growing a highly profitable cash crop lead to a small but significant (.2) price elasticity of supply for wheat" (11, p. 114).

In the Economic Journal of 1959 and 1960 (7, 8) there was an ex-
change on the price response problem. Nauer and Yamey and Hagg. essentially agree that there is a positive price response for the Nigerian cocoa producers, although they differ in the magnitude of the response.

R. N. Mathur and H. Ezekiel (9) maintain that generally the behavior of food grain prices is dependent not only on the total output of food growing but on the proportion of it which is marketed. This amount is usually described as the marketable surplus. The term implies marketing what is left after satisfying one's own consumption, utilizing the returns in buying other requirements and holding the balance in the form of money savings. They further claim that in the less developed countries the above analysis of the marketing process underlying the concept of marketable surplus hardly describes the true situation.

"... farmers sell that amount of the output which will give them the amount of money needed to satisfy their cash requirements and retain the balance of their output for their own consumption. The residual is thus not the amount sold but the amount retained. If prices rise, the sale of a smaller amount of food grains provides the necessary cash and vice versa. Thus, prices and marketable surplus tend to move in opposite directions." (9, p. 397)

According to the above, the farmer saves in kind rather than in money and the stock is disgorged when prices fall. This implies an inverse relationship between prices and marketed surplus.

The controversial "abominable snowman" which is a familiar phenomenon in the price-response problem has taken in the case of the "fixed requirement hypothesis", the form of a "backward rising supply curve" discussed by M. G. R. Allen, Farnsworth, and Jones (10, 11).

Some economists tried to show empirical evidence to invalidate the
"negative price-response hypothesis."

R. C. Olson (12) indicates that the inability to increase output in agriculture is not because producers are unresponsive to price, but to other factors such as the lack of knowledge, non-availability of fertilizer, lack of credit institutions, etc. Improvements require government action in providing more irrigation and drainage facilities, an aggressive extension program, and efficient agricultural supply system, an effective credit system and the like.

The farmer, rather than being unresponsive or responding very little, has, because of the absence of these facilities, not been able to respond.

To show that farmers in less developed countries are responsive to normal economic incentives, Professor Schultz (13, p. 64 - 65) stresses the fact that

"... studies of the observed lag in the acceptance of new agricultural factors show that these lags are explained satisfactorily by profitability."

To conclude, there is considerable disagreement on the effect of product price on the supply curve of agricultural products in less developed countries.

8. Factors Determining the Marketable Surplus

The second group of economists are concerned with identifying, measuring, and evaluating the variables that determine the level of the marketable surplus for farmers individually and as a group. In the
following, we shall consider such factors.

1. Output and intensity of production

According to one hypothesis, the level of production of the commodity under consideration is the important variable which influences the level of the marketable surplus. The findings of Khan and Chowdry, who tested the above hypothesis in relation to wheat in Pakistan, were that "one unit change in output is directly related to three-tenths of a unit of marketable surplus" (11, p. 36).

In another study, S. Saran (15, p. 72) shows that there need not always be a positive relationship between production and marketing. This can be explained by the fact that an increase in production does not necessarily result in an increase in the per capita production because of a higher rate of increase in the size of the population.

Other authors (e.g. Shastri, 16, p. 97) emphasize the "intensity of cropping" as distinguished from the "level of production", i.e., to increase the per acre yield for realizing higher output and larger marketable surplus.

2. The farmer's income

Nagvi (17, p. 63 - 69) maintains that the farmer's income is significant in determining the size of the marketable surplus. The richer the farmer, the higher the probability of his selling more of his produce and the reverse holds true. Both the marginal propensity to consumer and income elasticity of consumption are high. This led some economists like
Bansil (13, p. 23) to conclude that various land reform measures had in fact reduced the marketable surplus.

3. The relative importance of cash crop in a particular region

The relative importance of cash crop in a particular region, as suggested by Khan and Chowdry (14, p. 365), affect the size of the marketable surplus of the food crops grown in that region. The more important the cash crop in relation to the food crop, the larger the cash income source for the farmer, the higher the marketable surplus of food crops.

4. The family size and composition

The size and composition of the family is believed to influence the size of the marketable surplus because a larger portion of the produce is consumed by the same family unit. Misra and Sinha (19, p. 64), however, concluded in their study that this relationship is not significant.

5. Cash requirement

According to some economists, prices and marketable surplus tend to move in opposite directions. P. N. Mathur and H. Ezekiel (9) maintain that farmers sell a part of their output sufficient to meet their cash requirements and retain the balance of their output for their own consumption. The implication of this is that a higher price for the product will reduce the size of the marketable surplus.

Khan and Chowdry (14, p. 355) show that "other income" is in-
versely related to the marketable surplus because it contributes a part of the farmer's cash requirements.

V. S. Rao (20, p. 104) does not accept the backward bending supply curve implied by this argument, and he questions the underlying assumptions. In his model, it is assumed (a) that the major part of the marketable quantity comes from the small producers; (b) that these producers are most often living at subsistence level and as such their income elasticity of demand for home produce is quite high; (c) that they have fixed cash needs. His data from South India suggest that the bulk of marketed quantity comes from rich irrigated tracts where big cultivators contribute most of the marketed quantity. But this observation does not invalidate the applicability of the above hypothesis in other regions.

6. Consumption habit

The differences in consumption pattern in different regions and consumption habits influence the size of the marketable surplus according to Kahlon and Reed (21, p. 48).

7. Size of holding

The nature of the relationship between the marketable surplus and the size of the holding is controversial. Bansil (19, p. 29) found a positive correlation between the two. However, Rao (20) found the correlation negative in five out of seven villages.
g. Price level

We have seen that the change in the price of a commodity affects the marketable surplus though the direction and magnitude is controversial. Not only the direct rise in the price of the commodity, but also the decrease in the price of the factor inputs influence the marketable surplus.

The reasons for the disagreement on the effect of prices is "largely the result of failing to distinguish between cash and home-consumption crops, (2) between yield and acreage response, (3) between total production in the aggregate and relative production of particular commodities, and (4) between total good crops grown and the food crops grown for the market. In addition, insufficient attention has been given to the effect of farm size, uncertainty, seasonal price movements and technical limitations. The latter are particularly important in explaining rational behavior on the part of small farmers." (4, p. 29)

C. The Role of Marketable Surplus in Economic Development

John W. Mellor (22, p. 219) stated that the rapid population growth and relatively high income elasticities for agricultural products require that large increases in the supply of agricultural commodities accompany economic development in low income countries. Meeting this demand with more agricultural commodities conflicts with the need for the utilization of the limited foreign exchange to import capital goods for industrialization. The need for foreign exchange requires an increase in the production and export of agricultural commodities. The failure to increase
the domestic agricultural output when embarking on a policy of economic development is largely inflationary because of the heavy weighting of food in consumption expenditures. This, of course, is quite unlike the situation in high-income countries.

In the preconditions for the take-off to economic development Rostow (23, p. 22) maintained that a country in the early stages of development needs a lot of working capital for modernization. Such capital can be obtained through "higher productivity in agriculture and extractive industries."

"It is thus the multiple, distinctive but converging consequences of the revolution in agriculture which give to it a peculiar importance in the period of preconditions. Agriculture must supply expanded food, expanded markets, and an expanded supply of loanable funds to the modern sector."

Rostow, (23, p. 24)

S. K. Bose (24) discussed the important role of agricultural surpluses in economic development of underdeveloped economies. The necessary capital equipment for industrialization has to be imported from abroad. Only the agricultural sector is likely to have any capacity for export. Hence, the marketable agricultural surpluses must go up to finance the growing imports of capital equipment necessary for development.

The magnitude of the export surplus, in the absence of foreign aid, initially almost directly regulates the rate of growth of industries, though subsequently, as the other sectors develop export capacity, the strain on the primary sector is correspondingly reduced. S. K. Bose, (24, p. 37)

Economists differ about the effect of the import of food on
developing countries. Some of them consider it as conducive to economic growth; others claim that it has an adverse effect. T. W. Schultz suggested that surplus disposal may have adverse effects on agricultural production in the receiving countries, thereby hindering their long-run economic development. Discussing the effects of the P. L. I430 farm products in India, he states that:

as things are going, the effects of P. L. I430 imports upon agriculture are likely to be adverse... Cultivators in India, however, would be confronted by some decline in the relative prices of the farm products they produce and sell. Here, too, there would be an income effect reducing their consumption. The incentive to maintain or expand agricultural production would have taken the wrong turn. Schultz, (25, p. 1023)

On the other hand, Khatkhate, taking Schultz’s general warning as a starting point, presented a theoretical analysis showing why there is no reason to believe that this danger exists. He gave a detailed account of the price response mechanism of agricultural producers in India. He concluded that since agricultural production (acreage) in under-developed agrarian economies is not responsive to price changes, the question is to determine the extent to which surplus disposal has prevented food prices from rising, thereby checking wage inflation in the nonagricultural sector of the economy. He argues that, "... prices would not have any impact on (agricultural) production..." Khatkhate (26, p. 189)

Beringer (27) disagrees with Khatkhate. He suggests that "Mr. Khatkhate has placed too much reliance on the well-known theory of the backward sloping supply curve in under-developed countries as a basis for ruling out potential adverse effects of surplus disposal in agriculture.
I shall argue furthermore that the surplus disposal program as it has been administered in Pakistan has had substantial negative income effects for agriculture, very likely retarding the agricultural development efforts in that country."

Beringer challenged Khathkate's statement by supplying empirical evidence which shows the acreage response to lagged price in Pakistan both for cash and food crops are positive and statistically significant. He added that the import of agricultural surplus disposal is harmful to productivity, self-sufficiency and the allocation of resources between cash and food crops by causing substitution of inputs in favor of cash crops. The results of the empirical study undertaken by Falcon (28) show the positive direction of farmer response to relative prices in South Asia. Falcon concludes that:

If, as these empirical results indicate, there are likely to be significant changes in the composition of agricultural output as the result of the price-depressing effect of importing one or more surplus commodities, Khathkate's policy conclusions may be inappropriate. Falcon, (28, p. 325)

D. Elasticity of the Marketable Surplus

To determine the elasticity of the marketable surplus, we need to know the elasticities of output with respect to income and price, and the elasticity of home consumption with respect to income and price.

We have seen that economists differ on how price affects output. The effect of income on both output and consumption and the effect of
price on the level of consumption also remains to be determined.

Following Krishna (6), the estimable functions of the marketable surplus is the equation:

\[ e_M = \frac{Q}{M}(e_{Q_I} + e_{Q_P}) - (\frac{Q}{M} - 1)(e_{C_I} + e_{C_P}) \]

where:

- \( Q \) = the quantity of dura produced
- \( C \) = the quantity of dura consumed
- \( M \) = the quantity of dura marketed
- \( Q/M \) = the output marketing ratio
- \( P \) = the relative price of dura
- \( I \) = the total income of the farmer

- \( e_{MI} \) = the elasticity of marketable surplus with respect to income
- \( e_{MP} \) = the elasticity of marketable surplus with respect to price
- \( e_M = e_{MI} + e_{MP} \) the total elasticity of marketable surplus
- \( e_Q \) = the elasticity of output with respect to income
- \( e_{QP} = e_{Q_I} + e_{Q_P} \) the total elasticity of output
- \( e_C \) = the elasticity of home consumption with respect to income or the income elasticity of demand for dura
- \( e_{CP} = e_{C_I} + e_{C_P} \) the elasticity of home consumption with respect to price or price elasticity of demand
- \( e_C = e_{C_I} + e_{C_P} \) the total elasticity of home consumption

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1 The total income of the farmer includes income from crops other than dura, farm labor, non-farm employment, etc., and also includes the value of dura consumed at home.
Now we may consider the previous equation for the measurement of the elasticity of the marketable surplus:

\[ e_M = \frac{Q}{M}(e_{Q_I} + e_{Q_p}) - (\frac{Q}{M} - 1)(e_{C_I} + e_{C_p}) \]

The sign of \( e_M \) can be investigated by determining the signs and magnitudes of each of the parameters on the right-hand side of the equation.

The ratio \( \frac{Q}{M} \) will always be positive. It ranges from 1 in the case of the purely commercial farmers to infinity when purely subsistence. Expressed mathematically, the output marketing ratio should be defined as \( 1 \leq \frac{Q}{M} \leq \infty \). This implies that the quantity \( (\frac{Q}{M} - 1) \) would never be negative.

The price elasticity of demand \( (e_{Q_p}) \) will always be negative because of the assumption of a downward sloping demand curve. The income elasticity of demand is always larger in absolute value than the price elasticity of demand. Thus, the second part of the equation is always a negative quantity.

The elasticity of output \( e_Q \), according to the model, is the sum of the income elasticity and the price elasticity of production. This gives rise to the controversial problem already discussed. Some economists whom we have already considered undertook some empirical studies and claimed that the price response is positive. The sign of the income elasticity of production as one component of \( e_Q \) remains to be considered (Mubyarto, 29).

Contrary to the above, Khatkhate (26) argues strongly that "prices
do not have any effect on agricultural production. However, it does affect marketed surplus but negatively." (26, p. 139)

If the values of the parameters of the model are determined in the future, the model will serve as decision indicator, in the manipulation of the variables by policymakers in decisions pertaining to agricultural planning in the Sudan.
III. RESOURCE USE IN THE STORAGE OF DURA

A. General

Storage facilities compete with other forms of production in the use of the limited resources of the society. When the objective of the society is the maximization of welfare in the Pareto sense, there are marginal conditions relating to production and exchange which are to be met. The marginal production conditions are those insuring the most efficient use of the factors of production.

In an abstract sense these conditions can be applied to the use of resources in storage so as to make the activity consistent with the objective of the society.

The purpose of this chapter is to indicate the general conditions of efficiency in the use of resources in the storage of dura.

B. The Optimum Level of Dura Storage

As with any other forms of production, storage can lend itself to economic analysis. Storage, as any other form of production, involves the use of the limited available means. Thus, the problem is one of the allocation of scarce resources between competing alternatives. In resource use one must consider storage as an intertemporal problem because it involves the element of time.

For the society as a whole, an efficient use of resources in the
storage of dura is not different from the general efficiency conditions in the use of resources in any other form of production. In an economic system where consumer sovereignty is a fundamental economic tenet, for economic efficiency in the utilization of resources, it is necessary that production should meet the desires of the society and that resources should be combined and coordinated in a way so as to maximize total output from the given inputs. In a static economy and under perfect competition, an optimum allocation of resources may be attained. But in a dynamic economy and with imperfections in the market, the above efficiency criteria would only provide a norm by which the degree of efficiency or inefficiency can be appraised.

Though public storage programs can be directed toward different objectives such as the maximization of farmers' incomes, stabilization of dura prices and the like, the overall objectives of storage should be consistent with the maximization of the society's objective function. For a choice indicator to express the relative desires of society with respect to present and future consumption of dura, either the pricing mechanism or society's indifference map\(^1\) or both may be employed. Having imperfections in the pricing mechanism, the two indicators will reflect the same relative values of society at any specific period of time.

From the standpoint of production theory, grain in two periods can be considered as two products. Given a situation where society has some quantity of dura available at some discrete point of time, say the

\(^1\)This is a theoretical concept which implies making interpersonal comparisons of utility, an act which is regarded as impossible.
present, which can be consumed presently or stored for consumption in some future time period, the optimum level of storage to maximize society's intertemporal objective function is expressed in Figure 1.

The present time period might be thought of as the beginning of a dura marketing year at which time the total supply of dura possessed by the community or by the society would be the carry-over of dura from the previous marketing year plus the current year's production of dura. With limited resources available for use in the storage of dura and given the technological conditions of storage, the production possibility curve AB would represent all possible alternatives open to society of consuming dura at the present or storing it into the future time period, T₁. The distance OA is greater than the distance OB by an amount equal to the quantity of dura which has physically deteriorated over the time span considered. The exact nature of the production possibility curve, however, is open to speculation. While deterioration is a function of time, whether the marginal rate of substitution between the two products should be increasing, as illustrated, or constant will depend mainly upon the length of the time interval considered.

Given society's indifference curve, IC, which shows that future and present dura substitute in consumption at a diminishing marginal rate, the optimum level of storage is indicated by the tangency point of the community indifference curve and the production possibility curve. At the point of tangency, the marginal rate of substitution of dura in T₁ for dura in T₀ in the production plane is equal to the marginal rate of substitution of dura in T₁ for dura in T₀ in the consumption plane. With a given distribution of income, the maximization of society's intertemporal
Figure I. Optimum Level of Dura Storage
welfare can be attained when a quantity of dura equal to OA', is consumed at present and a quantity equal to OB', is stored for consumption in the future.

If the time span considered in this example is sufficiently short so that the price of dura in the future can be determined by the future market, the price ratio of the two products might serve as a choice indicator reflecting society's values between present and future consumption of dura. The discounted price line ER, in Figure 1 indicates a situation where the price ratio of the two products serves as a choice indicator. In the illustration used, the point of tangency between the price ratio curve, ER, and the production possibility curve, AB, occurs at the same point as the tangency between IC and AB. However, it should be indicated that the coincidence of the two tangency points is not, of course, necessary. The price line ER may not be an accurate reflector of the values of society. It is also possible that society may "vote" differently through the two choice indicators used in the example.

While the foregoing model is useful for a broad conceptual analysis of the problem at hand, its shortcomings are obvious. In the first place, the model fails to show per unit consideration of direct storage costs. Indirect storage costs resulting from deterioration of grain over time are, however, exemplified in the model. Presumably in a static economy and under the conditions of perfect competition, storage services would be provided at a minimum cost (the lowest average total unit cost of storing a given quantity of dura) in the long run and in a volume sufficient to store the quantity OB' of dura. In the second place, the model would be unrealistic for any time period greater than
one marketing year. Finally, the model is also unsatisfactory when more than two time periods are considered.

When considering the optimum amount of dura to be stored, we can also add to our analysis the direct cost of storage by means of the following simple algebraic model. Dura should be stored when

\[ P_{xto} + M.U.C.S. < P_{xtl} \]

where \( P_{xto} \) is the per ton price of dura in the present, \( T_0 \), and \( M.U.C.S. \) is the marginal unit cost of storing a ton of dura over the relevant time period and \( P_{xtl} \) is the per ton price of dura in the future, \( T_1 \).

On the other hand, dura should not be stored into the future time period, \( T_1 \), when \( P_{xto} + M.U.C.S. > P_{xtl} \).

An equilibrium will be attained and the optimum amount of dura to be stored with the conditions

\[ P_{xto} + M.U.C.S. = P_{xtl} \]

The optimum level of storage, considering direct and indirect costs of storage, could also be indicated by simply considering the problem as a single production problem facing the society as a whole. The inputs in production would be dura, output would be dura in some future time period, \( T_1 \). If it is assumed that the two types of inputs combine in fixed proportions, the two inputs may be grouped together and treated as a single input. With these assumptions and given the production function, a marginal cost function of producing the product could be determined. Given price of dura in the future, \( T_1 \), the optimum amount of dura to be
stored would be fixed at a level of output which equates the discounted marginal cost and the discounted marginal value productivity of the input. On applying a number of different inputs in the production of several products (duka stored for various periods of time) and relaxing the assumption of fixed proportions of variable factors, the optimum level of output for each product would be at the point of equality of the discounted marginal value productivity and the discounted marginal cost for each input utilized in producing each output. This presumes, of course, that the least cost combination of inputs in being used.

The previous model is not sufficiently capable of indicating the optimum level of dura storage over relatively lengthy periods of time during which the output is subject to sharp intertemporal variations (Farrell, 30).

With the maximization of society's intertemporal welfare, in a Pareto sense, as an objective, Johnson (31, p. 156) remarked that storage (neglecting carrying costs) which stabilizes supplies is always beneficial to the society as a whole. He admits that in certain cases, such policy would reduce the consumer's surplus but such losses will be more than compensated for by gains in producer's income. The producers can potentially compensate consumers for their losses, but they do not necessarily do so.

Johnson (31, p. 156) also mentioned that the same results as in the public storage can be attained by private storage, if the latter is not monopolistically controlled, provided that the private and public marginal resource cost of storage are the same.
C. The Optimum Geographical Location of Dura Storage

In the previous sections, we have discussed the determination of the optimum amount of dura to be stored between two time periods. There remains the decision as to where to locate stocks geographically and the choice between alternative types of facilities.

The objective of this section is not to arrive at rigid models which determine empirically the optimum location of storage stocks but to develop general models which serve as a base in decision-making for administrators facing such problems and which will serve as a norm for efficiency comparisons of alternative locations of storage stocks.

According to Tolley (32, p. 530 - 531) in determining the location of grain stocks at least cost, present and future production and use of grain between localities, costs of storage, costs of transport, and the rate of interest are all interrelated. For example, if we suppose that grain is grown and consumed in two localities, and the storage of a certain stock of grain for a future time period is decided upon the problem facing us is how much of the grain shall be stored in each locality. The problem can be discussed from the point of view of only one locality, since, if the amount to be stored in one locality is determined, the amount to be stored in the other is merely the residual.

It is appropriate to mention here that linear cost functions with no fixed costs will be assumed so that no distinction is needed between average and marginal cost. Also, the latter assumption implies that no distinction is being made between short and long run costs.
If we assume that all grain is produced in one locality and consumed in another locality and transfer costs are greater than zero, the optimum location of storage stocks would be either at the production or the consumption area depending upon which area has the lowest average total costs of storage. Transfer costs include transportation costs of moving grain between localities plus costs associated with moving grain into and out of storage facilities.

We shall discuss only one case where two localities have an excess of production over use in the present year and an excess of use over production in the future year, with the combined production in the first locality for both years greater than its combined use for both years. In this case the costs of "blackhaul" of grain as well as cost of storing must be taken into consideration.

If the cost of storing in the first locality (I) is sufficiently less than that at the second locality (II), storage might take place in the first locality. We must, however, observe the condition that it must be profitable to ship the present excess of production over use in the second locality to the first and then ship it back in the following year. The cost of this operation is equal to the present transport cost between the two localities plus discounted future transport cost. It follows that for all storage to take place in the first locality, its cost of storage must be less than storage cost in the second minus the cost of shipping in both the present and future year.

Algebraically, all storage would take place at the first locality (I) when
where \( ATC_I \) is the average total unit cost of storing given quantity of grain at locality (I) over the time period considered, \( ATTC \) is the average total transfer costs of moving grain between the two localities and \( ATC_{II} \) is the average total unit cost of storing grain at locality II.

Now, the question becomes whether the first locality should transfer its export to the second locality in the present or the future year. If grain is to be transferred in the present year, we shall take into consideration undiscounted transport costs and the cost of storing in the second locality must fall below cost in the first locality by more than the difference between present and future transport costs; otherwise, export will take place in the future year.

1. **Type of facilities**

If both the unit fixed costs and the unit variable costs of storing in one type of facility are less than those of other facilities, storage will be at least cost, if such type is used exclusively. Besides, if facilities are used to capacity for the whole period of their life, the only type of facility to be used is that whose fixed cost, plus variable cost is the least. Under other conditions, it may be profitable to build both types of facilities, and the question of how much of each type to build poses itself. In this connection, the criteria provided by Tolley (32) is that if the difference in fixed costs is less than the sum of the discounted difference in variable cost over every year, a decrease in total cost will be obtained by expanding "elevator" capacity, and the
conclusion is reached that this type of capacity should at least be equal to the minimum amount of storage. If the difference in fixed costs is more than the sum of the discounted difference in variable costs, no "elevator" capacity will be built, all storage taking place in "bins". This has been discussed in greater detail by Tolley (32, p. 530 - 543).

Having discussed the economic environment for efficient use of resources in storage facilities, we shall survey in the next chapter the production and marketing prospects of the dura.
IV. THE NATURE OF DURA PROBLEM

A. Production, Present and Potential Markets in Sudan and the World

Sorghum (Arabic 'dura') has been grown in the Sudan for many years. Up to the 1939-45 war, however, no great encouragement was given to its production. Early in the war it was decided to encourage sorghum production in the Central Rainbelt Area in order to relieve food shortages and unemployment in the towns (33, p. 1). The high returns realized from this production attracted more and more investment and the area under cultivation was greatly expanded. Since then Sudan's acreage in dura reflects marked fluctuations around a moderately rising trend.

According to the Food and Agriculture Organization 1957 year book (34, p. 22) the total area in sorghum and millet in the world during 1956 season was 104.3 million hectares. Of this 81.3 million hectares were in the Far East, 1.3 million hectares in North America and 15.2 million hectares in Africa. The Sudan had an area of 1.567 million hectares, of which one million hectares were under dura, or about 1.5 percent of the world's total.

Total world's production of sorghum and millet, according to the same source, was 70.3 million metric tons, of which 51.4 million metric tons were in the Far East, 5.2 million metric tons in North America, and 9.2 million metric tons were in Africa. The Sudan had a total production of 1.332 million metric tons or about 1.85 percent of the world's total. Notice that the Sudan had a per acre yield which was higher than the world's average.
Table 1 gives a breakdown by destination of Sudanese exports of dura and dukhn during 1957/58. Only half of the 3,365 metric tons listed under "others" in the table went to Western Europe.

Table 1. Destinations of Sudan exports of dura and dukhn 1957/58

<table>
<thead>
<tr>
<th>Destination</th>
<th>Dura</th>
<th>Dukhn</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quantities in metric tons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aden</td>
<td>2,675</td>
<td>--</td>
<td>2,675</td>
</tr>
<tr>
<td>Egypt</td>
<td>16,830</td>
<td>--</td>
<td>16,830</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>5,264</td>
<td>4,115</td>
<td>9,379</td>
</tr>
<tr>
<td>Others</td>
<td>3,365</td>
<td>--</td>
<td>3,365</td>
</tr>
<tr>
<td>Total</td>
<td>29,181</td>
<td>4,115</td>
<td>32,299</td>
</tr>
</tbody>
</table>

(Source: (35, p. 4))

Data showing the destination of dura exports is not available for any subsequent years. Notice that approximately 90% of the total exports were destined for the Sudan's traditional dura market. It is not likely that a substantial change has taken place in this distribution recently but there is some evidence to suggest that exports to the non-traditional markets have increased relatively somewhat more than total exports.

Consider now the distribution of dura production in recent years. A representative year is 1963. On that year total output of dura can be split in three parts according to modes of production:

- Modern mechanized rainland production: 400,000 tons
- Irrigated production: 250,000 tons
Traditional production 650,000 tons

The output figure given for dura in the traditional sector is little more than a rough estimate. However, most of the growth in dura output is taking place in those areas which are classified as mechanized rain-land production areas for the above table. Output grew from 60,000 tons in 1954/55 to the 100,000 tons reported above for 1963 (36, p. 8).

Before considering exports it should be pointed out that the home market for dura and millet is quite large. For 1963, total consumption is estimated at 1,200,000 tons. Since production was about 1,300,000 tons, this left about 100,000 tons as surplus for export. This corresponds to the amounts exported in recent years. Consider the following table. The table also presents estimates of production and average dura prices in pounds sterling.

Table 2. Exports, production and prices over specified years

<table>
<thead>
<tr>
<th>Year</th>
<th>Exports</th>
<th>Production</th>
<th>Prices in West Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>000 tons</td>
<td>000 tons</td>
<td></td>
</tr>
<tr>
<td>1954</td>
<td>55</td>
<td>653</td>
<td>20.7</td>
</tr>
<tr>
<td>1955</td>
<td>73</td>
<td>767</td>
<td>13.6</td>
</tr>
<tr>
<td>1956</td>
<td>8</td>
<td>777</td>
<td>21.3</td>
</tr>
<tr>
<td>1957</td>
<td>13</td>
<td>1067</td>
<td>23.3</td>
</tr>
<tr>
<td>1958</td>
<td>13</td>
<td>1097</td>
<td>17.3</td>
</tr>
<tr>
<td>1959</td>
<td>12</td>
<td>1372</td>
<td>18.1</td>
</tr>
<tr>
<td>1960</td>
<td>73</td>
<td>1313</td>
<td>18.3</td>
</tr>
<tr>
<td>1961</td>
<td>70</td>
<td>1051</td>
<td>18.0</td>
</tr>
<tr>
<td>1962</td>
<td>93</td>
<td>1166</td>
<td>13.6</td>
</tr>
<tr>
<td>1963</td>
<td>76</td>
<td>1285</td>
<td>18.1</td>
</tr>
</tbody>
</table>

aSources: (35, p. 4); (37, p. 293); (33, p. 17)
Several factors influence the level of durum exports. For some of the factors data are not available. The model presented below was conditioned by a knowledge of economic relationships on the one hand and the availability of data on the other. Write

\[ Y_t = a + b_1 X_{1t} + b_2 X_{2t} + b_3 X_{3t} + e_t \]

where

\[ Y = \text{durum exports} \]
\[ X_1 = \text{durum production} \]
\[ X_2 = \text{durum prices in Western Europe} \]
\[ X_3 = \text{trend} \]
\[ e = \text{a random term} \]

Let the subscript \( t \) apply to time and assume that \( y \) is a linear function of the variables \( X_1, X_2 \) and \( X_3 \) to allow the use of least squares in estimating the values of the \( b \)'s.

The results of regression analysis on the model presented above are reported below where the top figure is the estimate of \( b \) and the lower figure the \( t \) value:

<table>
<thead>
<tr>
<th>( b_1 )</th>
<th>( b_2 )</th>
<th>( b_3 )</th>
<th>( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.52</td>
<td>-9.99</td>
<td>1.62</td>
<td>.58</td>
</tr>
<tr>
<td>1.57</td>
<td>1.23</td>
<td>2.06</td>
<td></td>
</tr>
</tbody>
</table>

Some of the outcomes are curious. A consideration of the circumstances under which durum is sold will partially explain the apparent anomalies.
First, it must be remembered that a high proportion of the exports are destined for Sudan's traditional markets in Egypt, Ethiopia, Aden and Saudi Arabia with only a small portion sent to West European markets (see Table 1). The terms of the agreements reached for the 'traditional' portion of the two exports are significantly influenced by non-price considerations.

Consider now the negative relation between exports and production as evidenced by the estimate of $b_1$. Notice that a high proportion of the exports of the Sudan are destined for Egypt and Ethiopia. Given the proximity of these two countries to Sudan it does seem likely that relative levels of production will move in the same direction within the three as a consequent of weather systems dominant over the entire area. Then, high production in Sudan is accompanied by high production in Ethiopia and Egypt. If so, then the need for imports in the latter will be negatively related to production in the former.

The relation between price and exports is less clear. These prices, of course, are West European prices and hence relevant to only a small portion of the exports during this period. Still one might expect exports to increase as prices increase with other things equal. Lines of reasoning explored to explain this relationship have not been fruitful. It might be the case that the prices used are not appropriate. That is, the exports of a particular year, e.g. 1955, were assumed to be influenced by the prices of the same year, 1955. Perhaps it is actually the case that prices in 1955 influence exports in 1956. This might be especially true if a significant part of the exports to West Europe were arranged on a contractual basis. Notice, too, that the estimate of $b_2$ is not signifi-
cantly different from zero at the .70 level.

Finally the relation between $x_3$, trend, and exports can be explained in terms of the growing populations in the traditional markets. This growth occurs over time, and puts an ever increasing pressure on domestic food supplies, and hence leads to an ever increasing need for imports. It should be noted here than an implicit assumption in this formulation is that the Sudan was not a food deficit country during the period considered.

One feature of the relationship should be noted before moving on to an alternative model. This is the high simple correlation between $x_1$ and $x_3$, production and trend. Such an outcome, of course, casts some suspicion on the estimates of the accompanying b values.

The other model considered duplicates the first except for production. In this model it was assumed that production in year 't' influences exports in year 't + 1'. The model then is

$$y_t = a^1 + b^1_1x_{1t-1} + b^1_2x_{2t} + b^1_3x_{3t} + e_t$$

Regression analysis of this model yielded outcomes essentially like those of the first in the sense that the signs on the estimated b values were the same. The $R^2 = .35$ was smaller and no estimates of the b values were significantly different from zero at the .05 level. In fact the largest T value of this model, 1.04, is smaller than the smallest T value of the other, 1.23.

It is obvious that many other factors influence dura exports. It is hoped that subsequent work on this topic can consider a wider range of
variables as more and more data become available.

It is worthwhile at this point to re-examine the figures for production in Table 2. It is obvious that there is a considerable expansion in dura output due to the rapid increase in area under dura over the whole country. During the years 1962 and 1963 output has declined from 1,436,000 tons to 1,245,000 tons. A possible explanation for this sharp decline is that the acreage under cultivation in the mechanized rainlands is responsive to the relative domestic price of dura which was low during the period when 1963 production decisions were being made.

Another possibility which must be considered is that the 1962 figure is overstated. Notice that production has apparently increased by nearly 40% from 1961 to 1962. It does not seem likely that such an increase would take place in one year. Were this figure lower than the 1961-63 trend might be ever increasing. It should be observed here that the fluctuations in production over the 10 year period covered by Table 2 are such as to be suspicious. It might, for example, be the case that a new estimator was employed for the first time in 1957, leading to an apparent production increase of nearly 40% over 1956, without accompanying adjustments in the estimates of previous years. It is, of course, acknowledged that one of the assumptions made in employing least squares - given a desire for unbiased estimates of the coefficients - is that the independent variables of the model are estimated without error. To then comment on the high probability of such error is to imply the absence of unbiasedness in the estimates of the coefficients.

The next question to be tackled is the evaluation of world's exports and imports of dura. Consider Table 3.
Table 3. World exports and imports of millet sorghum and other cereals, in 1,000 metric tons

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Europe:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>100</td>
<td>60</td>
<td>2,915</td>
<td>2,250</td>
<td>1,970</td>
<td>Net importer</td>
</tr>
<tr>
<td>Belgium-Luxembourg</td>
<td>4.2</td>
<td>33.8</td>
<td>10.9</td>
<td>633.1</td>
<td>1,659</td>
<td>1,000.0</td>
<td>Net importer</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.2</td>
<td>0.2</td>
<td>0.3</td>
<td>269.9</td>
<td>226.5</td>
<td>112.6</td>
<td>Net importer</td>
</tr>
<tr>
<td>W. Germany</td>
<td>1.5</td>
<td>7.5</td>
<td>15.2</td>
<td>106.9</td>
<td>206.2</td>
<td>222.3</td>
<td>Net importer</td>
</tr>
<tr>
<td>Netherlands</td>
<td>13.9</td>
<td>14.3</td>
<td>17.1</td>
<td>671.0</td>
<td>711.9</td>
<td>726.7</td>
<td>Net importer</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>5.4</td>
<td>6.2</td>
<td>5.0</td>
<td>575.7</td>
<td>1,234.4</td>
<td>279.9</td>
<td>Net importer</td>
</tr>
<tr>
<td>North and Central America:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2,190</td>
<td>3,020</td>
<td>2,530</td>
<td>60</td>
<td>180</td>
<td>140</td>
<td>Net exporter</td>
</tr>
<tr>
<td>United States</td>
<td>2,179.3</td>
<td>3,018</td>
<td>2,520.9</td>
<td>9.9</td>
<td>11.7</td>
<td></td>
<td>Net exporter</td>
</tr>
<tr>
<td>Asia:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>50</td>
<td>50</td>
<td>520</td>
<td>930</td>
<td>1,570</td>
<td>Net importer</td>
</tr>
<tr>
<td>Near East Asia</td>
<td>20</td>
<td>50</td>
<td>50</td>
<td>220</td>
<td>170</td>
<td>210</td>
<td>Net importer</td>
</tr>
<tr>
<td>Far East Asia</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>300</td>
<td>766</td>
<td>1,360</td>
<td>Net importer</td>
</tr>
</tbody>
</table>

*Source: (39, p. 22)*
<table>
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<tr>
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<tbody>
<tr>
<td><strong>Africa:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>280</td>
<td>110</td>
<td>220</td>
<td>100</td>
<td>50</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Tanganyka</td>
<td>1.4</td>
<td>--</td>
<td>0.8</td>
<td>1.2</td>
<td>0.8</td>
<td>1.7</td>
<td>Net exporter</td>
</tr>
<tr>
<td>Egypt</td>
<td>--</td>
<td>0.5</td>
<td>0.9</td>
<td>9.7</td>
<td>6.7</td>
<td>1h.h</td>
<td></td>
</tr>
<tr>
<td>Morocco</td>
<td>25.9</td>
<td>0.5</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Sudan</td>
<td>37.7</td>
<td>7h.h</td>
<td>7h.h</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Union of South Africa</td>
<td>151.8</td>
<td>16.5</td>
<td>--</td>
<td>0.1</td>
<td>--</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td><strong>Oceana:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>39.3</td>
<td>54.3</td>
<td>8.2</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>Net exporter</td>
</tr>
</tbody>
</table>

Table 3 (Continued)
Table 3 is a broad balance sheet of the world's exports and imports of this group of grains. From it we can see that the major importer is Western Europe. Though the Far East is the largest producer, it is a net importer because its consumption is greater than its production. The net exporting regions are the United States of America, Canada, Africa, and Australia, among which the most important exporter is the United States.

The main supplies of Western Europe in order of importance come from the United States, the Union of South Africa, and Australia. The latter two countries are the major exporters to the United Kingdom which, to that extent, draws less on the United States than do the Netherlands and Belgium-Luxembourg.

Table 4. Sorghum and millet to Europe by specified exporting countries 
July, 1958 through June, 1959

<table>
<thead>
<tr>
<th>Main source</th>
<th>Main destination</th>
<th>Total four countries</th>
<th>Australia</th>
<th>Syria</th>
<th>Sudan</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe:</td>
<td>Belgium-Luxembourg</td>
<td>176.3</td>
<td>1.5</td>
<td>2.3</td>
<td>1.7</td>
<td>167.3</td>
</tr>
<tr>
<td></td>
<td>Denmark</td>
<td>226.4</td>
<td>0.3</td>
<td>--</td>
<td>--</td>
<td>226.1</td>
</tr>
<tr>
<td></td>
<td>W. Germany</td>
<td>157.3</td>
<td>0.3</td>
<td>--</td>
<td>0.1</td>
<td>156.4</td>
</tr>
<tr>
<td></td>
<td>Netherlands</td>
<td>164.7</td>
<td>1.1</td>
<td>--</td>
<td>0.2</td>
<td>163.4</td>
</tr>
<tr>
<td></td>
<td>United Kingdom</td>
<td>538.2</td>
<td>73.2</td>
<td>--</td>
<td>--</td>
<td>165.0</td>
</tr>
</tbody>
</table>

*Source: *1950, p. 35)

Table 4 reflects export-import trends. Now let us consider the trend in world total imports and West European imports of sorghum and millet.
Table 5. Trend in European as compared with world imports of group sorghums and millets, in 1,000 metric tons

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>World total</td>
<td>1,420</td>
<td>2,900</td>
<td>3,400</td>
<td>2,720</td>
<td>3,220</td>
<td>3,790</td>
<td>3,740</td>
</tr>
<tr>
<td>Europe total</td>
<td>1,170</td>
<td>2,360</td>
<td>2,790</td>
<td>2,015</td>
<td>2,510</td>
<td>2,250</td>
<td>1,970</td>
</tr>
<tr>
<td>Importers other than Europe</td>
<td>230</td>
<td>540</td>
<td>610</td>
<td>705</td>
<td>710</td>
<td>1,540</td>
<td>1,770</td>
</tr>
</tbody>
</table>

Source: (39, p. 22)
From Table 5 we can trace a sharp rise in world imports of sorghums and millets. The imports of Western Europe have risen from 1,170,000 tons in 1957/58 to 1,970,000 tons in 1963/64 after a peak of 2,790,000 in 1959/60. In the same time imports by other parts of the world have risen from 290,000 tons in 1957/58 to 1,777,000 tons in 1963/64. Obviously then, the European market for these items has been growing rapidly. It is reasonable to predict that the demand for this type of cereal will continue to increase in Western Europe because it is increasingly being used as feed to meet the expanding demand for livestock products which is accompanying the fast-rising standards of living.

B. World Prices and Cost of Production of Dura in the Central Rainbelt

The next important question is whether our production costs compare favorably with world prices, particularly those prevailing in Western Europe. For this problem we shall consider the supply price of the United States in Western Europe and compare them with the Sudan’s prices as illustrated by Tables 6 to 9. Our purpose here is to give some attention to the possibility of expanding exports to Western Europe. The expanding demand there coupled with expanding production in the Sudan suggests that exports to Western Europe should be considered as a potential source of the foreign exchange.

Table 6 shows the price of dura in Western Europe and our supply price at Port Sudan or the demand price of our traditional customers. During the period covered, 1955 to 1962, the West European price ex-
Table 6. Prices of dura in European ports and Port Sudan, in Sudanese pounds per metric ton\(^{a}\)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prices in European ports</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21.4</td>
<td>23.7</td>
<td>17.3</td>
<td>17.6</td>
<td>18.5</td>
<td>17.5</td>
<td>18.1</td>
<td>17.9</td>
</tr>
<tr>
<td><strong>Prices in Port Sudan</strong></td>
<td>19.1</td>
<td>19.7</td>
<td>20.3</td>
<td>22.8</td>
<td>22.8</td>
<td>16.4</td>
<td>20.03</td>
<td>22.7</td>
</tr>
</tbody>
</table>

\(^{a}\)Sources: (37, p. 298), (41, p. 32), (42, p. 117), (43).

Note: one pound sterling = 0.975 Sudanese pound
ceeded the Port Sudan price in three of the eight years. In 1960 the excess was so small that it is quite likely that shipping costs would more than exhaust the difference. In short, then, in only two of the eight years between 1955 - 1962 was the European price sufficiently above the Port Sudan price to encourage exports to move into the European market.

Among the factors influencing Sudan's ability to compete in the West European market one of the most critical is the cost of production. Little data on such costs are available and virtually all of it relates to the rainfed belt in Sudan. In 1957/58 Ahmed Abdalla (11) made some case studies on mechanical crop production schemes at Dali which we reproduce in Table 7, and in Table 3 we reproduce some cost accounts reported by the Senior Inspector of Agriculture, M.C.F.S. Cedaref in 1955/56.

Calculation of the average cost for the entire production requires, of course, substantially more data than are available. In point of fact, the quantities produced with the several methods of production are but rough estimates. At this time analysis must be confined to the few observations at hand and any conclusions drawn must necessarily be quite tentative.

Table 7. Cost of cotton production at Dali in Ls. per metric ton, including sacks and other handling charges delivered at the railway station*  

<table>
<thead>
<tr>
<th>Farm area</th>
<th>Station of delivery</th>
<th>Cost per metric ton in Ls.</th>
</tr>
</thead>
<tbody>
<tr>
<td>750 feds.</td>
<td>Singa</td>
<td>Ls. 8.065 m/ms.</td>
</tr>
<tr>
<td>700 feds.</td>
<td>Singa</td>
<td>Ls. 7.253 m/ms.</td>
</tr>
<tr>
<td>1100 feds.</td>
<td>Renk</td>
<td>Ls. 9.159 m/ms.</td>
</tr>
</tbody>
</table>

*Source: (11, p. 5)
Table 3. Extract from cost accounts of operations on pilot farms at N.C.F.S. Gedaref

<table>
<thead>
<tr>
<th>Tractor used</th>
<th>Massey Harris</th>
<th>Fordson Major</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place</td>
<td>Camp. 3</td>
<td>Sugura</td>
</tr>
<tr>
<td>Output in metric tons</td>
<td>695.2 kT</td>
<td>393.7 kT</td>
</tr>
<tr>
<td>Total expenses including depreciation and 3 percent interest on capital in Ls. m/ms.</td>
<td>3,610.522</td>
<td>3,226.218</td>
</tr>
<tr>
<td>Cost in Ls. m/ms. metric tons</td>
<td>5.193</td>
<td>8.195</td>
</tr>
</tbody>
</table>

*Source: (k5, p. 4)*

The following figures are based on the data appearing in Tables 7 and 3. Notice that the first entry in each column of Table 9 includes cost of delivery (35, p. 8). This entry, taken together with data in Tables 7 and 3, implies a delivery charge of 2.6 Ls. from N.C.F.S. Gedaref to the station and of 3 Ls. from Dali to Dali-Singa station. Relative distances suggest that transportation charges relevant to the latter should be less than for the former.

We may reasonably take the sum of Ls. 12,000 per ton of dura as an operative figure for delivering dura at Port Sudan. To this we have to add the cost of freight and insurance to NorthWestern Europe. The freight rate of the transport of dura to any Northwestern European port (as given by Cellately Company, a shipping agency) is 45 shillings and the insurance is about 5 shillings per ton. Thus, the cost of delivery of dura C. I. F. Northwestern Europe per ton comes to Ls. 15,000 per
Table 9. Cost of dura delivered at Port Sudan from the Rainlands

<table>
<thead>
<tr>
<th></th>
<th>At Dali-Singa station</th>
<th>At Gedaref-Gedaref station</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Cost of production and delivery to the stations, say</td>
<td>3,000</td>
<td>9,500</td>
</tr>
<tr>
<td>(ii) Railway freight to Port Sudan</td>
<td>2,100</td>
<td>1,800</td>
</tr>
<tr>
<td>(iii) Add 10 percent of (i) for profits and other charges, e.g. storage</td>
<td>1,300</td>
<td>1,950</td>
</tr>
<tr>
<td>Total cost to Port Sudan</td>
<td>10,900</td>
<td>12,250</td>
</tr>
</tbody>
</table>

metric ton. If we assume prices of inputs remained the same, then the figures give a high margin of profits. Comparing this value with the prices in Europe quoted in Table 6, we can reach the conclusion that we can produce and deliver dura to Northwestern Europe at prices which compare favorably with even the lowest prices quoted in this study. It should be pointed out here that the prices quoted for Port Sudan reflect at least two additional considerations. The first is that these prices apply to grain which is, for the most part, destined for the traditional market. The other is that a substantial part of the grain was grown under conditions which might have higher costs than those given in Tables 7 and 8.

Finally, we should be aware that any complete study of the economics of dura production must also consider other agricultural products (e.g. oil and seeds). It is not the absolute level of returns, but the level
of returns relative to the returns received by other products that is relevant. Dura must compete with other products for resources such as land and capital and this implies the need for the study of the net returns of each product to determine which product or combination of products should be produced and what quantity of each.

Briefly, we have examined the market for dura, dura production, and the cost of production. On the basis of the limited information available it appears that increased dura trade with Western Europe would be profitable in an absolute sense. Before making policy recommendations, however, costs of production and prices for alternative activities must be considered.
V. SOME PUBLIC MEASURES FOR INCREASING OUTPUT AND REDUCING WASTE

To reduce the fluctuations in the level of output, the size of the marketable surplus, and the export proceeds, the public sector could supplement the efforts of the private sector by creating conditions conducive to more investment in agriculture and less uncertainty. Several measures could be followed depending on their feasibility under the different circumstances. Here we shall consider the increase of output and decrease of waste through (a) price policies, (b) certainty, and (c) storage.

A. Price Policies

"Agricultural production suffers from a good deal of natural instability due to weather, pests, and plant diseases. As if it were not enough to relieve the monotony of rural life, the notorious cyclical variations in export proceeds are superimposed on the random changes in output. If movements in the supply side were the dominant factor in the export trade of primary producing countries, these export prices and quantities would tend to fluctuate inversely. Actually prices and quantities accentuate, instead of mutually offsetting each other in their effect on the export proceeds of primary producing countries."

Markse (b6, p. 181)

1. Buffer funds

A well-known device is based on taxing exports of primary commodities in good times and subsidizing them in bad times. The purpose of such a policy is not the reduction of the variations in world market prices, but to soften their impact on the domestic economy by steadying the dis-
possible income realized by primary producers. According to Mokse (146), this would be done in one of three ways: (a) A central marketing agency can be established which guarantees a certain price to domestic producers and sells the products abroad at whatever price they may bring in the export market. The domestic price paid to producers could conceivably be fixed in such a way that the scheme would amount to a tax in good and a subsidy in bad years. (b) A scheme of essentially the same kind may operate expressly in the form of variable export taxes and export subsidies. (c) An exchange control agency can do the same thing by lowering and raising the official buying rates at which it takes over the foreign exchange proceeds of exporters. If its selling rates of foreign exchange remain constant, the agency can operate so as to make a profit in periods of high export prices abroad and a loss at other times (146, p. 146).

The first method is exemplified by the West African Market Boards for cocoa, groundnuts, palm oil, etc. The second method has been employed by various countries in South-East Asia in recent years. The third method, which depends on the manipulation of the exchange rate, is a familiar practice in Latin America. All three methods tend to sever the connection between fluctuations in external prices and export proceeds, on the one hand, and the net prices and incomes received by producers on the other hand. They provide a mechanism that can be used for cyclical stabilization purposes in primary producing countries. Each can be operated in such a way that a "buffer fund" of foreign exchange is accumulated when export proceeds are high and is drawn upon when export
prices are low.

Morkset, (46), in stating the above idea, mentioned that just as commodity inventories and cash holdings are to some extent alternative means of coping with uncertainty and instability in the business world, so buffer stocks and buffer funds are alternative methods of stabilization policy for less-developed countries. He goes on to say, "Nevertheless, the whole principle of variable taxation and subsidization, whatever administrative form it may take, is open to objections" (46, p. 43).

If export supply is completely inelastic then the above policy will have at least no bad effect. If supply is "perversely" elastic then it will be advisable in boom periods to tax exports so heavily as to cut down the net price received by the farmers, and in slumps to subsidize them so as to increase it.

There is evidence that the supply of primary products is generally, though perhaps not invariably, elastic with respect to price. In this case, the policy under discussion, by stabilizing the prices received by producers, interferes with the incentive to produce more when export prices are high, and serves perversely to keep up production for export when export prices are low. Evidently, this is not a pattern that maximizes export proceeds over the business cycle or that helps to stabilize the international markets for primary commodities.

It should be emphasized that the desire to stabilize incomes of particular groups is basically inconsistent with an awareness of the resource-allocating functions of the price mechanism. Messrs. Bauer and Paish, for example, say that the various methods of general taxation used
for cyclical stabilization "... are not neutral in their effects on the allocation of resources between different activities and the commodities" (L7, p. 176). Nurkse argues that the notion of income stabilization makes sense only when applied to the disposable national income.

"Variation of prices within a stable aggregate framework thus serves to maximize the real national income by creating the right incentives for expanding, and contracting the supply of staple products for export at the 'right' times in the course of the external trade cycle" (L7, p. 216).

He accepts the practicability of "buffer funds" but he warns against undue reliance on the particular method of constituting buffer funds which operate through variation in export taxes rather than through the variation of taxation in general. He agrees that export taxation is easier than fiscal policy as a policy instrument, but it is not the ideal (L7).

The general fiscal policy advocated by Nurkse aims at stabilizing disposable national income, and hence national expenditure, while leaving the domestic prices of export producers considerable freedom to vary in response to external market forces. In addition, he stated that (a) some substitution is generally possible between production for export and production for local consumption and (b) it is possible to seek stability in disposable income in the face of export fluctuations by enforcing inverse fluctuations in domestic investment. The cyclical behavior of the foreign balance would then be matched by a counter-cyclical pattern of home investment (L7, p. 253).
B. Uncertainty

In recent years there has been considerable discussion on the subject of variability in commodity markets and their impact in countries producing primary products. Among these countries, particularly those striving toward economic growth, some are disturbed by the yearly market fluctuations in the prices of food grains and have shown concern with the instability of their export proceeds. The fluctuations in proceeds have affected adversely the pace of growth and hindered smooth development. The uncertainties to which the producers in these countries are exposed are largely responsible for the fluctuations in the marketable surplus from the supply point of view, and consequently cause the undesirable variability of foreign exchange earnings.

In a dynamic economy, production over time takes place under conditions the course of which cannot be predicted with accuracy due to several types of uncertainties. In our case, decisions of entrepreneurs are affected by the degree of uncertainty attached to the production and prices of dura over time. The higher the degree of uncertainty, the shorter the economic horizon of the entrepreneur. The term "economic horizon" here refers to the length of time over which the individual plans economic activity.

There are several types of uncertainty to which producers are exposed. In some cases the degree of uncertainty can be reduced through actions of decision makers. Before commenting on this point, it will be useful to identify some of the more important sources of uncertainty.
1. General types of uncertainty

Haydy (48) lists the types of uncertainties facing the producer when he plans a course of action, as follows:

a. **Price uncertainty**  This does not only refer to the price of the product but also to factor prices. The individual farmer, as the entrepreneur of a competitive firm, has no control over prices. As an exogenous variable, price instability or unpredictability is never quite as great in other industries as in farming. Price variability and uncertainty arise in agriculture particularly from (a) the fluctuations in material income and prosperity, (b) the recurring commodity cycles for farm products generated by discontinuous production cycles, e.g. the hog cycle, and so forth, and (c) random disturbances growing out of weather fluctuations.

b. **Technical or yield uncertainty**  Technical uncertainty denotes variation in the production coefficients for a given technique. This type of uncertainty is absent in some non-agricultural industries but is almost universally present in the various lines of agricultural production. The decision maker, when formulating production plans for use of resources, is faced with uncertain yields and uncertain prices.

c. **Technological uncertainty**  Technological change leads to variability which gives rise to uncertainty in both agricultural and non-agricultural industries. This is reflected through price uncertainties: the development of, or reduced costs of production for, an entirely separate but rival commodity which might affect the product under consideration.
d. Sociological and legal framework  Farm firms face the problem of land tenure, purchase contracts, and related types of uncertainty. Government programs might also contribute to uncertainty and lack of predictability.

The costs of the above four types of uncertainty to society may be reflected in a smaller output from some fixed inputs, or conversely may be reflected in higher cost of producing a given amount of output as compared to production under conditions of certainty. As such, uncertainty implies a cost to society wherever production is planned under inaccurate expectations. The reduction of uncertainty lengthens the economic horizon of producers and leads towards more efficient utilization of resources.

C. Storage Facilities

A way to reduce price fluctuations and the accompanying price uncertainty is through storage facilities.

In the past, producers in the Sudan resorted to three methods for the storage of their crops, namely: pits, pavements, and elevated sheds. The three methods did not prove to be completely successful. On the contrary, some of them have proven to be complete failures. Pits appear to be better than the other two methods, but still they did not protect crops stored in them for a long period against pests and humidity. An experimental survey showed that the damage undergone by crops stored in pits ranged from 98 per cent to 1.5 per cent in the best cases (49, p.
The local peasant cultivators usually store the grain in round pits (matura) which vary in capacity from 2 cwt. sacks to over 200 sacks. (A ton of grain has a capacity of 1. hm^3.) When possible, these pits are dug in hard, non-cracking, sandy clay soil (gardud) and are not lined. In the cracking clay (badob) soil, such as the soil ordinarily associated with the crop production schemes, the storing of grain in pits is much more risky, and grain is seldom held for more than a year. The chance of water entering the pit through a crack is high, and a watch must be kept for possible cracks during the rains. To reduce this chance, the pits are lined with a mud and grass plaster (33, p. 18).

Private entrepreneurs in the Sudan use the three methods mentioned before at the points of production and others maintain some stores at different towns for storing dura and other grains. Storage facilities require relatively high investments in fixed assets. If producers have high risk aversion and attach great uncertainty to future outcomes, they add new storage facilities with caution. This will be reflected in a shortage of storage services throughout the dura marketing system when the demand for these services is high.

The insufficiency of storage facilities leaves the government with several alternatives. It can build new facilities of its own, provide incentives to entrepreneurs to encourage the expansion of private storage facilities or employ both of these alternatives. For example, private storage facilities can be encouraged by special low taxes for new facilities. It must be remembered, however, that for optimal allocation
of resources, both public and private facilities should be built up to the point where the expected marginal social cost is equal to the expected marginal social gain.

Relatively little research has been conducted in the Sudan pertaining to the cost of storage of dura with the objective of planning storage facilities. Factual data pertinent to decision-making is lacking. The demand for dura storage services is essentially a derived demand in that the demand for those services is dependent on the demand for dura, except for governmental policy. The storage services for dura will be in demand only when the anticipated value of stored products is greater than the present value of the dura by an amount greater than the cost of storing over the relevant time period. It is important that the government should know the storage cost-output relationship to establish storage rates that attract just the right amount of services. To obtain satisfactory estimates of storage costs, information on the deterioration and shrinkage in reserve stocks of dura while in storage is extremely important.

1. **Effect of silos**

The nature of the prevailing storage facilities is not compatible with low production cost which is a prerequisite for competing as exporters in the international market. They necessitated certain additional expenses such as jute sacks used for packing food grains. Deterioration can be reduced and consignment loaded in bulk rather than in sacks, if silos facilities are provided.
Silos facilitate the storage of surplus crops so as to meet periods of drought and poor production. Besides, they help to stabilise prices and spread the supply of food grains smoothly throughout the year, thus lessening the price fluctuations which are being experienced in the country at the beginning of every season when there is a heavy influx of food grains and at the end when there is relative scarcity and consequently balance the supply side of the market with the demand. Storage of food grains will enable the dealers to benefit from credit facilities afforded by institutions such as The Agricultural Bank on the security of crops they keep in store. The seasonal pressure on the railways will also be reduced. Another obvious benefit is that the Sudan might be able to take advantage of yearly price changes in the international market. This would be quite advantageous from the standpoint of acquiring foreign exchange.

One of the prerequisites of the construction of silos is the use of special railway wagons designed to "suck" grains. As a result the cost of handling food grains from the farm to the train and from the train to the quays and the labor engaged in the carriage of grains from the train to the ship, will be saved. It should be noted in passing that Sudan does not have the excess labor which characterizes some underdeveloped economies.

Finally, to evaluate the benefits that will accrue to the economy through the construction of modern storage facilities which will lower the cost of marketing and reduce deterioration of grain, we shall compare the costs of storage in the two new elevators at Cedarsf and Port Sudan with the traditional means of storage.
1. Gedaref Elevator

In view of the arrivals during the limited harvest period of three or four months and consideration of the practical railway abilities, it was decided to make the elevator at Gedaref of a capacity of 100,000 tons.

The estimated cost of construction of the Gedaref elevator is about Ls. 1,700,000. The running cost is estimated at approximately Ls. 129,000 per annum. If we add to this interest on, and depreciation of capital, the annual expenses would amount to Ls. 328,900. When we consider that only 200,000 tons of dura would be handled by the elevator, the cost per ton would be:

\[
\frac{328,900}{200,000} = 1.645
\]

The present cost of handling a ton of dura from Gedaref market to the railway wagons is Ls. 2.070. If the grain is stored for one month, handling and storage expenses would raise the figure by Ls. 0.030, thus making a total of Ls. 2.100. For every additional month of storage, a charge of Ls. 0.010 may be added to the cost with a possible increase for a possible deterioration.

The direct minimum savings that would result from the Gedaref Elevator are expected to be about Ls. 2.100 - 1.645 = Ls. 0.756, i.e., Ls. 0.756 per ton (35).
2. **Port Sudan elevator**

On considering movement of grain from Gedaref and other minor areas to Port Sudan, it is found that Port Sudan elevator should have a capacity of 50,000 ton.

The total cost of the elevator is estimated at Ls. 900,000. The annual running cost (including interest and redemption of capital) is estimated at Ls. 227,000.

The cost per ton of dura is thus

\[
\frac{227,000}{200,000} = 1.135
\]

The present expenses at Port Sudan amount to 0.900 per ton. The handling cost of the elevator would be Ls. 0.235 more than the present rate. However, for some time in the future Port Sudan elevator may also handle our imports of wheat (now 100,000 tons). Nevertheless, when taking the two schemes as one unit, net savings will be about Ls. 0.521. The two elevators will make it technically possible to use adjusted wagons which will be tied up to the Gedaref-Port Sudan railway line (35).

The net direct savings when taking the two elevators as one economic unit will approximately amount to Ls. 0.521 per ton; i.e., Ls. 104,200 in a marketable surplus of 200,000 tons.

The above is however based on the following assumption:

(a) All the exportable surplus of about 200,000 tons would be marketable abroad.

(b) That the railway freight rate would remain the same for both grain handled in bulk and sacks.
Besides the savings realized there are other important advantages that will result from the construction of the two elevators:

Firstly, elimination of damage due to pests and/or climatic conditions valued at Ls. 75,000 (equivalent to 3 per cent of the average susceptible to damage of 100,000 tons at Ls. 15 per ton).

Secondly, the laboratory attached to the elevator would analyze incoming and outgoing grain and formulate standards. Such standardization may assure buyers of better quality and may stimulate exports.

Thirdly, the "receipts" issued by the elevator to the producer gives the weight, the analyzed characteristics of the grain as regards moisture contents, protein and starch percentage, etc. Thus the elevator management guarantees not only the crop is safely stored but also guarantees the quality. The receipt may be cashed or discounted like other securities.

Finally, the seasonal pressure on the railways will be reduced.
VI. SUMMARY AND CONCLUSIONS

The yearly fluctuations in income from exports of most newly developing countries producing primary products has brought considerable discussion on the subject. Stabilization and augmentation of the marketable surplus of different products becomes a popular objective. The foreign exchange for mechanization can be met through the proceeds from agricultural marketable surplus.

This gave rise to the question of the nature of the farmers' response in less-developed countries to price, as we have seen in Chapter II. Some writers maintain that farmers in these countries respond very little, or not at all, or respond perversely, to price changes. Others maintain that the response is positive. The factors that determine the size of the marketable surplus include the level of output and intensity of production, farmer's income, the relative importance of a cash crop in a particular region, the family size and composition, cash requirement, consumption habits, size of holding, and price level.

In the Sudan, the period 1956 - 63 witnessed sizeable expansion in area and output of sorghum (Arabic dura) which provides the staple food for the majority of the Sudanese. The surplus which is marketed abroad was subjected to disturbing fluctuations. High cost of both production and distribution adversely affect our competitive position in external markets.

Marketing costs may be reduced through the provision of modern
storage facilities. Due to lack of storage facilities, the dura is exposed to deterioration of quality. The action of pests and climatic conditions leads to a reduction in national wealth. The construction of elevators when economically feasible for both bulk handling and scientific storage are recommendable urgent measures for improving our competitive position. The construction of the two elevators at Gedaref and Port Sudan is expected to result in a reduction of marketing costs by at least Ls. 0.521 per ton. As a result, the provision of some more modern storage facilities is considered.

But resource use in the storage of dura gives rise to two major questions: (a) What is the optimum interseasonal level of dura storage stocks? (b) What is the optimum intertemporal location of grain storage stocks? These problems have recently become of increasing importance because of the increase in dura output.

The analysis in this study involved first pointing out the aggregative aspects of allocative efficiency in the use of resources in dura's storage; and second, the formulation of an economic framework within which the problems associated with resource-use in the storage of dura could be evaluated. At a least cost equilibrium the marginal cost of each input used in storing dura would be equal to the marginal value product of the stored product in each storage plant and between each of the alternative storage plants. The determination of the optimum location of dura storage stocks involves consideration of the present and future production and use of dura between localities, costs of storage, transfer costs, and the rate of interest.

The criteria suggested in this study provides a general norm for
testing the feasibility of dura storage.

Given the conditions under which storage costs will be minimized, we have a means for gauging the efficiency of decisions made by the market. The study thus provides a basis for evaluating and improving performance in storage.

The material in Chapter IV shows the Sudan and the United States as net exporters of dura. The Sudan stands a good change of selling in the Western European Markets if the cost of production and distribution is lowered by a small margin. The fluctuations in exports can be explained in terms of supply and demand conditions. From the supply side the highly arbitrary policies of determining the food reserve, which is not based on accurate estimates, is partly responsible for the fluctuations. On the other hand, the demand conditions are also partly responsible for these fluctuations. The exceptionally low prices in 1957 - 58 were highly responsible for the low exports in that particular period. The fluctuations in the domestic output of the countries which compose our traditional market is also reflected in their demand of Sudanese dura.

A linear model in which dura exports are a function of production, average yearly prices at West European markets, and a trend variable was tested with data from the period 1953 to 1963. The results of the analysis are essentially inconclusive but do suggest strongly that the exports are not a positive function of production. It is likely that this situation would change if the Sudan were to enter the West European market in a significant way.

Export taxation and subsidies can be employed by the government to stabilize and augment the marketable surplus of agricultural products.
Nurkse (47, p. 257) thinks that this will interfere with the optimum allocation of resources among different uses. He advocates as an alternative the use of general fiscal policy.

Construction of storage facilities and the reduction of the different types of uncertainty which faces the producer, may contribute appreciably towards the reduction of the production and distribution costs. Investment in human capital, improvement of communication, promotion of cooperatives, creation of farm credit institutions, reduction of transport costs, generalizing pilot projects over the whole country and making available extension services are also other means that can be employed for the same end.

Finally, this initial and exploratory study shows the importance of finding the nature of the response of the farmers, in the different parts of the country and in both the modern and traditional sectors, to price. This will help the policy makers to evaluate the effect of price changes on yield and when to use price as a policy instrument.
VII. LITERATURE CITED


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44. Osman, Ahmed Abdalla. Results of four case studies at Singa-Dali; mechanized crop production schemes. Mimeoographed. Khartoum, Sudan, Agricultural Economic Division, Department of Agriculture. ca. 1953.
VIII. ACKNOWLEDGMENTS

I wish to express my appreciation to my major professor Dr. Winkelmann for his encouragement and guidance during my graduate study and the preparation of this thesis.

Sincere gratitude is expressed to Dr. Beneke and Dr. Doerflinger who obligingly accepted to be members of my graduate committee.

I am also immensely indebted to Mr. Ahmed Abdalla Osman who provided me with the major part of the data employed in this study.

I should express my gratitude to my parents and family and Mrs. Norma Selland for their constant encouragement.

Finally, appreciation is also due to the authorities of the Ministry of Finance and Economics for providing me the opportunity of graduate study at I. S. U.
IX. APPENDIX
Table 10. Gross domestic product in million Sudanese pounds

<table>
<thead>
<tr>
<th>Year</th>
<th>Traditional sector</th>
<th>Modern sector</th>
<th>Total</th>
<th>Modern as of total</th>
<th>Population in millions</th>
<th>Per capita in pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1956</td>
<td>160.3</td>
<td>123.9</td>
<td>284.2</td>
<td>44</td>
<td>10.265</td>
<td>27.4</td>
</tr>
<tr>
<td>1957</td>
<td>164.4</td>
<td>133.2</td>
<td>312.6</td>
<td>43</td>
<td>10.657</td>
<td>29.3</td>
</tr>
<tr>
<td>1958</td>
<td>170.0</td>
<td>137.9</td>
<td>397.9</td>
<td>45</td>
<td>10.953</td>
<td>28.1</td>
</tr>
<tr>
<td>1959</td>
<td>174.2</td>
<td>144.3</td>
<td>318.5</td>
<td>45</td>
<td>11.267</td>
<td>28.3</td>
</tr>
<tr>
<td>1960</td>
<td>180.9</td>
<td>165.2</td>
<td>346.1</td>
<td>43</td>
<td>11.535</td>
<td>29.9</td>
</tr>
<tr>
<td>1961</td>
<td>186.2</td>
<td>167.6</td>
<td>353.8</td>
<td>43</td>
<td>11.928</td>
<td>29.7</td>
</tr>
<tr>
<td>1962</td>
<td>191.2</td>
<td>204.3</td>
<td>395.5</td>
<td>52</td>
<td>12.264</td>
<td>32.3</td>
</tr>
</tbody>
</table>

*Source: (50, p. 4)*
Table 11. Area, output and yield for dura, ground nuts and seseme

<table>
<thead>
<tr>
<th>Year</th>
<th>Dura</th>
<th>Ground nuts</th>
<th>Sesame</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area</td>
<td>Output</td>
<td>Yield</td>
</tr>
<tr>
<td></td>
<td>0000 ft</td>
<td>000 t.</td>
<td>kg</td>
</tr>
<tr>
<td>1957</td>
<td>1890</td>
<td>653</td>
<td>346</td>
</tr>
<tr>
<td>1958</td>
<td>2492</td>
<td>1067</td>
<td>423</td>
</tr>
<tr>
<td>1959</td>
<td>2607</td>
<td>1097</td>
<td>437</td>
</tr>
<tr>
<td>1960</td>
<td>3253</td>
<td>1372</td>
<td>422</td>
</tr>
<tr>
<td>1961</td>
<td>3251</td>
<td>1313</td>
<td>404</td>
</tr>
<tr>
<td>1962</td>
<td>3067</td>
<td>1051</td>
<td>343</td>
</tr>
<tr>
<td>1963</td>
<td>3520</td>
<td>1245</td>
<td>354</td>
</tr>
</tbody>
</table>

a Source: (50, p. 5)
Table 12. Area, output, and yield of cotton

<table>
<thead>
<tr>
<th>Year</th>
<th>Area</th>
<th>Output (312 lb)</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>1925</td>
<td>160,000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1942/52</td>
<td>380,356</td>
<td>1,239</td>
<td>3.26</td>
</tr>
<tr>
<td>1949</td>
<td>337,533</td>
<td>1,239</td>
<td>3.20</td>
</tr>
<tr>
<td>1950</td>
<td>411,364</td>
<td>1,341</td>
<td>3.21</td>
</tr>
<tr>
<td>1951</td>
<td>519,081</td>
<td>2,005</td>
<td>2.86</td>
</tr>
<tr>
<td>1952</td>
<td>549,235</td>
<td>1,211</td>
<td>2.21</td>
</tr>
<tr>
<td>1953</td>
<td>590,724</td>
<td>1,773</td>
<td>3.01</td>
</tr>
<tr>
<td>1954</td>
<td>620,314</td>
<td>1,853</td>
<td>2.95</td>
</tr>
<tr>
<td>1955</td>
<td>659,603</td>
<td>1,873</td>
<td>2.85</td>
</tr>
<tr>
<td>1956</td>
<td>576,393</td>
<td>2,050</td>
<td>3.56</td>
</tr>
<tr>
<td>1957</td>
<td>735,979</td>
<td>2,361</td>
<td>2.89</td>
</tr>
<tr>
<td>1958</td>
<td>701,369</td>
<td>1,060</td>
<td>1.51</td>
</tr>
<tr>
<td>1959</td>
<td>351,053</td>
<td>2,663</td>
<td>3.12</td>
</tr>
<tr>
<td>1960</td>
<td>907,957</td>
<td>2,592</td>
<td>2.87</td>
</tr>
<tr>
<td>1961</td>
<td>905,340</td>
<td>2,400</td>
<td>2.65</td>
</tr>
</tbody>
</table>

\*Source: (51, p. 14)\*
Table 13. The number of livestock for selective years

<table>
<thead>
<tr>
<th>Year</th>
<th>Cattle</th>
<th>Sheep</th>
<th>Camels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>000 head</td>
<td>000 head</td>
<td>000 head</td>
</tr>
<tr>
<td>1944</td>
<td>3,195</td>
<td>4,308</td>
<td>1,109</td>
</tr>
<tr>
<td>1956</td>
<td>6,907</td>
<td>6,946</td>
<td>1,500</td>
</tr>
<tr>
<td>1962</td>
<td>10,400</td>
<td>8,700</td>
<td>2,300</td>
</tr>
</tbody>
</table>

*Source: (50, p. 7)*

Table 14. The production of gum arabic (1939 - 1960)

<table>
<thead>
<tr>
<th>Year</th>
<th>Production</th>
<th>Year</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>000 m.t.</td>
<td></td>
<td>000 m.t.</td>
</tr>
<tr>
<td>1939</td>
<td>19.5</td>
<td>1954</td>
<td>37.9</td>
</tr>
<tr>
<td>1940</td>
<td>29.9</td>
<td>1955</td>
<td>49.5</td>
</tr>
<tr>
<td>1943</td>
<td>37.1</td>
<td>1956</td>
<td>41.3</td>
</tr>
<tr>
<td>1950</td>
<td>33.3</td>
<td>1957</td>
<td>41.8</td>
</tr>
<tr>
<td>1951</td>
<td>44.5</td>
<td>1958</td>
<td>43.9</td>
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<td>1952</td>
<td>41.4</td>
<td>1959</td>
<td>37.4</td>
</tr>
<tr>
<td>1953</td>
<td>39.7</td>
<td>1960</td>
<td>51.1</td>
</tr>
</tbody>
</table>

*Source: (51, p. 20)*