A METHODOLOGY FOR FORECASTING SUGAR DEMAND: THE CASE OF KENYA NATIONAL TRADING CORPORATION {KNTC}

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This management project is my original work and has not been presented for a degree in any other University.

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This management project has been submitted for examination with my approval as University Supervisor.

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ABSTRACT

KNTC plays a major role in the economy of this country. It is the main distributing agent of essential commodities from both domestic production and imports. The corporation handles provision and produce and hardware products. Like many other business organisations, KNTC faces problems in availing these products to the consumers in the right quantities at the right time. Among these problems include the sales forecast of these products, especially sugar. OR techniques could be utilized in solving this problem. It is within such a background that this study was initiated to see if KNTC's sugar sales could be modelled using time series.

The study developed forecasting models for sugar demand in 34 depots. In constructing these models, the researcher considered both technical and managerial aspects as viewed by KNTC management. The models were validated by using one year data.

The models developed were found to be predicting demand for sugar fairly good. These models were validated by using one-year data and comparison between the predicted and the actual sugar demand for that year showed minimal variation.

The need for an OR specialist in KNTC management has been recommended. Such a specialist would develop an efficient and effective sugar distribution system with the help of other officers of the corporation.

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CHAPTER 1

INTRODUCTION

1.1 Background to the study

Consumers today place enormous faith in the system of distribution that supplies them with material goods and services.[1] Consumers are confident that shops will be replenished and seldom enquire how goods find their way onto the shops. When supply of goods is interrupted, distribution attract much public attention. Physical distribution is a collective term combining interrelated functions (transport, stockholding, storage, goods handling, and order processing) involved in the physical transfer of finished goods from the producer to the consumer. The importance of physical distribution was recognized about three decades ago both in industrial and business circles. Distributive functions[2] were commonly regarded as 'low grade nuisances' thus accorded little managerial status and assigned less able staff. Warehousing was considered to be a 'necessary evil' and transportation 'a dismal calculus of rates and routes'.

Managerial attitude to distribution has changed. Today, distribution is generally considered to be a major cost centre, an important marketing tool and a critical determinant of profitability. In many organizations, distribution costs represents a large and rising percentage of sales. Beattle[3] said;

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[1] McKinnon Alan C., **Physical Distribution Systems**, Routledge, New York, pp 1.

[2] Cited by McKinnon Alan C., Physical Distribution Systems, Routledge, New York, pp 1-2.

[3] Beattle, D.W., "Improving the Structure of Distribution Systems." Operational Research Quarterly , Vol. 24, No. 3, September 1973, pp 353-364.

"Distribution function is increasingly being regarded not as a regrettable though unavoidable additional cost but as a vital part of the function of serving customers."

Physical distribution is therefore a major growth area in the economy and is subject to a rapid rate of technological and managerial change. Due to this significance, the managers concern ought to apply modern Operations Research (OR) and Statistical tools in an attempt to minimize physical distribution costs.

Costs incurred in the functions of physical distribution vary greatly within and between industrial sectors. A study done in USA in 1984 arrived at the figures shown in table 1.1 below[4]

Table 1.1 Distribution costs expressed as a percentage of sales revenue (1984)

Sector	Percentage
Electrical Engineering	14.5
Food, Drink and Tobacco	13.4
Distributive trades	11.4
Textiles	8.2
Chemicals and allied products	6.2

Variability between industrial sectors is mainly attributed to the nature of products and services they offer.

IN Britain, a survey done in 1986 by the Institute of Physical Distribution Management[5] came up with functional disaggregation of total physical distribution as shown in table 1.2 below.

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[4] McKinnon Alan C., Physical Distribution Systems, Routledge, New York, 1989. pp 10.

[5] ibid pp 10

Table 1.2 Physical Distribution costs expressed as percentage of Total Physical Distribution costs.

Component	Percentage
Transportation	48
Inventory	20
Storage	25
Administrative/others	7

Transportation receives slightly more expenditure than stockholding/storage, and together these functions account for roughly 90% of the total distribution costs.

The quantity of the products being distributed depend on the demand for those products. Before distributing the product to the wholesalers and retailers, the amount required in the respective markets to be served should be approximated. This is because the cost incurred in distributing the product(s) depend on how much is being demanded. Therefore sales forecast is the building block of market planning. Sales forecasting also plays an instrumental role in production scheduling, financial planning, inventory planning and procurement and determination of personnel needs. Inaccurate forecasting would result in incorrect decisions in each of the areas named above. The firm would incur costs in stockholding and storage and tie its capital in stocks if it over-estimates demand. Underestimating demand would lead to loss of sales and drop in customer service level. Hence, if the firm does not estimate the demand for its products and services, it will incur unnecessary expenditure. Therefore, management need to strike a balance between the supply of and the demand for its products.

It is evident that forecasting has great impact on the functions of physical distribution and accurate forecasting will

definitely lead to less distribution costs.

1.2 KNTC and Sugar Distribution in Kenya

Sugar is distributed by KNTC, a subsidiary wholly owned by the Industrial and Commercial Development Corporation (ICDC). KNTC was created in 1965 and charged with the joint responsibilities of Africanizing the whole trade including import/export trade in Kenya and of increasing efficiency in the distributive sector[6]. Once KNTC is made responsible for a given commodity, it becomes the main distributing agent of all domestic production and imports of that commodity. It accomplishes the objective of Africanisation by appointing African wholesalers as sub-agents. These sub-agents are usually specific to one of two main categories, namely provisions and produce and hardware. In turn, each sub-agent is specific to one district. The number of sub-agents appointed for each category of commodities in each district is restricted. The major commodities which KNTC handles to date include the following:

1. Provision and Produce
   a) Sugar
   b) Rice
   c) Cottonseed oils
   d) Salt
   e) Soaps
   d) Matches

2. Hardware
   a) Bicycles and bicycle parts
   b) Cement and cemwash
   c) Flashlights and dry-cell batteries
   d) Charcoal irons
   e) Galvanized corrugated iron sheets

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[6] The following descriptions of KNTC operations was obtained from officers of KNTC and various KNTC documentations.

f) Barbed wires
g) Nails

In the process of availing these products and commodities to the consumers[7], the corporation faces some problems. One of the problem is the determination of the quantities to be delivered in its depots. at the moment management determine such quantities arbitrarily. Another problem is that of inventory control. The management have not come up with any formal way of controlling stock. Orders are made when the commodities are demanded. There is no prior arrangement to order before demanded. This has led to unnecessary delays, shortages and subsequently loss of sales. KNTC is reluctant to promote customer service level. Customer needs is not of prime concern to the corporation, and this is another problem facing the corporation.

Thus large consumers like those of hardware products acquire the bulk of their commodities directly from the factories.

Sugar is one of the major products handled by KNTC. Much of the sugar is produced locally. Sugar is imported only when local factories cannot satisfy local demand. The corporation do not own the factories. They are owned by private individuals and organizations. Sugar is obtained from five sugar mills, namely:

1. Mumias Sugar Company
2. Chemelil Sugar Company
3. Nzoia Sugar Company
4. Muhoroni Sugar Company
5. South Nyanza Sugar Company

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[7] ibid 6.

The production capacity of these mills is known.

Sugar is distributed from the factories to 36 major depots in Kenya. Like other commodities handled by KNTC, sugar distribution is controlled in the Head office in Nairobi. The Chief Commercial Manager is in charge of the distribution of all products handled by the corporation at the national level. In order to enhance distribution of their commodities, the corporation has established six regions within the Republic. These regions are:

1. Coast
2. Nairobi
3. Eastern, North Eastern, and Central
4. Nyanza
5. Rift Valley
6. Western

An Assistant Distribution Manager, whose function is solely to coordinate sugar distribution reports to the chief commercial manager. The regional managers coordinate sugar distribution among depots and they report to the assistant distribution manager. The depot managers distribute the sugar to the appointed wholesalers, who sell the commodity to retailers. The depot managers therefore report to the regional managers. The organization structure of the personnel in the sugar distribution system of KNTC is given in figure 1.2 below:

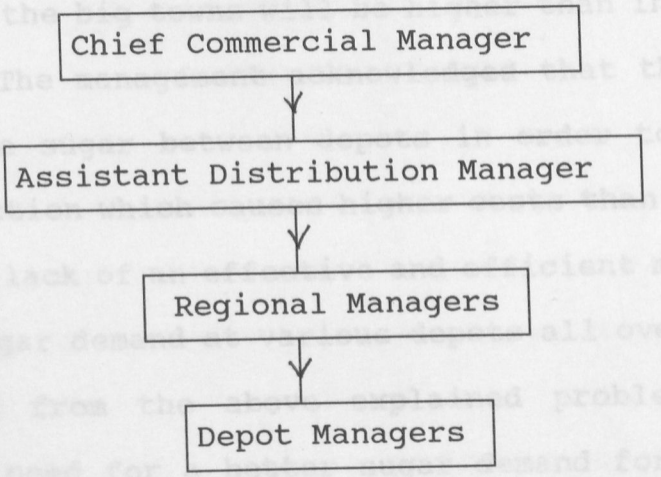

Figure 1.1 The structure of KNTC distribution system.

Whenever there is a shortage of sugar and other commodities in the depots, the depot managers requests replenishment through the regional managers to the chief commercial manager.

1.3 Statement of the problem

KNTC has recurrently faced situations of sugar stock-out in a number of their depots, especially in the urban areas. At the same time, depots in small towns always have enough sugar supply. This problem is attributed to poor forecasting of sugar demand in its depots. The management of KNTC employ a subjective method in determining the demand for sugar in its depots. Since its formation in early 1965, the corporation has continuously been assuming that sugar consumption rises by 5% annually in the entire Republic, hence increase depot requirements by the same rate. Increase in sugar consumption rate cannot be assumed to be uniform in all areas served by KNTC and may not be rising at a constant rate. In recent years, great number of rural dwellers have migrated to urban areas. Given that sugar is a necessity,

consumption in the big towns will be higher than in the rural and small towns. The management acknowledged that they are forced to redistribute sugar between depots in order to overcome the shortage, an action which causes higher costs than expected. The problem is the lack of an effective and efficient methodology for forecasting sugar demand at various depots all over the country.

Following from the above explained problem, this study addresses the need for a better sugar demand forecasting model which can be used to determine an efficient and effective distribution plan.

1.4 Objective of the study

To formulate a methodology for forecasting sugar demand in each of the KNTC's depots by using time series.

1.5 Significance of the study

This study is of great importance to the management of KNTC as it is expected to improve sugar distribution while reducing the level of sugar stock-outs in the depots.

If successfully implemented and fruitful results are realised, management may borrow and apply the same idea to other products. The study also is expected to pave the way for the academics who are interested in developing efficient distribution systems and related models in the distribution of various commodities in Kenya to do further research in related areas.

CHAPTER 2

LITERATURE REVIEW

2.1 Forecasting in planning and decision making

In recent years a tremendous emphasis has been placed on improving decision making in business and government. Leontief[8] believes that:

> "..no matter how well a company schedules its internal operations, its plans collapse if its sales forecasts are seriously in error."

One of the key aspects of decision making is being able to predict the circumstances surrounding individual decision situations. Forecasting plays a major role in planning and specifically in the following functional areas:

2.1.1 Marketing

A number of decisions can be improved significantly by basing them on reliable forecasts of market size and market characteristics. The marketing department could use such forecasts in planning advertising, direct sales and other key promotional efforts.

2.1.2 Production

A major need for forecasting is the one of product demand. This function involves predicting both volumes and mix so that the firm can plan for its optimal production schedules and inventory levels. Forecasts are also needed in the areas of

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[8] Leontief Wassily W., "Proposal for Better Business Forecasting", Harvard Business Review, November-December, 1964, pp 166-168.

material requirements, labour scheduling, equipment purchases and plant capacity planning.

2.1.3 Personnel

In planning for human resource requirements, personnel department need to use forecasts. Workers must be hired and trained for the need categories and benefits must be provided that are competitive with those available in the company's labour market. .

2.1.4 Finance and Accounting

These departments must forecast cash flows and the sales at which various expenses and revenues will occur in order to maintain company liquidity and operating efficiency. They must also forecast interest rates to support the acquisition of new capital, the collection of accounts receivables, to help in planning working capital needs, and capital equipment expenditure rates to help balance the flow of funds in the organization.

Forecasts that can be used as the basis for decision making are the most crucial because the general management function is central to successful operation of the firm. The most essential forecasts here are those of economic factors that can serve as a common background for all of the planning and decision making.

The figure below (2.1) illustrates the idea of such a forecasting system. Some or all of the inputs are processed through one or more forecasting models to develop demand estimates. The decision maker uses these demand estimates as the starting point for developing a forecast. The initial or

original inputs, the demand estimates from the forecasting model(s) and other inputs are used by the decision maker to finalise the sales forecast. This figure makes two key points;

(1) the outputs of forecasting models are not the forecast, but rather a single input to the sales forecast decision.

(2) the sales forecast is converted to the various production resource forecasts.

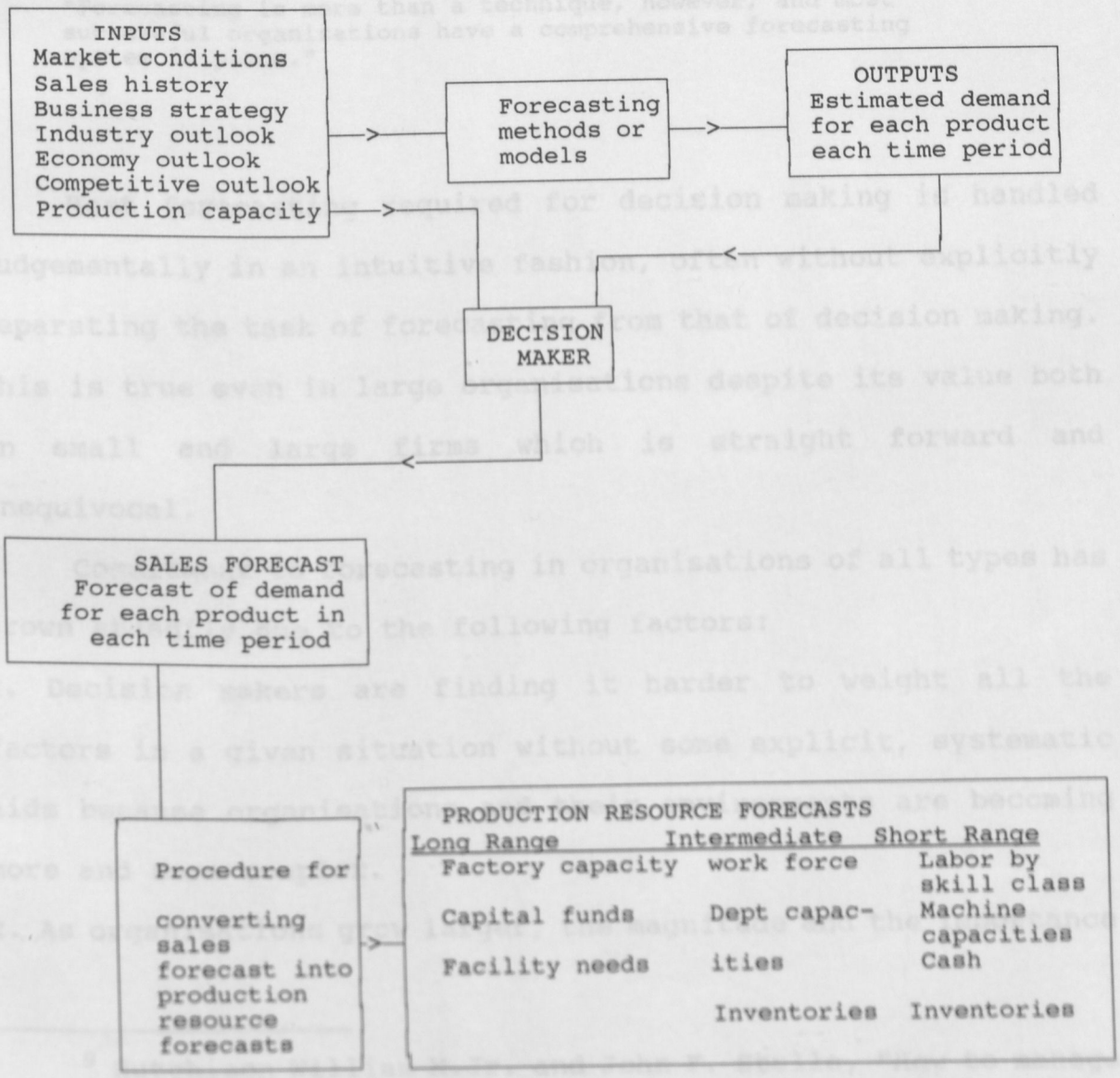

Figure 2.1 A Forecasting System in Production and Operations.

Apart from being the building block of planning, forecasting

also plays a great role in the general uplift of the customer service level. Customer service has a direct and often a measurable impact on a company's profits[9]. And therefore customer service is a decisive factor in marketing success.

As regards planning, forecasting enables new facility planning, production planning, workforce scheduling and financial planning. Norman Gaither[10], said that:

> "Forecasting is more than a technique, however, and most successful organizations have a comprehensive forecasting system in place."

Most forecasting required for decision making is handled judgementally in an intuitive fashion, often without explicitly separating the task of forecasting from that of decision making. This is true even in large organisations despite its value both in small and large firms which is straight forward and unequivocal.

Commitment to forecasting in organisations of all types has grown steadily due to the following factors:

1. Decision makers are finding it harder to weight all the factors in a given situation without some explicit, systematic aids because organisations and their environments are becoming more and more complex.
2. As organisations grow larger, the magnitude and the importance

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[9] Hutchison William M.Jr. and John F. Stolle, "How to manage customer service", Harvard Business Review, November-December, 1968, pp 85-96.

[10] Quoted by Krajewki/Ritzman, Operations Management: Strategy and Analysis, Second Edition, Addison-Wesley Publishing Company Inc., 1990, pp 345.

of individual decisions have grown.

3. The environments of most organisations have been changing at an accelerating rate. With key relationships no-longer stable, forecasting has proved to be one of the best tools for quickly identifying and understanding new relationships.

4. Many organisations have moved toward more systematic decision making requiring explicit justification of individual actions. Formal forecasting methods are now one way to support and evaluate such action.

5. Forecasting methods and cumulative experience concerning their application have been developed that can be applied directly by practitioners rather than by technical experts. The availability of mainframe, mini- and micro-computers have broadened this widespread access and applicability.

2.2 Matching the forecasting situation with the method

Manager applying forecasting in his decision making knows the importance of selecting the appropriate forecasting technique for the specific situation. Even though each situation is different and each technique has different strengths and weaknesses, it is very important to identify the general characteristics of forecasting situations and to contrast those with the general characteristics of available forecasting methods. These two sets of characteristics can be used as a basic framework for matching specific needs with specific approaches.

2.2.1 Characterising Forecasting Situations

There are six dimensions of planning and decision making

situations that play a key role in determining the requirements that forecasting must accommodate and respond to in order to be effective:

1. Time Horizon - The period of time over which a decision will have an impact and for which the manager must plan clearly affects selection of an appropriate forecasting method. Time horizon can generally be divided into immediate term (less than one month), short term (one to three months), medium term (three months to two years) and long term (more than two years). The time used to describe each of these four categories may vary with company and situation.

2. Level of Detail - Decision making tasks in many corporations generally are subdivided for ease of handling according to the level of details required. A firm may have a corporate planning department concerned with aggregate planning and others may have group of planners on product basis. Generally, the greater the level of detail and frequency that is required, the greater the need for an automated forecasting procedure and vice versa.

3. Control versus Planning - In control, management by exception is the procedure. Hence, what is needed is some way to determine when a process is out of control. Therefore a forecasting method in such a situation should be able to recognise changes in basic patterns as early as possible. In planning, the existing patterns are assumed to continue into the future. The major issue thus is to identify and exploit those patterns into the future.

4. Number of Items - The procedure used in forecasting a single item can be much more detailed and complex than forecasting many items.

5. Existing Planning Procedures - Instituting any forecasting method involves changes in the company's planning and decision process. In many organisations, built-in resistance to change is imminent. Because of this, it is thus important to start with those forecasting methods that are most closely related to the existing procedures.

6. Constancy - Forecasting a constant situation is different from a stochastic one. In the stable situation, a quantitative forecasting method can be adopted and checked periodically to confirm its appropriateness. In a dynamic environment, what is needed is a method that can adapt continually to reflect the most recent results and the latest information.

Once these have been identified and understood for a given situation, it is possible to consider the features of various forecasting methods in order to find a good fit between the method selected and the situation.

2.2.2 Characterising Forecasting Methods

There are six major factors that are considered important in describing available forecasting methods. They reflect their inherent capabilities and adaptability and they include;

1. Time Horizon - There are two aspects of the time horizon related to individual forecasting. One is the span of time in the future for which different forecasting methods are best suited. Qualitative methods are used more for long term forecasts, whereas quantitative methods are used more with intermediate and short term situations. Another one is the number of periods for which a forecast is desired. Some techniques are suitable for forecasting one or two periods only into the future.

2. The pattern of data - Underlining the majority of forecasting methods is an assumption as to the type of patterns found in the data to be forecast. Different forecasting methods vary in their ability to identify different types of patterns, hence the importance of matching the presumed patterns in the data with the appropriate technique.

3. Accuracy - The level of detail required in a forecast is closely related to the required accuracy.

4. Cost - Three direct elements of cost involved in the application of a forecasting procedure include development, data preparation and actual operation. The variation in costs has an impact on the attractiveness of different methods for different situations.

5. Simplicity and ease of application - The manager is held responsible for his decisions which are based on forecasts. If these forecasts are not understood, then there is little personal

confidence in executing the decisions. Thus, the forecasting technique should be understood by the person using the forecast.

6. Availability of Computer Service. The package used should be easy to use, well documented and free of major "bugs" so that managers can apply them and effectively understand and interpret their results.

In the process of assessing alternative forecasting methods for a specific situation, management must consider four key areas:

1. The item to be forecast - This calls for studying the characteristics of the situation, paying particular attention to whether one is trying to predict the continuance of a historical pattern, etc.

2. The interaction of the situation with the characteristics of available forecasting methods - Here, the manager must be aware of values, costs and the relative changes in value and costs when the level of accuracy changes.

3. The amount of historical data available - The manager thus must consider the quantity of data at hand, the appropriateness of the data and the cost of gathering additional data.

4. The time allowed for preparing forecast - The urgency in many situations can influence the selection of a method.

The manager can therefore, incur a lot of costs from unexpected source in connection with forecasting. Hence, diligence must be

exercised by the manager in choosing the forecasting method.

2.2.3 Why forecasting systems fail

Managers involved in the implementation of forecasting systems ought to take care when putting forecasting plan into action. Some organizations have impressive forecasting plans on papers but cannot put them in practice due to a number of reasons, some of them are:

1. Failure to recognize that the forecasting model is an element of the forecasting system and not the system.
2. Failure of the organization to involve a broad cross section of people in the forecasting system. Individual effort is important, but the need to involve everyone who has pertinent information and who will need to implement the forecast is also important.
3. Failure to forecast the right things. For example, it is too common for organizations to forecast demand for raw materials that go into finished products. The demand for raw materials need not be forecast because these demands can be computed from the forecasts for the finished products. Forecasting too many things can overload the forecasting system and cause it to be too expensive and time consuming.
4. Failure to recognize that forecasts will always not be true. There is no such thing as perfect forecast. Estimates of future demand are bound to be subject to error and the magnitude of error tends to be greater for forecasts that cover longer spans of time. When operations managers have unrealistic expectations of forecasts, the fact that the forecasts were not on the nose

is often used as an excuse for poor performance in operations. Excuses will not result in improved forecasts and improved performance in operations.

5. Failure to track the performance of the forecasting models so that the forecast accuracy can be improved. The forecasting models can be modified as needed to control the performance of the forecasts.

6. Failure to select an appropriate forecasting method.

2.2.4 Early studies on forecasting

Various studies have been conducted on this area of prediction or forecasting demand for products and services. Green M. and Harrison R. J.[11], carried out a study which was concerned with forecasting goods in a mail order company. The particular goods forecasted were ladies dresses and it was made live on a sample of 93 types. The study forecasted dress demand by using five months data (August to December 1970). Apart from demand forecast, the company was also facing the problem of returned dresses. The authors used time series(decomposition method) to solve the problem. The comparison of actual sales and model results showed high degree of accuracy.

Johnston F. R. and Harrison P. J.[12], forecasted demand for cider in UK after its sales experienced an upsurge in demand during the good summer in 1975 and the record drought in 1976.

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[11] Green M. and Harrison P. J., "Fashion Forecasting for a mail order Company using a Bayesian Approach", Operational Research Quarterly, Vol. 24, No. 2, June 1973, pp. 193-205.

[12] Johnston F. R. and Harrison P. J., "An Application of Forecasting in the Alcoholic Drinks Industry", Journal of Operational Research Society, Vol. 31, 1980, pp 699-709.

The authors anticipated future demand by using time series combined with dynamic linear model developed by Harrison and Stevens. The model included growth and seasonality plus the effect of exceptional weather together with price, inflation and transfer effect of price changes. The results were satisfactory compared to those of previous models.

Bamber D. J.[13], considered a simple method of tackling the problem of producing a versatile and effective management control system of demand forecasting in both shoe and food industries. In solving the problem, the author used Box-Jenkins method of forecasting. The results of the study enabled those companies in the two industries to forecast demand and supply requirements two years ahead with a high degree of accuracy.

The demand forecasting and reordering sub-systems in inventory management have traditionally been considered to be independent of each other. In practical life, this is not the case said Richard B. Watson.[14] He argued that treating the two independently will have adverse effects on customer service. Therefore demand forecasting and reordering sub-systems are not independent of each other.

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[13] Bamber D. J., "A Versatile Family of Forecasting Systems", Operational Research Quarterly, Vol. 20, Special Conference Issue, pp 111-121.

[14] Richard B. Watson, "The effects of Demand-Forecast fluctuations on customer service and inventory cost when demand is lumpy." Journal of operational Research society. vol. 38, No. 1 1987 pp 75-82.

Schultz Carl R.[15], did a study combining both inventory control and demand forecasting. He considered a situation with lumpy or sporadic demand, implying that demand is characterized by larger transactions separated by periods of zero demand. The author formulated a forecasting procedure to be used in conjunction with a base stock(order-up-to) inventory control policy under periodic review. The procedure also determined the size and the timing of replenishment orders. The system showed that a delay in placing the order can result in significant holding cost reductions with little additional cost of stock-outs.

Consumer durable goods purchases represent a huge market but relatively few management science models have been successfully implemented in this area of business. Glen L. Urban et al[16], developed and applied a prelaunch model and measurement system to the marketing planning of a new automobile. The analysis addressed issues that are important in understanding consumer response to durable goods. A detailed consumer flow model which monitors and projects key consumer transitions in response to marketing actions was formulated. Comparison of the model's results to actual sales data suggested reasonable accuracy.

It is not only in demand for products that forecasting has been useful. Almost all the activities carried out within an organization require some planning in one way or the other.

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[15] schultz Cart R., "Forecasting and inventory control for sporadic Demand lender periodic review.", Journal of Operational Research Society, vol. 38 No. 5 1987 pp 453-458

[16] Glen L Urban et al, "Prelaunch Forecasting of New Automobiles", Management Science, Vol. 36, No. 4, April 1990, pp 401-421.

Silver M. and Goode M.[17], developed a model for forecasting rents for the U.K. retail property market. The authors considered the use of multivariate approach important because there were good prior reasons to suspect such rents to be related to a range of economic variables. Ordinary least squares method was used and the results of the paper suggested the need for care in the use of econometric models for forecasting retail rents. Particular attention was devoted to the multicollinearity of the model, an issue often not considered in multivariate forecasting since the predicted values of models suffering from multicollinearity are unbiased.

Mail survey response rates and their prediction are important issues for researchers. A study on this subject was done by Jobber D. and Saunders J.[18] The paper ought to develop an improved method of predicting the response rate to industrial mail surveys. The prediction mail-survey allows computation of the number of questionnaires to send out in order to achieve the desired sample size. The authors came up with a model which enabled them to have better results compared to previous models.

From the foregoing explanation, forecasting is an essential activity in business environment. The future of business operations is full of uncertainties which could lead to the collapse of many firms if they are not planned for. In order to

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[17] Silver M. and Good., "Econometric Forecasting Model for Rents in the British Retail Property Market." OMEGA, International Journal of Management Science, Vol. 18, No.5, 1990, pp 529-539.

[18] Jobber D. and Sounders J. " the prediction of Industrial mail-Survey Response.", Journal of operational Research Society, Vol 40, No. 10, 1989, pp 839-847.

predict the future, there is need to have the past knowledge of the business and the environment of operation. Several scholars have argued that the use of the past data to predict the future is not acceptable because the past and the future are not the same. Reacting to this argument, Patrick Henry[19] said:

> "I know of no way of judging the future but by the past."

Many other scholars and business organizations have supported the view that the future is related to the past in some way. Makridakis Spyros[20], advocated the importance of forecasting in his article, where he said that:

> ".... the forecasting industry is flourishing and high interest is maintained as shown by recent books, and articles published, the number of people attending conferences and the opportunities for consulting in business and government."

Forecasting is therefore the basis for corporate long-run planning.

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[19] Cited by Ebert, R.J. and Everett E. Adam Jr., Production and Operations Management, Fourth Edition, Prentice Hall, pp 70.

[20] Makridakis Spyros, "Forecasting Accuracy and the Assumption of Constancy", OMEGA, The International Journal of Management Science, Vol. 9, No. 3, 1981, pp 307-311.

CHAPTER 3

STUDY DESIGN

The research project is a case study of KNTC, where sugar distribution especially its demand is being addressed.

3.1 Data collection

The study has made use of secondary data which was obtained from the records of KNTC. The data used in the study cover a period of six years(1986-1991). Information was sought from the the chief commercial manager and the company statistician. The information obtained included the amount of sugar bags sold in each depot during the period of study.

A data collection form was used(see appendix A).

Time series (decomposition method) was applied in analyzing the data.

3.2 Model construction

Many business organizations and governments use time series in forecasting their activities. Two factors are very important in a time series model, they are the data to be forecast and the period of time to be used. Time series model assumes the following:

1. That some pattern or combination of patterns is recurring overtime. Thus by identifying and extrapolating that pattern, forecasts for subsequent time periods can be developed.
2. That the underlying pattern can be identified solely on the basis of historical data from that series.

Several models may be used to characterize time series. The classical model used by economists provides the clearest explanation of the following four time series components of variation, namely:[21]

a) Secular Trend (T_t)

b) Cyclical movement (C_t)

c) Seasonal fluctuation (S_t)

d) Irregular variation (I_t)

Secular trend is defined as the long-range general movement in Y_t (observation) over an extended period of time. It can be approximated by a straight line but an exponential, S-curve or some other long-term pattern may exist in certain situations.

Cyclical movement is characterized by wide swings, usually a year or more in duration and is downward or upward from the secular trend. It is common to such series as the gross national product, demand for housing, etc. The cycle often follows the pattern of a wave, passing from a large to a small value and back again to a large value.

Seasonal fluctuation is a generally recurring upward and downward pattern of movement in Y_t, usually on an annual basis. Seasonal fluctuations are assumed to be caused by exogenous forces, are deemed uncontrollable, and hence are removed before further analysis. The relative predictability of the seasonal component (albeit imperfect) is part of the economists' desire

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[21] Lawrence L. Lapin, Statistics For Modern Business Decisions, Fourth Edition, Harcourt Brace Jovanovic Inc., 1987, p 592.

to remove it before analyzing the remainder, for not only is it due to basic forces of a fundamental nature which would be folly to try to modify by fiscal means but the rhythm is a recognizable one, to which we are accustomed and whose removal we do not desire."[22]

The difference between seasonality and cyclicality is that the former repeats itself at fixed intervals such as a year, month, etc. while the later have a longer duration that varies from cycle to cycle. Irregular variation are events that are completely unpredictable (referred to as random factors). This error is assumed to be the difference between the combined effect of the three subpatterns of the series and the actual data.

These components can be related to the forecast variable by a general mathematical equation as follows:

$$X_t = f(S_t, T_t, C_t, I_t)$$

where X_t is the time series value at period $_t$.

S_t is the seasonal component (or index) at period $_t$.

T_t is the trend component at period $_t$.

C_t is the cyclical component at period $_t$.

I_t is the random component at period $_t$.

The specific functional relationship used to relate these four subpatterns can take on a variety of forms. The most straightforward are additive (simply summing the four elements) and multiplicative (taking the product of the four elements). Since the multiplicative form is the most commonly used, this

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[22] As cited by Maddala, G. S., Econometrics, McGraw Hill Inc., 1987, p. 338.

study will apply the same. The multiplicative model is expressed as follows:

$$X_t = S_t * T_t * C_t * I_t$$

Decomposition Process

The decomposition of the data into the components described above can be done as explained below:

(i) Seasonality

Data is deseasonalized by computing moving averages (MA) that covers one complete set of season (could be quarter of a year, months etc.). In this study, a season is twelve months thus 12-point centred moving average. The moving average values are relatively smooth and give a more precise picture of how sugar consumption behave with regard to trend and cycle.

$$MA = T * C * I$$

(ii) Trend

In order to remove variation due to trend in the data, deseasonalized data are fitted in a line. The trend might be linear or nonlinear. Linear trend can be estimated using simple regression. The equation of line would be:

$$T_t = a + bt$$

where a is a constant term,

b is the trend (for example the amount by which sales increase in each season) and

t is the month

(iii) Cyclical movement

MA divided by the trend would give Cyclical.

$$MA/T = (T * C) /T = C$$

The irregular variations are not easy to capture because they reflect no systematic influence[23], hence they are of little practical use in traditional forecasting methods.

After completing the steps above, forecasting can be done by multiplying the trend values with the seasonal indices and the cyclical values.

The study has forecast demand based on the data for 1986 to 1991. In developing the model, the data for 5 years (60 months) was used. Five years are adequate to forecast sugar demand pattern. The remaining data for 1 year (12 months) was used to validate the model.

Practically, managers prefer simple methods of forecasting to those which require a lot of computations. In the recent Mentzer and Cox (1984) study[24], it was found out that forecasting users are very familiar with the subjective methods, whereas moving average is the most familiar of the objective methods. Classical decomposition is the second least familiar method although it is one of the most useful since it can distinguish the various subpatterns of a data series and can also be used to deseasonalized a data series.

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[23] op. cit. 20, p 618.

[24] Steven C. Wheelwright and Spyros Makridakis, Forecasting Methods For Management, 4th Edition, p. 350.

Table 3.1 Familiarity With Forecasting Methods (as a percentage of those responding).

Method	Very Familiar	Vaguely Familiar	Completely Unfamiliar
SUBJECTIVE			
Jury of executive opinion	81	6	13
Salesforce composite	79	5	16
Customer opinion	73	7	20
OBJECTIVE			
Moving average	85	7	8
Straight line projection	82	11	7
Exponential smoothing	73	12	15
Regression	72	8	20
Trend-line analysis	67	16	17
Simulation	55	22	23
Lifecycle analysis	48	11	41
Classical decomposition	**42**	**9**	**49**
Box-Jenkins	26	9	65

CHAPTER 4

DATA ANALYSIS

The quantity of sugar sold in the depots showed an upward movement though fluctuates at times. However, these fluctuations were minimal. For the purpose of this study, a time frame of one month was chosen in formulating the forecast models. The amount of sugar sold in each depot in a given month are sugar bags of 100 kgs each.

The actual sales of sugar were extracted from the records of KNTC. Appendix to Appendix give the sales in each depot during the six years (1986-1991) of the study.

4.1 Model results

A model for each depot was formulated. After deseasonalising the actual sugar sales, the moving averages were fitted into a line using regression analysis. The moving averages removes fluctuations due to seasons and the regression lines account for the trend. The cyclical and the random error movements were not extracted because they do not help in forecasting future sugar sales. The study came up with 34 models although the corporation has 36 depots in total. Two of the depots were established in late 1990 hence do not have enough data points to warrant formulation of forecasting models which can give a clear trend of sugar consumption. Below are the models of the 34 depots.

DEPOT	MODEL	T VALUE	PROB.LEVEL	R SQUARED
Bungoma	6032 + 26t	11.5	0.0000	74%
Busia	4780 + 49t	5.0	0.0001	65%
Eldoret	14897 + 132t	10.0	0.0000	68%
Embu	10105 - 6t	-1.0	0.0230	51%
Garissa	1954 + 97t	14.6	0.0000	86%
H/Office	1104 + 7t	4.0	0.0014	57%
H/Bay	2417 + 45t	9.9	0.0000	69%
Kabarnet	713 + 15t	27.3	0.0000	94%
Kakamega	6025 + 265t	11.5	0.0000	74%
Kapenguria	2362 + 51t	25.0	0.0000	95%
Kapsabet	4607 + 35t	11.6	0.0000	75%
Karatina	14301 - 38t	-1.4	0.0008	48%
Kericho	14694 + 12t	2.0	0.0060	53%
Kitale	9580 + 19t	4.6	0.0003	64%
Kitui	5364 + 14t	2.6	0.0127	46%
Kisii	10336 + 122t	10.3	0.0000	70%
Kisumu	29133 - 179t	2.4	0.0074	56%
Lodwar	-20 + 88t	15.0	0.0000	92%
Machakos	8169 + 82t	8.8	0.0000	63%
Malindi	292 + 65t	14.7	0.0000	83%
Maralal	1423 + 35t	29.0	0.0000	97%
Meru	9846 - 11t	8.7	0.1936	36%
Migori	4154 + 10t	10.0	0.0000	69%
Mombasa	3352 + 390t	11.2	0.0000	73%
Muranga	9202 - 9t	-1.5	0.1537	43%
Nairobi	87215 + 66t	3.7	0.0501	61%
Naivasha	4912 + 45t	17.7	0.0000	87%

Nakuru	15672 + 54t	27.2	0.0000	94%
Nanyuki	8385 + 7t	3.9	0.0333	54%
Narok	3181 + 3t	6.3	0.0013	62%
Nyahururu	6700 - 5t	-3.5	0.0022	52%
Siaya	2862 + 119t	20.6	0.0000	95%
Thika	14765 + 27t	5.7	0.0096	65%
Voi	2819 + 79t	13.5	0.0000	80%

The models were constructed at a significance level of 95%. The coefficients of t in the models are significant for the majority of the depots except Meru (with probability level of 0.1936) and Muranga (with probability level of 0.1537). All the other depots have probability level less than 0.05 which is the significance level. The hypotheses of testing the significance of a regression parameter (or predictor variables) at any level of significance is as given below:

H_o: $B_i = 0$, H_1 is not equal 0.

If the probability level is greater than 0.05, we fail to reject H_o and that the constant is insignificant, that is, it has no influence on Y. In this study, it means that time (month) has no significant influence on sugar demand (sales). If the probability level is less than 0.05, we reject H_o and conclude that the predictor variable has high influence on Y, that is, time has high influence on sugar demand. Concerning the model fitness, r-squared would be used. In this study, a model with r-squared of 50% and above would be deemed fit to be used in forecasting. This r-squared, sometimes known as coefficient of determination shows the percentage of variation which the model

explains. For example a coefficient of determination of 78% means that the line fitted explains 78% of the total variations and does not explain 22% of the total variation. Some of the models constructed above have r-squared below 50% and others above. Those models whose functions have r-squared below 50% include Karatina (48%), Kitui (46%), Meru (36%) and Muranga (43%). The forecasting models for these depots would be constructed by using other methods other than decomposition time series.

In order to facilitate forecasting by decomposition method, there is need to compute the monthly seasonal indices. The following are monthly seasonal indices for each depot.

	DEPOTS					
MONTH	**BUNGOMA**	**BUSIA**	**ELDORET**	**EMBU**	**GARISSA**	**H/OFFICE**
1	102	127	100	104	74	110
2	100	93	98	88	83	93
3	103	108	93	98	151	106
4	99	93	99	105	86	116
5	102	104	97	101	129	77
6	96	90	88	79	126	121
7	102	97	98	103	109	144
8	93	98	108	110	144	109
9	90	88	120	98	98	109
10	94	89	95	99	86	73
11	93	100	89	102	57	81
12	120	111	110	110	55	59

MONTH	H/BAY	KABARNET	KAKAMEGA	KAPENGURIA	KAPSABET
1	107	109	96	103	105
2	99	98	97	94	97
3	92	103	94	143	104
4	104	96	97	98	93
5	89	115	97	98	100
6	84	94	89	88	95
7	89	116	90	84	93
8	96	93	101	98	96
9	107	102	112	97	97
10	105	94	115	97	99
11	96	85	97	99	103
12	132	95	115	102	115

MONTH	KARATINA	KERICHO	KITALE	KITUI	KISII	KISUMU	LODWAR
1	102	101	102	99	93	94	180
2	89	88	101	87	87	126	99
3	102	97	104	102	102	87	91
4	97	100	102	105	105	101	89
5	85	100	105	112	105	91	87
6	77	83	91	84	92	92	83
7	92	107	91	108	100	100	64
8	100	102	97	108	97	100	95
9	105	100	93	105	96	100	75
10	111	106	93	101	99	97	90
11	116	105	97	103	105	93	121
12	124	108	124	104	129	118	126

MONTH	MACHAKOS	MALINDI	MARALAL	MERU	MIGORI	MOMBASA	MURANGA
1	94	105	106	108	89	93	93
2	97	111	103	98	87	247	99
3	110	108	89	98	88	120	100
4	107	103	90	89	96	100	104
5	91	83	104	90	99	81	89
6	87	93	101	59	97	80	77
7	91	91	94	101	112	89	105
8	118	80	121	108	122	57	94
9	98	127	88	113	107	93	107
10	89	109	91	103	99	72	105
11	98	77	110	113	92	68	100
12	121	113	101	117	112	98	99

MONTH	NAIROBI	NAIVASHA	NAKURU	NYANYUKI	NYAHURURU	NAROK
1	85	85	99	97	94	83
2	87	89	86	107	102	87
3	84	102	101	112	96	96
4	78	101	103	94	93	102
5	228	110	96	84	101	100
6	96	95	94	82	107	112
7	100	110	104	104	101	113
8	81	104	103	110	93	105
9	90	97	97	98	100	105
10	88	99	103	116	95	99
11	83	92	100	92	98	102
12	98	115	108	104	117	97

MONTH	SIAYA	THIKA	VOI
1	97	96	91
2	132	94	101
3	114	102	107
4	93	103	89
5	91	111	93
6	82	81	94
7	86	90	120
8	113	104	90
9	104	102	105
10	91	100	105
11	88	102	90
12	106	115	114

4.2 Comparison of Results

The table below compares the actual sugar sales of 1991 and the model results for the same year. This comparison shows clearly that majority of the depot sales (actual) and the estimated vary very much. However, we cannot rule out the possibility of a better model which could be used to do the same. This comparison confirms the previous test of the model fitness and the subsequent significance of the predictor variable (time) in the models.

	BUNGOMA		BUSIA		ELDORET	
	Actual	Projected	Actual	Projected	Actual	Projected
1	8038	7833	4751	7720	28180	23045
2	6656	7706	4312	7035	8146	15003
3	6967	7965	5727	7035	13101	20892
4	11202	7760	7973	7361	18049	21011
5	8636	8021	7915	8283	15819	20660
6	4386	7502	6777	7292	12040	20776
7	5911	8076	8405	7740	20744	23029
8	5529	7317	10045	7949	15265	18143
9	5107	7106	7301	7180	15526	19204
10	6458	7368	8090	7306	16891	21723
11	5538	7393	5144	8175	17840	19415
12	7667	7979	7400	9220	22900	26841

	EMBU		GARISSA		H/OFFICE	
	Actual	Projected	Actual	Projected	Actual	Projected
1	11139	10031	3283	5915	760	1684
2	9564	8565	3130	6474	720	1384
3	10853	9534	5909	7372	720	1638
4	10707	10207	6901	6632	720	1800
5	8936	9812	5003	6711	1120	1247
6	6798	7670	3036	6366	1480	1566
7	7705	9994	4101	7728	1780	1793
8	10633	10473	5601	12160	1480	1722
9	9432	9497	7035	7907	1800	1714
10	10809	9588	9928	7640	2760	1196
11	8874	9873	8599	5120	1920	1921

12	6911	10640	7414	5450	1600	1608

	H/BAY		KABARNET		KAKAMEGA	
	Actual	Projected	Actual	Projected	Actual	Projected
1	4400	5475	1510	1775	19949	21302
2	4292	4686	1089	1594	16309	20210
3	3865	4727	1025	1658	15552	20448
4	4812	5297	1080	1606	19171	20687
5	4066	4754	1440	1688	21170	22553
6	3614	4525	1220	1533	18662	20693
7	5141	4834	1362	1718	21008	21164
8	5159	5203	1170	1473	24529	24285
9	4849	5522	1257	1503	25036	27227
10	5483	5845	1159	1586	23702	24575
11	4671	5331	1248	1422	18910	23846
12	5040	5091	1530	1703	20775	25105

	KAPENGURIA		KAPSABET		KARATINA	
	Actual	Projected	Actual	Projected	Actual	Projected
1	3827	5473	6962	7079	15231	12223
2	3090	4972	5398	6506	14548	10512
3	3360	5575	6400	6812	15934	12145
4	4032	5457	6473	6368	16225	11513
5	3348	5109	6697	6882	9378	10056
6	3412	4983	6213	6571	5915	9081
7	3523	4854	6294	6465	9485	10697

8	3369	5247	6533	6708	10617	11717
9	3255	5293	6478	6741	11466	12263
10	3832	5339	6973	6986	11477	12805
11	3854	5385	7250	7305	8145	13459
12	4542	6034	6887	7483	6360	11565

	KERICHO		KITALE		KITUI	
	Actual	Projected	Actual	Projected	Actual	Projected
1	17300	15580	15110	11062	5402	6156
2	13657	13585	10730	10866	5138	5422
3	13724	15141	13330	11208	7123	6371
4	17222	15617	12199	11012	7137	6636
5	16221	15629	7423	9734	7242	7027
6	12744	12699	4938	9751	3944	5282
7	18139	16500	8029	9768	6685	5672
8	17620	15820	9073	10546	6230	6758
9	17615	15677	8070	10020	6221	6583
10	17461	16466	10935	10146	5582	6471
11	18434	16323	9631	10601	5887	6549
12	15084	16803	8539	10948	6195	6373

	KISII		KISUMU		LODWAR	
	Actual	Projected	Actual	Projected	Actual	Projected
1	15380	16356	21140	17303	1542	5348
2	14043	15573	18271	22544	1116	4892
3	16559	17121	18909	15713	1149	4419
4	18663	18325	20858	18030	1479	4489

5	17896	18997	21930	17498	1560	4560
6	15436	16549	20466	18358	1614	3473
7	17120	18510	25254	17826	1451	5523
8	19376	17887	23881	18657	1537	5368
9	18658	17816	23629	21817	1597	4539
10	19424	18498	25909	15939	1676	4912
11	21276	19948	23884	15439	1717	7474
12	20817	22944	31890	19494	1869	7579

	MACHAKOS		MALINDI		MARALAL	
	Actual	Projected	Actual	Projected	Actual	Projected
1	12205	12249	2660	4427	2354	3558
2	8192	12723	2120	4322	2164	3593
3	11324	13335	2260	4387	1854	2902
4	12506	14222	2969	4452	2590	3698
5	10683	12149	2900	3614	2900	3614
6	6091	11680	2105	4124	2049	3733
7	7964	12433	1838	4182	2194	3391
8	10933	13745	2120	3770	2311	3803
9	8909	11062	1433	4777	2090	3340
10	12812	12240	2269	4842	2251	3486
11	8808	12592	2127	3435	2231	3908
12	7648	7881	1809	4972	2059	2760

	MERU		MIGORI		MOMBASA	
	Actual	Projected	Actual	Projected	Actual	Projected
1	11449	9909	4622	4240	25400	25242
2	7978	8981	4122	4153	17814	22852

3	13003	8878	5342	4210	19396	27922
4	14660	8136	5171	4794	23300	28312
5	8151	8127	4960	4708	19650	22962
6	4576	5381	4698	4612	10790	23274
7	6197	9109	5899	5355	15650	23586
8	7518	9098	6028	5897	17869	15936
9	4834	9087	6324	5183	15420	22999
10	10045	9348	6132	5825	25576	22069
11	10667	10243	6165	6080	21132	21109
12	5344	10503	7207	5459	23508	28289

	MURANGA		**NAIROBI**		**NAIVASHA**	
	Actual	Projected	Actual	Projected	Actual	Projected
1	8754	8047	84647	76642	7461	6508
2	8379	8471	62464	73046	6660	6778
3	8445	8635	74863	76753	7003	7747
4	9838	8971	79844	70408	8185	7870
5	7241	7669	82336	86930	7424	7837
6	6040	6628	48956	86992	4197	7094
7	8111	8599	91881	90721	6400	7927
8	8738	7731	79137	75196	7735	7972
9	8476	9182	78784	82592	8036	7937
10	9566	9001	96720	90896	8137	8062
11	6179	8563	63222	73521	6608	7296
12	5689	5910	70172	73573	7584	8152

	NAKURU		NANYUKI		NAROK	
	Actual	Projected	Actual	Projected	Actual	Projected
1	22199	18776	7775	8460	3243	2792
2	18877	17118	8284	8819	2519	2896
3	19466	19265	8503	9709	2528	3235
4	22384	19893	8885	7950	3850	3440
5	22813	21100	9644	9282	3348	3376
6	15318	18082	3387	7078	2032	3379
7	23701	21219	6416	8854	3048	3619
8	20735	20118	9805	9747	2322	3385
9	20159	19398	9328	8867	2430	3080
10	21255	20230	10407	10295	2849	3323
11	19597	19311	7183	8171	3628	3496
12	22079	20930	5926	8889	2710	3261

	NYAHURURU		SIAYA		THIKA		VOI	
	Actual	Proj.	Actual	Proj.	Actual	Proj.	Actual	Proj.
1	7504	7674	8515	9817	15723	15591	6009	6874
2	4950	6390	6880	10240	13829	14795	4585	7717
3	6823	6385	7286	10359	15576	16466	5520	7796
4	6363	6316	8921	9745	17655	16988	7664	7009
5	6955	6503	8084	9643	10138	16520	6009	7318
6	4658	6370	8465	8787	8446	13238	4871	7471
7	5611	6429	9192	9210	11395	13260	6813	6352
8	7111	6678	10238	12049	14420	16601	7901	7372
9	7859	6355	8645	11073	10155	12471	7301	8270
10	7626	6477	9177	10073	13679	14990	6844	7097

11	7831	7931	8068	9841	9268	12345	5778	6742
12	8252	7608	9414	11430	9014	16709	7379	8507

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study was carried out to meet one objective; that is to formulate a methodology for forecasting sugar demand in each of KNTC's depots by using time series. This study made use of secondary information which was obtained from the records of the corporation. Five years (1986-1990) actual sugar sales were used to develop the models and one year (1991) actual sugar sales were used to validate the models. The models were constructed by using time series (decomposition method) as a forecasting technique. The study took the depots of KNTC as the final consumption points though this could be extended further to the wholesalers and the retailers. The modelling of the sugar demand or consumption required the choice of a planning horizon that takes into consideration the seasonality of sugarcane production from the farmers.

The findings of the study have shown that sugar demand patterns could be modelled using forecasting techniques (in this case decomposition method) by developing forecasting models for the sugar depots in the country. The study came up with 34 models representing 34 depots although KNTC has 36 depots in the Republic of Kenya. Sugar demand could not be modelled for 2 depots because they were established in the early 1991 and therefore do not have enough data to be used to construct the forecasting models. The models were shown to have high predictive powers and therefore could be used to forecast sugar demand at the depots.

Comparison of 1991 actual sugar sales and the predicted revealed that the individual model results were very close to the actual sales. The deviation between the actual and the predicted was minimal thus confirming the strength of the models to predict accurately.

The models are important as planning tool. The corporation can use them in making crucial decisions concerning production of and distribution of sugar, estimation of personnel needs in its depots and also improvement of financial and accounting operations. However, the model solutions would have to be modified in making daily decisions due to the changing business environments.

5.2 Recommendations

Forecasting is one of the many OR and statistical techniques. Like all other OR techniques, forecasting is subject to various assumptions outlined in chapter two. The application of OR techniques to KNTC's sugar distribution needs the services of an OR specialist or a statistician. The results of this study have shown that the management of KNTC would derive meaningful decisions from the use of OR techniques. Such techniques requires proper knowledge of the processes involved in converting raw data into useful information otherwise wrong analytical tools could be used. In addition to this, the analyst should be able to understand the assumptions of the model used, its application conditions and the limitations.

The implementation phase of the model is a delicate task which must be handled with great care. Before being implemented,

OR models require reorientation of management thinking. The managers ought to know the functioning of the entire model. They should be able to acknowledge that OR tools are there to help provide answers to which management would apply judgement to help arrive at meaningful decisions. Affleck-Graves et al[25], emphasized this clearly in their article which assessed managers' perceptions and desires in a developing country on Quantitative methods. They argued that:

> "The view that quantitative methods must necessarily provide a 'right' answer is no longer widely held. Instead, it should provide management with both information and insights which will help them in making choices in complex situations. The optimal solutions generated by quantitative methods may be used as a starting point to which management's judgement may be applied rather than as an end in itself."

Bearing the above explanation in mind, it is recommended that KNTC management should give serious thought to the utilisation of the forecasting models developed for making sound management, production and distribution decisions rather than the current ad - hoc methods. This will minimize the recurrent shortages experienced at certain depots while the overall sugar supply in the country is adequate. It is advisable that KNTC should establish an operations research department manned by an OR specialist or make use of the available OR consultants on a continuous basis.

5.3 Limitations

The major limitation of this study has been the time period available. The time was too short to cover all aspects one would

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[25] Affleck-Graves et al, "Quantitative Methods in a Developing Country: Managers' Perceptions and Desires". Omega, Vol. 15, No. 6, 1987. p.525.

have liked to include in the study in order to come up with more meaningful results. The adopted time frame in the study limited the researcher to the data available in the Head office. It is possible that more meaningful information would have been obtained from the depot and regional managers themselves who interact with both wholesalers and retailers.

There exists the general limitations of the adopted analysis technique. It is possible that the assumptions enumerated in chapter two did not hold throughout the period of study.

Another limitation is that the study relied on secondary data which had been compiled by someone else. Therefore, there is the possibility that mistakes could have been made when the depot monthly sales were being compiled. Potential problems arise when the person writing the report records wrong figures or wrong units of weight.

Operationally, the suggested use of forecasting model may pose difficulties in that the K.N.T.C. will have to acquire the necessary equipment and personnel before putting it into use. The administrative process needed to approve the implied expenditure may therefore take some time. In implementing any OR decision making model, it's always necessary to retrain the current personnel, acquire additional equipment and software, and generally change management philosophy, factors that will all cost money and time. But with the discussed benefits at stake, all these may be worthwhile investment.

5.4 Areas for Further Research

It is being recommended that a similar study could be replicated on other products handled by KNTC because like sugar, other commodities distributed by KNTC pose the same problem to the management.

The depots of KNTC have been used by the researcher as the final consumption points of sugar, whereas in the real sense, the final point of sugar distribution is the retailer. A study could be carried out that estimates the demand for sugar at this point so that the results can be compared with this study's to see if there is any difference and hence alternative courses of action.

Another area for further research could be the determination of the Economic Order Quantity of sugar in all the depots. This would improve the internal stock control of sugar. This study found that the management of KNTC do not use any objective method (statistical tool) in determining when to place the next order of sugar and the quantity to order.

APPENDIX A

DATA COLLECTION FORM

DEPOT _____

YEAR	MONTH	SUGAR DEMAND (BAGS)
1986	1	_____
	2	_____
	3	_____
	.	.
	.	.
	12	_____
1987	1	_____
	2	_____
	3	_____
	.	.
	.	.
	12	_____
1988	1	_____
	2	_____
	3	_____
	.	.
	.	.
	12	_____

1989

1

2

3

.

.

12

1990

1

2

3

.

.

12

1991

1

2

3

.

.

12

APPENDIX B

SUGAR DEMAND FOR KNTC DEPOTS (100 KG BAGS)

MERU

MONTH	1986	1987	1988	1989	1990	1991
1	9087	11147	10829	11865	7597	11449
2	7884	10874	9816	11865	5622	7978
3	7975	10644	11303	8531	7830	13003
4	9391	9707	12819	5495	7395	14660
5	3709	8236	7907	7607	11284	8151
6	4919	829	5720	7748	8507	4576
7	7340	12050	12296	6857	13926	6197
8	8335	11451	11759	8781	16555	7518
9	9575	11945	12966	7877	9947	4834
10	9212	10534	9691	8792	8385	10045
11	10237	11807	10451	9562	12757	10667
12	11825	10847	11094	10027	10858	5344

NYAHURURU

MONTH	1986	1987	1988	1989	1990	1991
1	6604	5402	7208	6365	5918	7504
2	6128	7377	6982	7055	6021	4950
3	3738	7202	7178	6283	5138	6823
4	5737	7216	5930	4682	7203	6363
5	6033	6830	5772	6510	8224	6955
6	4377	6840	8011	6703	7363	4658
7	6007	6418	6026	7547	9601	5611
8	7265	6862	3859	5927	7454	7111
9	6519	6278	6112	7005	6369	7859
10	6752	7476	5726	4810	7251	7626
11	6266	6827	6187	6340	6943	7831
12	8140	9127	7756	5791	7925	8252

MARALAL

MONTH	1986	1987	1988	1989	1990	1991
1			1046	1865	1990	2354
2			1250	1680	2227	2164
3			1670	1495	1938	1854
4			1103	1509	2041	2590
5			1493	1843	2300	2174
6			1520	1903	2135	2049
7		665	1425	1668	2569	2194
8		914	1890	2181	2864	2311
9		1483	1400	1590	2290	2090
10		1076	1408	1730	2519	2251
11		1420	1638	2289	2236	2231
12		1338	1714	1911	2572	2059

MIGORI

MONTH	1986	1987	1988	1989	1990	1991
1	3502	3824	4953	9055	5880	4622
2	3413	4086	5296	8745	5089	4122
3	3274	3709	5910	8070	6081	5342
4	4297	4864	6135	7905	6424	5171
5	5287	4377	5477	9468	7423	4960
6	3906	4634	5982	9089	6444	4698
7	4197	4639	10478	9253	8880	5899
8	4843	4940	10051	11896	6875	6028
9	4779	5020	7730	9867	5618	6324
10	5136	5086	6572	7712	6363	6132

11	4261	4304	6473	7158	5122	6165
12	5363	6033	8748	8583	5792	7207

SIAYA

MONTH	1986	1987	1988	1989	1990	1991
1			2293	3615	6685	8515
2			2780	6707	6959	6880
3			3170	5322	7438	7286
4			3019	4320	6584	8921
5			2796	3702	7790	8084
6			4013	3255	7477	8465
7		2437	2918	4195	8292	9192
8		2964	3836	6214	10739	10238
9		2653	4332	4933	8566	8645
10		2191	3036	5670	9618	9177
11		2522	3696	4747	6934	8068
12		3174	3850	7202	8890	9414

HOMA BAY

MONTH	1986	1987	1988	1989	1990	1991
1	4401	2539	2539	3592	4839	4400
2	3552	3212	3212	3226	3988	4292
3	2872	1968	1968	3801	4418	3865
4	4292	3313	3313	2968	5947	4812
5	4137	2195	2195	3095	5942	4066
6	4398	2615	2615	3280	4572	3614
7	3386	2505	2505	3535	5552	5141
8	2920	2576	2576	4373	6272	5159
9	3090	2591	2591	4690	5415	4849
10	3089	2766	2766	5205	5567	5483
11	2387	3212	3212	4233	4974	4671
12	3634	4843	4843	5107	5231	5040

LODWAR

MONTH	1986	1987	1988	1989	1990	1991
1			530	595	4076	1542
2			400	470	1885	1116
3			420	420	1902	1149
4			315	500	1700	1479
5			321	425	2176	1560
6			286	622	1658	1614
7			346	418	2082	1451
8			540	706	2057	1537
9			474	486	1733	1597
10			380	1258	2121	1676
11			515	1888	1371	1717
12			520	2237	1473	1869

KAPENGURIA

MONTH	1986	1987	1988	1989	1990	1991
1		2605	2522	3371	4301	3827
2		2077	2676	2036	3622	3092
3		3285	3154	7671	3634	3660
4		1554	2584	3434	4229	4032
5		2273	3408	3573	3028	3348
6		2161	2646	3003	3659	3412
7		2398	2504	2531	2586	3523
8		2541	3034	3229	4805	3369
9		2485	2845	3844	4123	3255
10		2635	2737	3852	6550	3832
11		2654	2756	4076	3634	3854
12		2696	3256	3930	4122	4542

VOI

MONTH	1986	1987	1988	1989	1990	1991
1	5104	2078	4534	6155	7638	6009
2	3452	3630	5159	6490	5941	4585
3	4437	3011	5909	7692	7364	5520
4	4678	1571	5387	8180	6360	7664
5	2648	2190	5019	6482	8511	6009
6	3771	2593	7520	6442	5594	4871
7	4797	2476	9094	9000	8932	6813
8	3407	2410	7700	5354	7931	7901
9	3317	4990	7466	5354	5612	7301
10	3974	4055	7045	6187	8907	6844
11	2028	4525	6535	6321	6086	5778
12	3590	5723	7340	7434	6385	7379

NAIROBI

MONTH	1986	1987	1988	1989	1990	1991
1	64681	47915	73695	79481	60216	84647
2	54438	51239	70293	79585	71869	62464
3	59450	50756	72958	114933	50533	74863
4	69339	48660	69669	94955	50749	79844
5	35185	42640	73563	99947	84506	82336
6	34117	53984	79418	86498	97904	48956
7	55361	68545	87808	85174	91510	91881
8	35118	59539	90349	58873	82324	79137
9	38885	68169	93049	80752	74786	78784
10	38703	69837	79635	92300	92750	96720
11	38059	66219	79353	90150	77360	63222
12	67357	74923	81558	65716	66160	70172

THIKA

MONTH	1986	1987	1988	1989	1990	1991
1	17502	16172	14829	15590	13960	15723
2	15590	16610	15125	16209	12040	13829
3	16127	14254	17075	17405	16440	15576
4	12769	15093	14635	17810	18303	17655
5	5636	14005	16060	15473	25870	10138
6	3978	14990	16665	8725	11906	8446
7	10771	15705	16255	12068	19725	11395
8	14053	15595	16760	15790	12250	14420
9	14348	15310	17377	13905	16522	10155
10	13049	17150	16801	13680	16449	13679
11	12188	16985	17591	16128	15939	9268
12	21220	18290	17222	14577	17795	9014

MURANGA

MONTH	1986	1987	1988	1989	1990	1991
1	6635	7399	9012	9937	7873	8754
2	7559	7497	9862	10922	7812	8379
3	7850	9239	10397	8189	8860	8445
4	9791	9429	9877	8034	10780	9838
5	4325	8160	7705	8722	8020	7241
6	4395	9486	6526	3801	8803	6040
7	9452	10045	9709	8101	10913	8111
8	8980	8091	10339	6405	9749	8738
9	9661	9738	10118	8547	10044	8476
10	9587	10997	8492	8223	10120	9566
11	8193	10173	9504	8207	9432	6179
12	11749	12112	11775	9517	10819	5689

NAROK

MONTH	1986	1987	1988	1989	1990	1991
1	3469	3250	3347	3015	1514	3243
2	2879	3239	3135	2967	2339	2519
3	2889	3213	3424	3041	3382	2528
4	4102	3403	3285	3722	3424	3850
5	2024	3337	2651	3623	3951	3348
6	643	3490	3374	2125	6546	2132
7	3316	3513	3972	3634	4521	3048
8	2867	3211	3777	3477	4521	2322
9	3080	3180	3762	3233	3591	2430
10	3255	3104	3586	2562	3574	2849
11	3056	3687	3186	3101	3489	3628
12	3598	3538	3174	2367	3581	2710

NAKURU

MONTH	1986	1987	1988	1989	1990	1991
1	15070	18229	18419	19476	29850	22199
2	13938	17328	19336	18774	17589	18877
3	13923	18202	22533	21066	25717	19466
4	18599	20452	19912	23389	26015	22384
5	12864	17213	20289	23546	27011	22813
6	7759	18311	18777	22107	23780	15318
7	16349	19538	18700	29599	26075	23701
8	16545	18340	20823	27942	24950	20735
9	16018	18345	20176	24120	23819	20159
10	16977	19812	19926	28339	25236	21255
11	15285	19313	21098	28044	21092	19597
12	20888	22105	22712	23770	22386	22079

MOMBASA

MONTH	1986	1987	1988	1989	1990	1991
1	17003	125	19474	22167	24379	25400
2	15392	5890	23079	19783	19347	17814
3	16168	743	27170	30835	25348	19396
4	37501	595	20929	29675	25395	23300
5	31031	505	20038	26640	16677	19650
6	28595	405	18625	27338	20350	10790
7	3242	670	23870	45390	25881	15650
8	487	305	22786	24842	24581	17869
9	1130	9875	23972	24040	26762	15420
10	361	6395	23877	21928	32365	25576
11	560	5154	22899	23032	19474	21132
12	740	16330	24665	23124	20485	23508

NAIVASHA

MONTH	1986	1987	1988	1989	1990	1991
1	4950	4327	4550	6380	5260	7461
2	4270	4789	5480	5990	5110	6660
3	4939	4700	6580	6800	6886	7003
4	5190	5620	5020	7005	7228	8185
5	4816	5375	5864	8700	7780	7424
6	4863	4880	5790	7140	6012	4197
7	6320	5490	6220	7379	8616	6400
8	5010	5150	6570	7770	7856	7735
9	5035	5414	6052	5990	7400	8036
10	5175	5660	6330	5920	8042	8137
11	4620	5320	6010	5700	7955	6608
12	6661	6729	7830	6010	7732	7584

MALINDI

MONTH	1986	1987	1988	1989	1990	1991
1	2420	240	1680	2440	2729	2660
2	1870	300	1945	2065	2220	2120
3	1520	180	2360	2660	2765	2260
4	3480	160	2050	3210	2970	2969
5	1143	160	2070	2615	2136	2900
6	490	240	2050	3280	2320	2105
7	1610	140	2080	1975	2765	1838
8	357	200	3005	2955	3400	2120
9	450	1330	3200	3625	2960	1433
10	80	1440	3650	3030	2972	2269
11	150	765	2425	2490	2640	2127
12	260	1696	2580	3250	3030	1809

KITUI

MONTH	1986	1987	1988	1989	1990	1991
1		2640	7000	5240	4659	5402
2		3037	5210	5020	4771	5138
3		4204	6125	6018	5678	7123
4		4636	5625	6910	5942	7137
5		3541	5415	6930	7415	7242
6		2935	5395	3808	5832	3944
7	3512	3657	5841	4950	7426	6685
8	3385	4724	6075	6457	7604	6685
9	3565	5678	6250	4990	7267	6221
10	3508	6325	5622	4482	8168	5582
11	2818	6140	5553	5270	6131	5887
12	5575	6107	6187	5130	6936	6195

NANYUKI

MONTH	1986	1987	1988	1989	1990	1991
1	10019	6647	9660	7784	8722	7775
2	8030	8965	10422	8745	8274	8284
3	9484	8362	11557	9750	8661	8503
4	11316	8883	9089	6489	7960	8885
5	5647	7583	8910	5621	7271	9644
6	5813	8100	6328	5323	8964	3387
7	9901	9645	7494	7900	12444	6416
8	7928	9630	9969	9292	9646	9805
9	7695	7485	9975	7751	9817	9328
10	8439	10452	11312	8686	12609	10407
11	5399	8710	9025	7738	9048	7183
12	6235	11246	9520	8110	7538	5926

GARISSA

MONTH	1986	1987	1988	1989	1990	1991
1		166	1343	3139	4437	3283
2		1554	1604	4656	4028	3130
3		1650	3892	8880	5580	5909
4		2780	2387	4477	3832	6901
5		2005	4687	3867	6985	5003
6		2164	1448	8924	6792	3036
7		2024	3727	4580	6867	4101
8		2316	5459	6840	5779	5601
9		1879	4358	3657	4122	7035
10		1780	3513	3733	4842	9928
11		1878	1789	1814	1866	8599
12		1027	2342	2968	2424	7414

KITALE

MONTH	1986	1987	1988	1989	1990	1991
1	13700	8680	10875	10000	10595	15110
2	9620	10030	9720	10500	9445	10730
3	9760	6910	13040	11160	10240	13330
4	12180	9110	9600	11950	10095	12199
5	10732	11390	10315	11900	8486	7423
6	9750	8740	8540	10720	8540	4938
7	10370	8460	8390	9230	9805	8029
8	10190	7860	10430	10440	13035	9073
9	9750	7694	9090	10640	10518	8070
10	10010	8460	8600	9860	15275	10935
11	9725	8530	10360	9900	10550	9631
12	13285	12566	12220	10740	15275	8539

KISII

MONTH	1986	1987	1988	1989	1990	1991
1	10263	10876	9234	10590	20274	15380
2	9841	10401	10945	10290	15480	14043
3	10127	10298	11783	12190	18396	16559
4	13999	12648	12530	14812	15061	18663
5	11833	10909	12115	15160	20573	17896
6	11685	11241	11340	11458	17206	15436
7	11888	11632	12045	15242	16686	17120
8	12291	11368	12192	13531	18898	19376
9	12397	10916	12192	13720	17350	18658
10	12714	11268	11946	15451	17964	19424
11	12944	11838	13223	17518	18438	21276
12	16327	16292	16350	18798	20762	20817

KISUMU

MONTH	1986	1987	1988	1989	1990	1991
1	39292	25722	30294	43092	25090	21140
2	30707	39759	30268	87521	17369	18271
3	32165	14693	34362	48751	20912	18909
4	37501	25955	33963	50130	23722	20858
5	31631	25995	36230	25640	24666	21930
6	28575	29171	31068	35965	20371	20466
7	30745	25855	34574	47603	23587	25254
8	29212	20954	39140	49171	26900	23881
9	29985	25880	39845	38746	22809	23629
10	25612	29243	36754	35941	24804	25909
11	20781	26800	41682	35692	20674	23884
12	33679	33722	51400	36753	23665	31890

BUNGOMA

MONTH	1986	1987	1988	1989	1990	1991
1	12480	12165	8220	13965	7264	8083
2	9775	9880	8990	15427	6741	6656
3	11085	9905	10846	14825	6409	6967
4	13205	10705	9450	12030	7317	11202
5	10355	9095	11710	11176	8157	8636
6	10705	9105	12150	9797	6555	4386
7	11965	9780	12450	9335	8867	5911
8	12080	8690	12805	6462	10058	5529
9	12430	9110	11036	5702	8007	5107
10	13400	8969	10339	6353	8791	6458
11	11920	8680	11005	6685	8095	5538
12	16915	11035	13775	7730	8493	7667

BUSIA

MONTH	1986	1987	1988	1989	1990	1991
1	2395	8095	3792	12185	5761	4751
2	1618	6368	4896	7052	3622	4313
3	1306	6630	5655	9703	4453	5727
4	1946	5868	6871	5807	4660	7973
5	2745	4997	8382	7669	5815	7915
6	2277	4226	8085	5255	5901	6777
7	2372	2898	10030	7174	6533	8405
8	2536	4247	9523	6558	10400	10045
9	2959	6632	6129	3446	10550	7301
10	4209	5028	5713	4506	11922	8090
11	4851	6086	4855	5805	10900	5144
12	6512	4107	7623	6872	7050	7400

KERICHO

MONTH	1986	1987	1988	1989	1990	1991
1	13329	13234	14416	16047	16184	17300
2	11583	12357	14938	14420	11118	13657
3	11942	13799	17484	16382	11871	13724
4	14911	15357	15600	14643	14905	17222
5	14592	12912	14810	17772	15047	16221
6	13025	13109	12519	10497	13631	12744
7	16035	14663	15301	17103	16877	18139
8	13257	14109	16407	14874	17681	17620
9	13768	14203	16715	15089	15215	17615
10	16672	14654	16342	15301	17707	17461
11	13925	18034	18131	10406	16993	15084

MACHAKOS

MONTH	1986	1987	1988	1989	1990	1991
1	8755	6622	8746	12275	10303	12205
2	10292	7625	9150	11665	10571	8192
3	10040	7580	14160	9731	10184	11324
4	11868	6930	10964	14159	12664	12506
5	5762	6995	10469	11978	8976	10683
6	7081	7260	7474	12702	9125	6091
7	7714	8850	9653	9279	13805	7964
8	13233	8956	13010	10451	13928	10933
9	7737	8850	12477	9231	12018	8909
10	5154	9290	11679	9584	15257	12812
11	5399	11036	12475	10508	11940	8808
12	9844	13270	14930	10101	11696	7648

ELDORET

MONTH	1986	1987	1988	1989	1990	1991
1	15675	15449	16380	18698	21952	28180
2	12520	16850	19624	19627	14628	8146
3	12485	13792	18330	20075	15760	13101
4	15230	18060	17230	20615	16588	18049
5	13580	16320	16336	22459	16544	16819
6	14160	15191	16610	18993	14236	12040
7	14170	17830	17549	18738	17860	20744
8	13195	14880	24486	26060	19641	15265
9	13940	20000	19721	33617	18151	15526
10	13087	15231	18020	21957	25328	16891
11	12496	15244	17745	18589	10250	17840
12	17441	19920	22287	18760	16090	22900

KAKAMEGA

MONTH	1986	1987	1988	1989	1990	1991
1	9327	8448	9511	10509	19583	19949
2	8733	11743	9015	9222	17624	16309
3	8040	7587	11057	10433	20559	15552
4	9669	9721	9790	10605	22122	19171
5	8849	9326	9946	12513	22149	21190
6	8848	9089	9510	11108	19901	18662
7	9123	8713	10008	10488	23060	21008
8	9472	8888	11915	14943	27684	24529
9	10095	9876	11622	20236	27099	25036
10	9438	9765	11088	25742	28717	23702
11	7585	9991	10216	19000	21246	18910
12	10635	11755	12249	20596	21336	20775

KARATINA

MONTH	1986	1987	1988	1989	1990	1991
1	14647	14625	13975	14160	11709	15231
2	12266	12870	14225	10371	10300	14548
3	13285	13872	14890	14723	11487	15934
4	14210	18275	13785	9420	11449	16225
5	6003	10885	13454	13552	7884	9378
6	5887	14077	7297	8821	11511	5915
7	9715	14400	15147	9991	14400	9485
8	10765	14130	14885	13130	17030	10617
9	13910	14680	14795	11928	13086	11466
10	14327	14210	16590	12841	16275	11477
11	14106	14860	15575	16112	14609	8145
12	19350	17582	17100	12010	17945	6360

EMBU

MONTH	1986	1987	1988	1989	1990	1991
1	10954	9234	8942	10687	12137	11139
2	9551	8724	9414	9312	7670	9564
3	10142	9106	11594	8750	9661	10853
4	12406	11497	9616	10525	10328	10707
5	5974	11564	10981	9008	9142	8936
6	7640	10205	8350	5138	8423	6798
7	10733	10623	11092	8736	12723	7705
8	10581	9714	11397	11448	10730	10633
9	10102	10130	11174	7529	11110	9432
10	9757	10658	9389	9241	12077	10809
11	8360	9764	11949	10417	11321	8874
12	10398	12320	12261	8789	10367	6911

KAPSABET

MONTH	1986	1987	1988	1989	1990	1991
1	5660	5027	4718	5959	7609	6962
2	4980	5040	4666	5368	6276	5398
3	4990	4605	5598	6037	6941	6400
4	6030	3404	4855	5767	7031	6473
5	5817	4675	5303	6187	6227	6697
6	3952	4605	4709	6010	6032	6213
7	5365	4877	4942	4528	6598	6294
8	5298	4741	5095	5441	6590	6533
9	5518	4602	5611	5177	6069	6478
10	5447	4760	5600	6789	7564	6973
11	5093	4754	5856	6789	6166	7250
12	6671	5737	6270	6278	6943	6887

HEAD OFFICE

MONTH	1986	1987	1988	1989	1990	1991
1	2385	1160	1845	1085	1120	760
2	1520	760	685	1410	1520	720
3	2840	400	1770	1370	1880	720
4	2565	1520	1480	1050	1480	720
5	800	725	760	1285	1120	1120
6	2680	1080	1805	1410	1880	1480
7	2205	1445	2170	1405	1880	1780
8	1560	1410	725	1845	1880	1490
9	1520	1420	685	1880	2600	1800
10	800	1845	-	1090	2600	2760
11	-	1482	1370	1120	360	1920
12	325	725	760	1120	1480	1600

KABARNET

MONTH	1986	1987	1988	1989	1990	1991
1	876	911	978	1030	1827	1510
2	690	778	1010	1139	1295	1089
3	835	696	1154	1221	1455	1025
4	897	860	921	1070	1356	1080
5	911	884	1209	1506	1515	1440
6	994	902	880	1038	1351	1220
7	1026	820	1034	1876	1300	1362
8	832	702	1065	1201	1355	1170
9	812	1019	1038	1336	1236	1257
10	856	796	1041	1230	1465	1159
11	602	889	944	1186	1050	1248
12	774	1032	955	1275	1215	1530

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