"FORECASTING STANDARD ONE ENROLMENT
USING MARKOV CHAIN PROCESS
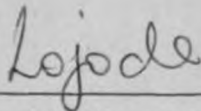A CASE OF NAKURU MUNICIPALITY"

BY

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A PROJECT SUBMITTED IN PARTIAL

FULFILMENT OF THE REQUIREMENT

FOR THE DEGREE OF MASTER OF
BUSINESS AND ADMINISTRATION

FACULTY OF COMMERCE
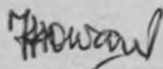UNIVERSITY OF NAIROBI
NAIROBI, KENYA

June 1989

THIS MANAGEMENT PROJECT IS MY ORIGINAL
WORK AND HAS NOT BEEN PRESENTED FOR   A
DEGREE IN ANY OTHER UNIVERSITY

Lojode

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THIS   MANAGEMENT   PROJECT   HAS   BEEN
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DEDICATION

TO
Sam
and
Titi

ACKNOWLEDGEMENTS

ABSTRACT

Standard one enrolment present a recurring problem to both the parents and the authorities in the urban centres in Kenya. The study detailed in this report sought to represent the standard one enrolment in Nakuru Municipality as a Markovian Model and to use the Model to predict the demand for standard one for the future.

Data on standard one enrolment from 1969 to 1988 and the demand for standard one places for 1989 were collected from the Municipal council records.

Part of the data collected was used to build a Model of the system and part was used to validate the said Model. The model was then used with the 1989 demand to predict the demand for 1990, 1991 and 1992. Similar analysis was performed for the boys only, the girls only and both boys and girls data combined.

The results of the study indicate that the demand for standard one will be greatest in the central zone, followed by the western and the eastern zones respectively. The boys demand for standard one places on the other hand will be greatest in the eastern zone followed by the central and then the western zones. The girls demand for standard one places will be greatest in the western zone followed

by the central zone and the eastern zone respectively.

With such results, it is recommended in this report for the Municipal council to concentrate their resources like administrative effort, time, money and personnel in the central zone, for administering in the area where demand will be greatest. It would also be appropriate to use the results given above as a resource allocation measure, so that resources are distributed equitably among the zones. Finally, the Model may be used to allocate most of the girls' exclusive facilities (like girls only schools) to the West and most of those exclusive to the boys (like boys only schools) to the East.

SECTION ONE

INTRODUCTION

1.1 BACKGROUND

From as early as 1965, Kenya had recognised certain constraints which educational planners had to face, vis; population growth, economic pressures, political pressures, teacher supply, manpower demand and need to maintain quality.[1] However, a quarter of a century has not been enough to meet most of these hurdles and planning for educational activity is becoming more complex, intricative and involving with the passage of time. In present day Kenya, the complexity in planning has resulted from such factors as; economic planning restructuring, that is, from the centralized form of planning at the central Government level to the decentralised form at the district level (The District Focus), population increase, rural-urban migration, restructuring of the education system from the "7-4-2-3" to the "8-4-4" system of education and other development related factors. Usually, the major manifestations of rapid change, and all the problems that change brings are found in the urban centres.[2] The degree of urban complexity tends to be a function of size and scale of operations. As the population increases in size, the larger the scale of modern sector activities, the more complex the urban society becomes and the more difficult it becomes for the Government to plan and respond to the problems created by changes.

In the developing countries, education and economics are closely interdependent for it is necessary to ensure that there are enough persons with all the skills needed for economic growth, and also enough jobs to take advantage of their skills - a balancing act that requires continuous adjustment and hence continuous planning. For appropriate manpower planning, therefore, education is necessary and is a basic foundation for national development. Primary school education, particularly, is important as this is the "mouldable" age, the kind of education exposure received determine to a great extent the direction of the future personal development opportunities. A common feature of most developing countries like Kenya is a "pyramidical" population structure, that is a population where the majority are young people (school age), this implies that by virtue of their number the youth deserve a lot of the country's resources. These resources must, therefore, be planned for adequately. It is in this light that education constitutes one of the most important national development priorities and consumes a large proportion (38%) of the Kenya National budget.

The importance vested on primary education is not a new phenomenon. For, as early as 1969, Municipal and County Councils were already vested with the responsibility of financing and developing of primary education. It is not until the Local Government (Transfer of Functions) Act, enacted in 1969, that the overall responsibility for primary education in rural areas

transferred to the Central Government.[3] In urban areas,
Municipalities have retained responsibility for financ-
ing and operating primary schools and this has resulted
into greater standadization within the town and better
(smaller) planning units.

An outstanding feature of most developing countries
like Kenya is a population growth rate (3.64%)[4] above
the annual economic development rate (3.5%)[5] This means
that whereas there is growth in the economy, the popu-
lation rate of increase outstrips this growth, thus
there is a general rate of decline within the general
economy.

This feature signifies a major problem to planners
as resources keep diminishing in the face of a largely
young populace. With an estimated annual net growth
rate (1980-1990) of 3.54% and an estimated population
of 24.9 million for 1990,[6] there is a greater need for
planning than ever before. The pressure of this popu-
lation on resources is felt most in the provision of
basic needs like food, shelter, health services and
education.

The Rural-Urban drift, a feature of countries
like Kenya, occurs when people move from rural to
the Urban areas in search of a better means of live-
lihood. This drift makes the population density

higher in the urban areas than the rural ones and the
impact of such a population is thus higher in the urban
areas than in the rural areas. With a higher population
density than the National average (this is diluted by
rural areas), the urban areas also have a higher popu-
lation rate of growth far above the National average.
Whereas the whole country is facing a projected rate
of growth of 3.64% for the population, Nairobi and
Nakuru both face a population growth rate of 4.71%,[6]
about one and a third (1 $1/3$) times the national rate.
The provision of school amenities is, thus, a major
problem to urban authorities, and the planning for
primary school enrolment alone is a very difficult and
complex process. With a projected population of 952,000
people by the year 2000, the primary school age child-
ren (5-14 years) shall constitute 291,023 or 31% in
Nakuru district alone![7] In Nairobi for instance,
parents miss schools for their children because the
schools are not enough. Indeed, cases abound where
parents stay in the cold as they queue for their child-
ren to enrol in standard one at the beginning of each
year (notwithstanding the fact the "place" was reserved
three years earlier) and Nakuru has not been spared
this pain! As a control measure, the Nakuru Municipal
insists that children must attend pre-unit (preprimary)
centres for about three years until they attain the
minimum age of 6 years before they can enrol in standard
one. A child whose age is five years and nine months

would not enrol and even where a child has attained 6
years, their older counterparts would be given priority.

Such problems as above are brought about by inade-
quate planning as well as slow growth in the provision
of the amenities in the face of an escalating population.
To arrest such a situation, more aggressive planning is
necessary especially in the urban areas of developing
countries like Kenya. Intensive research is necessary
if developing countries are to have a chance of making
sufficiently rapid progress in resolving their problems.
The painful alternative is to have their education too
much patterned on the advanced countries, unsuited to
their own needs, and far beyond their financial resources.

1.2   BACKGROUND OF NAKURU MUNICIPALITY

The origin of Nakuru town, just like many other towns
in Kenya, is closely linked with the development of the
Kenya-Uganda Railway. In 1900 when the first shop opened
its doors, apart from the indegenous people, Nakuru
residents consisted mainly of railway employees. The town
grew so fast that on January 28, 1904, the then British
Commissioner in Kenya declared Nakuru a township in the
Official Gazette. The town was then within only a mile's
radius of the entrance of Nakuru Railway station. In
1905, Nakuru township was just a collection of the
railway station, a few houses for the railway staff
and two shops. The following year the first hotel
Nakuru Hotel (now, Midlands) opened it's doors, followed by

the National Bank of India (The Kenya Commercial Bank today).

The town's status was bolstered when in 1912, following the completion of the railway survey of the line from Nakuru to Eldoret, it was decided that it should be the main junction for the line running to Kisumu as well as Eldoret. This new development necessitated the boundaries of the town to be expanded in 1913. In 1929, the town had become so important that a Municipal Board was formed thereby giving it Municipality status. Although the depression of 1930s and later the Second World War affected the town by reducing its rate of development, progress resumed after these which enabled the Governor of Kenya to proclaim the elavation of the Municipal Board to the status of a Municipal Council in 1952.

Nakuru Municipality consist of the town center and its suburbs (see Map), and, it is run by the Nakuru Municipal Council although the town also houses the headquarters of Nakuru County Council as well as the Provincial Commissioner's and District Commissioner's headquarters. The town is situated on the bed of the geographical wonder, the Great Rift Valley. It is the fourth largest town in Kenya and is surrounded by the Lion Hills, Lake Nakuru, the extinct volcanic hill, Menengai, and Honeymoon Hill to the Southern part. With an area of some 78 square kilometres, the town lies 36 degrees East and 0.4 degrees South of the Equator. Nakuru is some 97 miles from Kenya's capital city, Nairobi and 451 miles from the port town of Mombasa, at an attitude of 6,070 feet above sea level.

Nakuru is known as the capital of the country's rich
agricultural highlands while administratively, it is the
headquarters of the Rift Valley Province. His Excellency
President Daniel Arap Moi's Permanent home is barely 25
kilometres from the town at Kabarak, and his frequent
presence at the Nakuru State House has enhanced the
town's political status.

With a population of some 200,000 people, Nakuru's
appeal to people emanates from its healthy climate, which
is usually temperate to warm, varying with seasonal rains
between March and May while dry weather prevails during
Mid-November to the end of February. It receives an
average annual rainfall of 103.8 mm. Nakuru is famous
worldwide for its over 400 species of birds found at
the Lake Nakuru National Park.

The smooth running of Nakuru Municipal council is
made possible by a number of standing and special com-
mittees. Viz:-

(i) Finance and General Purposes Committee.

This has the superitendence, management and control of
the Town Clerk's and the Municipal Treasurer's Depart-
ments. The committee also; procures and examines esti-
mates of expenditure, from the several other committees
and prepares the general estimates of receipts and expe-
nditure; considers and reports to the council upon the
financial effect of any scheme or work proposed to be
carried out by the council; directs and superitends the
keeping of accounts of all the departments of the council,
examines and passes accounts for the salaries and wages

of the various officers, clerks and workmen of the council,
and, for the money payable to contractors of the council;
negotiates all loans of money which may be ordered by
the council; deals with the powers and duties of the
council in relation to matters of valuation of heredi-
taments within the Municipality; hears and determines
applications to be excused payment of any rates and
carries out the general instructions of the committee
in relation to fulfilling all duties not delegated to
any other committee of the council.

(ii) Town Planning and Works Committee.
This is involved with the implementation of both short
and long term plan to accomodate the town's ever growing
population. The Town planning department works very
closely with the Ministry concerned with urban develop-
ment and housing's physical planning, while the work's
department looks after the water supply, roads, trees
and gardens, sewers and sewage disposal, housing schemes,
construction of schools, street lighting and council's
workshop.

(iii) Housing and social services Committee.
Carries out the duties of providing houses for the council
staff and the general public within the municipality and
provides markets and trading centres in the Municipality.
The committee, through the social services department
looks after day nursery schools, destitutes, libraries
and information services, cinema shows, the stadium, youth
club activities and adult literacy and evening continuation classes.

(iv)   Public Health and Education committee

This has superintendence and control over the management of
public health department while taking into consideration all
questions affecting the health of the inhabitants of the
Municipality over which the council may have jurisdiction.
The Committee also looks after the education vote, plans
any development of education in the Municipality, and co-
ordinates the work of school committees with that of their
own local school committees. This Committee was split up
into two separate committees, Education and Public Health,
operating under two different Chairmen in 1988.

Currently, Nakuru Municipality has about twenty seco-
ndary schools (four of them being council maintained),
forty primary schools and fifty Nursery Schools. The number
of pupils attending primary schools within the Municipality
has risen from 17,050 in 1979 to 31,700 in 1989, while the
demand for standard one places rose from 3,170 to 3,550 in
the same period. In 1980, the council was maintaining only
about thirty primary schools, which number has risen to
thirty-eight. This rise has been necessitated by increase
in student population. The nursery schools have also
increased from thirty one to fifty (though the Municipa-
lity only maintains six of these), thus increasing demand
for standard one places.

The education department is manned by about thirty
staff members headed by the Municipal Education Officer
(M.E.O) and his deputy. This task force is responsible
to the committee for the administration of education

system within the Municipality. Due to the large
number of schools involved, three educational zones
were established in 1986 as follows: Central Zone,
with eleven schools, Western Zone - twelve schools
and Eastern zone-twelve schools. The zones are manned
by Zonal Inspectors; thus as well as facilitating
administration, the establishment of the zones was
meant to intensify easier schools' inspection. In
1987 an extra zone, the Southern Zone, was added and
in 1988 three more schools were started while some
old ones were expanded to accommodate increased enrol-
ment. The Zones were however reduced back to three
in early 1989, when one of the inspectors was promoted
to the post of Assistant Municipal Education Officer.
The map of Nakuru Municipality clearly shows the
distribution of the schools within the zones.

1.3 STATEMENT OF THE PROBLEM

The provision of Educational amenities in Kenya do
not match the needs particularly within the urban
areas. This mismatch is due to the problems of
high population growth and density in the urban areas.
The rural-urban migration also makes the population

growth rate within the urban areas high and in the
face of limited resources, the local authorities
cannot match the resources to the needs. This has
been evidenced in Nairobi and other towns in Kenya
where parents miss primary school places. The
major causes of the mismatch are the inability to
make accurate projections of needs (brought about
by the above factors) and lack of funds to meet the
needs.

There is a problem of lack of accurate projec-
tions of school enrolment, particularly, in standard
one in the urban areas. If accurate projections can
be obtained, the resources can be mobilised to meet
the needs from one year to the next. For instance,
if standard one enrolment can be projected with
some measure of accuracy, say, for the next five
years then, funds can be sought to prepare for such
now. To evolve an efficient system of education,the
activities need to be co-ordinated, for which an
abstract realization of real system may be necessary.
An effective projection or forecasting model is
necessary to enable adequate planning and co-
ordination. The forecasting of primary school
enrolment, particularly, in standard one would go
along way towards helping to match the resources
to the anticipated needs.

The purpose of this study is to use a stochastic model to forecast standard one enrolment in any year. The stochastic model is appropriate because the situation under study is dynamic. For instance the standard 1 enrolment in one year may stay constant for a certain period, fall below the previous period or rise above it. A stochastic model will accomodate all these possibilities.

1.4 OBJECTIVE OF THE STUDY

The objective of this study is to apply a stochastic model, specifically the Markov chain process in the prediction of standard one enrolment in the different zones in Nakuru Municipality for any given year.

1.5 IMPORTANCE OF THE STUDY

1. (a) The study will be of importance to educational planners in urban planning of education and for projecting enrolment. This will help them prepare for such by recruiting enough staff, building enough classrooms, acquiring equipment and other necessary facilities.

(b) Educationists could also use the study to analyse the educational characteristics like dropout and staying ratio of boys and girls, in different classes and in the different regions of the country.

2. The study may also be used to evaluate the new system of education against the old system with respect to the enrolment proportions of boys and girls.

3. Finally, it is intended to stimulate interest and research in stochastic model applications, in areas other than education like health planning, agriculture, and manufacturing in both business and non-business organizations.

SECTION TWO

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1. INTRODUCTION

Research in education is needed to answer such central
problems as; what kind of formal and informal education
should be developed in a country that cannot afford full
primary and secondary education for all children? Will
education differ not in degree, but in concept, from that
of an advanced country? How can it be planned so as to
contribute to social and economic development? How can
it be afforded? What forms of education are suitable for
a predominantly agricultural country? Are there approp-
riate models in advanced countries which can be studied?
For this reason, therefore, several varieties of quanti-
tative models for educational analyses have been developed.
Most of them focus on the flows of students through a
system as Steel (1979)[8] found out in his analysis. This
interest in the flows of students may be from the broad
perspective of a national planner evaluating the long
term implications of present educational policies in terms
of future availabilities of trained adults, or from the
narrow perspective of a departmental chairman deciding
on classroom assignments for the next semester.

As the only policy-making body with powers for
co-ordinating overall educational programs in Kenya, the
Ministry of Education has not laid emphasis on models which
link the total educational system to forecast of future
requirements. This is not only true of Kenya, but Steel
(1979) found out that even in Britain the primary focus

has been on the shorter term problems of local educational
institutions like universities and other educational insti-
tutions. In Europe for instance, only a few countries like
Sweden and the U.S.S.R have used intensive research in
formulating their educational policies. In most,education
has changed more slowly in response to varied pressures,
with little research to influence policy. Such a situation
is not accidental, the reason being that when looked at
in totality, the educational systems are generally very
wide and planners tend to lose sight of the objectives.
Most effective quantitative models for such analysis
would, therefore, be those which focus on the flows of
students through a system; particularly the stochastic
models. Stochastic models in particular are suitable
because of their inherent ability to encompass the
variability and dynamism underlying "real life" systems
behaviour.

In Kenya, Stochastic model applications have not been
widely researched on. A study by Owino J. (1982) used
Stochastic (Markovian) model for educational planning
which is not easy to apply in reality as the study
covered the whole country of Kenya which in itself is
so varied. The results of the study, the forecasted
enrolment for 1983 and the number of new classrooms fore-
casted for each class are total figures for the whole
country. In planning, one need to decide in advance
what to do, when to do it and how to do it. The know-
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what to do, when to do it and how to do it. The know-
ledge of such "block" figures would just highlight on

what should be done and when it should be done but not how,
thus may not be of much help for planning purposes. If
these totals are broken down for the different regions,
then distribution of the necessary resources can be done
according to the peculiar needs of each region. For instance,
the forecasts may be broken down to the smallest planning
unit possible, say the locational or sub-locational level.
The planning for standard one enrolment may be more urgent
in the urban areas than in the rural ones and such factors
need to be taken into consideration when aggregating.

Anklesaria (1986)[9] developed a stochastic model for
analysing time-series nominal data. This general purpose
model explicitly considers the observed time-relationship
as well as how previous behavior appears to affect later
behavior, and presented this information as a finite state
Markov chain. Markov analysis is used to predict a system's
behavior over time and the models have been used extensi-
vely to analyse system behavior, see Ashby (1956),
Bartholomew (1967), Hillier and Lieberman (1967). Most of
these models, however, are special purpose, they do not
take time relationships into explicit consideration and,
or ignore the effect of previous behavior or system's
memory. The study overcame these deficiencies and also
allows the aggregation and testing of several processes
with one another thereby allowing the determination of
similarities and differences.

Gani (1963) proposed one of the early Markovian
models for educational planning in Australian universities
when he used the model to forecast enrolment and degree

awards. Later on, Thonstad (1969) made an extensive use of stochastic models in his educational planning mannual. Nearer home, Uche (1978) applied Markovian models to Nigerian education system. One common feature in these studies is that the system under study is formulated as a Markovian process and the Markovian model then used to forecast or predict the future state of the system.

Stochastic models have also been used to study consumer behavior. Kuehn and Day (1964)[10] applied stochastic Models to study consumer behaviour by emphasising on the principle marketing variables (the four p's of product, price, place and promotion) rather than on sales forecasting. They used the idea that purchase probabilities for an individual consumer can be expected to change over time, thus, the dynamic feature necessary under stochastic process. They also emphasised the fact that a dynamic model of consumer brand choice behavior must provide a method of revising the individual's set of purchase probabilities to show changes induced by the passage of time, new purchase experiences, and exposures to mechandising influences. Their findings were that although they had gained considerable attention and were conceptually appealing, simple Markov chain models were of limited value as the basis of a brand choice model. Acting on this strong evidence "introduced" which suggests that brand choice behavior is substantially stochastic, Bass (1974) presented a general theory of stochastic preference and tested it ten years later. He used the theory of stochastic preference under dynamic conditions to show

from the empirical evidence from empirical studies of
individual consumer choice that this behavior is sub-
stantially stochastic. This suggests stochastic model-
ing in consumer behavior where the deterministic tradition
in theory seems to have been the mode. From these two
studies, it can be concluded that even though much remains
to be done before a model can be developed which can ade-
quately treat all the marketing variables under the assump-
tion of a stochastic consumer behavior, a modified
Markovian process offers an encouraging start. As Howard[11]
points out though, there are some major problems in using
markovian analysis under such circumstances. These can
be classified into three categories: irregular patterns
of purchase or random interpurchase time, difficulties
of aggregation, and difficulties in revising transition
matrices to reflect new information.

Another area where stochastic models applications
have been tried is in personal selling strategies.
Magee (1952) tried as early as 1952 to apply stochastic
models in personal selling, by arranging dealer customers
according to average order size, which provided the basis
for allocation of the sales effort to consumers. Having
allocated sales effort to control unit, the sales manager
then considers the call strategies to be used. The result
was not very practical until 1960's and after when
Shuchman proposed a modified markov chain approach to
the allocation decision.[12]

Personnel supply in an organization can also be fore-casted using markov chains to model the flow of people through various states (usually skill or position levels and sometimes years of service). The majority of Markovian manpower applications noted in the literature comes from military, government and public agencies rather than business.[13] More-over, much of the new works in this area have been published in volumes of conference proceedings, including Wilson (1969), Bartholomew and Smith (1977), and Bartholomew (1967). White's (1970) work on chain of opportunity is a detailed study of job mobility based on the idea of modeling the flow of vacancies through the system.

Although statistical tests for validating Markov chain models have been known for more than twenty nine years[14], they have been used only in few applications, especially, in the analysis of system behavior.[15] In demography, for example, Keyfitz has provided a basic source of methodology for mathematical analysis of population.[16] Chatfield and Goodhardt (1969) have also modelled buying behavior as a stochastic process. Hagerstrand's work on diffusion of innovations by use of stochastic methods has triggered quantitative georgraphers' interest in this area[17].

In business, Cyert and Thompson (1967) have used a stochastic model for selecting a portfolio of credit risks. It is a common practice with credit agencies to classify each credit applicant with several risk categories. This is usually done by a crude form of multiple regression model using "scoring functions" of relevant independent

variables. Suppose there are C risk categories and m+2
stages of the account; out of which 2 refers to the "paid
up" and the "bad debt" states of an account. Assuming
that the credit applicant passes through the states of
the account based on a transition probability matrix,the
management can determine the elements of C transition
probability matrices one for each risk category. This
seems to be a more realistic assumption than the one
based on a single transition probability matrix for all
credit applicants. The end objective of this procedure
is to enable the firm to arrive at a portfolio of
accounts receivables with different proportions of
customers in the various risk categories. From the
standpoint of total risk, the firm then should be able
to afford more people in higher-risk categories when
it has relatively more in the low-risk categories.
The criterion for this policy proposed by Cyert and
Thompson is based on the coefficient of variation of
the total expected receipts and acceptance of customers
as long as this coefficient remains below a preset
value.

The term structure problem can also be analysed
using a stochastic model. The problem of term struc-
ture may be considered to be a special case of the
problem of determining capital values under uncertainty.
The payments stream may be taken as deterministic, but
future interest rates are stochastic. In his study
Pye (1966) accounted for the stochastic nature of

interest rates, by assuming that there are finite number
of interest rates Pi (i=1,2,----m), and from period to
period the interest rates vary as a Markov Chain. Pye
also discusses the properties of the yield curves and
the behavior of the expected future one-period
interest rates based on the properties of the
transition probability matrix.

Stochastic models have also been used in the study
of the spread of rumours and epidemics, see Becker
(1968), Doley and Kendall (1965)

2.2. FORECASTING MODELS

Man has always striven to account for things that
he observed happening in the universe about him. One
reason for this is obvious: if man "understands" a
phenomenon, he may be able to control it in some way,
or will at least be able to predict future behaviour
from a knowledge of current behaviour. The formation
of theories (Models) which account for observed
behavior is not a new phenomenon. The historical
development of probability models for instance, has
been long and interesting. The Mathematic giants
P. Fermat (1601-1665) and B. Pascal (1623-1662) worked
on such Models (in connection with gambling problems).
The present approach to the axiomatic system commonly
called "probability theory" was proposed by A.Kolmogorov
in 1933. One striking difference between the earlier
models and the recent ones is associated with assess-
ment of the likelihood of various alternative outcomes in an
experiment.

Forecasting models can be seen as either causal or extrapolative. The various extrapolative models available can be subdivided further into: Trend curve analysis, Smoothing and Box-Jenkins methods, Bayesian forecasting (under which falls the Markov Chain analysis) and adaptive models. Although by custom trend curve analysis has more often been used for longer term forecasting while the remainder are usually perceived as suitable for the shorter term, they are all strictly comparable in terms of the criteria of cost effectiveness for the forecast user.

Statistical forecasting is generally based on the assumption of constancy, this has emphasised the traditional role of statistical forecasting as extrapolative. That is some model based on past data has been developed, which subsequently has been used to 'project' the past patterns and relationships beyond the sample date, thus providing forecasts for the future. This usually works well as long as the established patterns and relations do not change. However, if changes do occur, statistical forecasting cannot deal with this situation because the assumption of constancy will not hold. The resulting errors do not have to follow previous patterns: they can be non-random, their variance can be wider, and or they can be non-symmetric.

Major Functions in Forecasting
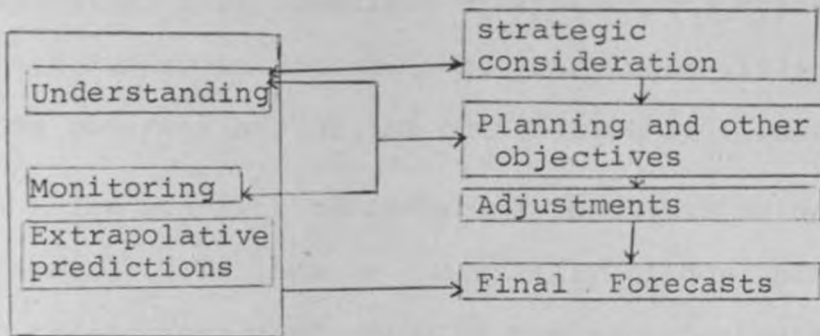
Fig. 2.2.1

If an enlarged role of forecasting is accepted
(Fig.2.2.1) then the problem becomes how to continue
forecasting when systematic changes from established
patterns and relationships are involved. Forecasters
and end users however, must accept the inevitable, this
being the inability to forecast statistically when the
assumption of constancy does not hold.

After using the regression models based on anti-
cipated workload, sales or economic indicators and the
Delphi procedures, to forecast personnel demand; Hopes
(1973) also used Markov Chains Model to forecast personnel
supply and these have been used with some measure of
success for manpower planning.

Several studies have been reported in which multiple-
objective approaches are used to select an appropriate
forecast model by comparing forecast statistics generated
by each method. Reeves G.R and Lawrence (1982) studied
combination of forecasting methods based on multiple
objectives. Bunn (1975) also studied linear combination
of forecasts while Carbone et al (1983) compared for
different time series methods, the value of technical

expertise, individualised analysis and judgemental adjustments needed in forecasting. Dickinson (1975) also made some observations on the combination of forecasts.

The benefits of combining forecasts using goal programming (G.P) lies in the ability of goal programming to reflect the preference of the decision-maker or planner. A Model may then be selected to yield forecasts which are implicitly "weighted" by either the preferences of the planner or a linear approximation of a preference structure.

Two questions usually dominate any assessment of a forecasting model:

(1) Is the model statistically satisfactory?

(2) Will the model once developed be used and perform cost effectively?

While much of research in statistics and operations Research has concentrated on the former question, it is the latter that is often of more concern in practical forecasting. Little (1979) suggests that as well as accuracy, a good model should be:

(i) Easy to understand for the user

(ii) Easy to control, that is, the user should be able to make the model behave in the way he wants it to, because of its comprehensive structure.

(iii) Adaptive, that is, should be able to accept fresh information and use it to update the values of the parameters.

(iv) Complete on important issues: It should include those factors perceived to be important by the user.

(v) Easy to communicate with: The user should be able to change user specified input information easily and obtain model output in a simple form with equal facility.

(vi) Robust: It should be specified so that it gives sensible answers to plausible input information.

In effect what these criteria demand,is a model as flexible as the forecaster himself and yet formalized so that statistical testing can be carried out. Any such model would be expensive and in most forecasting situations it would appear that a model is selected for its simplicity rather than with regard to the other five criteria. However, Little's somewhat idealistic criteria can serve as benchmark for assessing a model's accepta- bility to the user but note that points (iv)-(vi) are of more concern in causal modelling than extrapolative models.

Makridaki's et al (1982) summarises the criteria of selecting forecasting methods as depending on:

(1) The pattern of the data (2) The type of series

(3) The time horizon (4) The ease of application

(5) The cost and (6) The accuracy of the forecast.

2.3. THE MARKOV CHAIN PROCESS: DEFINATIONS AND PROPERTIES

Markov Chain analysis is attributed to A. Markov, a Russian Mathematician who developed the technique in 1907. As a descriptive (none normative) tool, the major objective of Markov Chain analysis is the prediction of the future behavior of managerial systems. Such prediction can be achieved, in some cases, by other tools such as decision trees (coupled

with complete enumeration) or simulation. The advantage of Markov chain analysis is that, the computational work is relatively uncomplicated and can be carried out very rapidly, and with the relevant computer packages in a few hours.

The analysis applies in a dynamic, probabilistic environment where most other management science tools fail; yet most management situations in reality are of such nature. Therefore, it is considered a good tool for providing information which can be used as a basis for making decisions by either complete enumeration of all alternatives or through additional optimization models. The relationship between Markov analysis and the managerial analysis is shown below:-

Managerial analysis using Markov Chains

| PROBLEM | → | Prediction of system's Behavior | → | Decision making via complete enumeration or an optimization model |

Fig. 2.3.1   MARKOV ANALYSIS   MANAGERIAL ANALYSIS
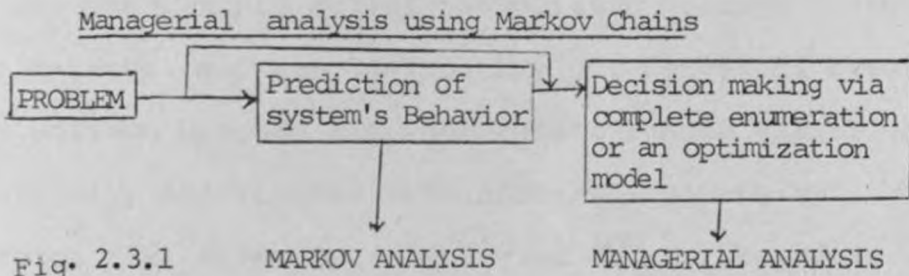
Stochastic means probalitistic, that is, with an exhaustive set of probabilities or chances of outcomes.

Some Common Stochastic Processes are:-

(i) The Bernoulli Process, that is a process with discrete state and parameter space. For instance, a series of independent repeated trials with two outcomes, say "success" and "failure" whose probabilities are p and q respectively at each trial; and (p+q) = 1. Sn implies the number of successes in n trials, thus (Sn) is a stochastic process with state space

The probability distribution of Sn for a given n is:

$$P(Sn = K) = \binom{n}{k} p^k q^{n-k}, K = o, 1, 2\ldots\ldots$$

The process (Sn) is a Bernoulli process. This process is a simple discrete time renewal counting process; it is also a Markov chain with discrete state space.

(ii) The poisson process, a process with discrete state space and continous parameter space.

Let $x(t)$ be the number of events occuring in time (o,t); the process $(x(t))$ is stochastic with state space $(s:o, 1, 2 \ldots)$ and parameter space $(t \geq o)$

For a given t, $x(t)$ has the poisson distribution with mean M:

$$P\left[x(t) = K\right] \; e \frac{-M(M)^k}{K!}, K = o, 1, 2 \ldots\ldots$$

The process $\left[x(t)\right]$ is called the poisson process. The time interval between consecutive occurences of events in a poisson process are independent random variables identically distributed with probability density function $f(x)$ given by : $f(x) = \lambda e \, \lambda^{\infty}$. Therefore the Poisson Process is also a renewal counting process, thus has the Markov property, consequently, the process is also a Markov process.

(iii) The Gaussian Process: This is a process with continous state and parameter space. Consider a stochastic process $\left[x(t)\right]$ with the property that for an arbitrary set of n time points $(t_1 \, t_2, \ldots t_n)$ the joint distribution of $x(tr)$, $(r=1, 2, \ldots n)$ is n-variable normal. Then the process is called Gaussian.

(iv) The Wiener Process (Brownian Motion Process).

This is a process with continous state and parameter spaces.

Consider a stochastic process $(x(t))$ with the following

properties-

(a) The process $[x(t), t \geq 0]$ has stationery independent

increments. This means that for $t_1, t_2 \in T$ (parameter space)

and $t_1 < t_2$, the distribution of $x(t_2) - x(t_1)$ is the same

as $x(t_2+h) - x(t_1+h)$ for $h > 0$, and for any non-overlapping

time intervals (t_1, t_2) and (t_3, t_4) with $t_1 < t_2 < t_3 < t_4$, the

random variables $x(t_2) - x(t_1)$ and $x(t_4) - x(t_3)$ are

independent.

(b) For any given time interval (t_1, t_2), $x(t_2) - X(t_1)$ is

normally distributed with mean zero and variance $\sigma^2(t_2-t_1)$.

Then the process $[x(t)]$ is called the Wiener process.

A Markovian Process for which all realization or

sample function $[X_t, t \in (0, \infty)]$ are continous functions,

is called a diffusion process. The poisson process is

a continous time Markov Chain and Brownian Motion is a

diffusion process.

Stochastic Processes occuring in most real-life

situations are such that for discrete set of parameters

$t_1, t_2 \ldots, t_n \in T$, the random variable $x(t_1)$, $x(t_2)$, ...

$x(t_n)$ exhibit some sort of dependence. For instance,

the state of the standard one after n periods (X_n) may

conceivably depend on the state of the same during the

preceding n-1 periods. The analysis of the process gets

complicated as the dependence structure becomes complex.

The simplest type of dependence is the first-order depe-

ndence underlying a stochastic process. This dependence

is termed Markov-dependence and may be defined as
follows:

Consider a finite (or countably infinite) set of
points t_0, $(t_1, \ldots t_n, t)$, $t_0 < t_1 < t_2 < \cdots < t_n < t$ and
t, $t_r \in T$ $(r = 0, 1, \ldots n)$ where T is the parameter space
of the process $X(t)$. The dependence exhibited by
the process $(X(t), t \in T)$ is called Markov - dependence
if the conditional distribution of $x(t)$ for given values
of $x(t_1)$, $x(t_2), \ldots x(t_n)$ depends only on $x(t_n)$ which
is the most recent known value of the process,
that is:

$$P\left[x(t) \leq x \mid X(tn) = Xn, x(t_n - 1) = X_{n-1}, \ldots, X(t_0) = X_0\right]$$
$$= P\left[x(t) \leq x \mid X(t_n) = X_n\right]$$
$$= F(X_n, x; t_n, t)$$

The stochastic process exhibiting this property is called
a Markov process. A Markov process is therefore, a
stochastic process whose probability of being in any
state depends only on its previous state and the transi-
tion matrix. In a Markov process, therefore, if the
state is known for any specific value of the time para-
meter t, that information is sufficient to predict the
behavior of the process beyond that point.

Depending on the nature of the state space and the
parameter space, we can divide Markov Processes into
four different classes (see table). Whenever the
parameter space is discrete, we shall call such Markov
process Markov chains, that is a Markov process with
constant transition probabilities (chances of a
system moving from one state to another). In this

Parameter space	state space
Discrete Markov chain with discrete state space	Markov chain with continous state space
Continous Markov process with discrete state space	Markov Process with continous state space

Table 2.3.1

study, the emphasis is on Markov chains.

A Markovian Decision Process (MDP) is the stochastic process that describes the evolution of a dynamic system controlled by a sequence of decisions. Such a process exist in a continous state space and more sophisticated tools for its analysis are needed.

Symbolically, a Markovian process can be defined in terms of the probability of being a given state S at time T as follows:

$$\text{Prob } (S_1 = K \mid S_{t-1}, S_{t-2}, S_{t-3}, \text{------}, S_1, S_o)$$
$$= \text{Prob } (S_t = K_t \mid S_{t-1} = K_{t-1}) \ldots\ldots\ldots\ldots (2.3.1)$$

Thus, the probability of being in a given state at time T depends only on the previous state the system was in. The Markov chain process describes the movement of a system from a certain condition (or State) in the current stage (time period) to one of n possible states in the next stage. The system moves in an uncertain environment. All that is known is the probability associated with any possible move (transition). This concept of the transition probability is the key to Markov analysis.

The transition probability at time t for a Markov chain is defined by:

$$Pij(t) = \text{Prob}(S_t = K_j \mid S_{t-1} = Ki) \ldots\ldots (2.3.2)$$

and gives the probability that the system is in state Kj at the time t given that it was in state Ki

previously (time t-1). Alternatively, it is the probability of moving from state Ki to state Kj in one time period (t). If the transition probabilities do not depend on t, that is the transition probabilities of moving from one state to the next remain constant over time, then it is said that the Markov chain is homogenous. In which case:

$$Pij = Prob(St = Kj \mid S_{t-1} = Ki) \ldots \ldots (2.3.3)$$

If the state space of the Markov chain is finite then it is discrete Markov chain, otherwise it is a continous Markov chain. In this paper the concern is with homogenous finite Markov chains.

Given a set of states i=1,....,M, then Pij is the percentage of time that state j is the outcome if the system starts in state i. The set of transition probabilities across any row (current state) is called a probability vector and represent all possibilities of moving from one state in the current period to one of the n states in the next period.

Given the transition Matix P:

To state at the next period

$$
P = \begin{array}{c} \text{From} \\ \\ S_1 \\ S_2 \\ \vdots \\ S_i \\ \\ \vdots \\ \\ S_n \end{array}
\begin{array}{cccc}
S_1 & S_2 \ldots S_j \ldots & S_n \\
\hline
P_{11} & P_{12} \ldots P_{ij} \ldots & P_{in} \\
P_{21} & P_{22} \ldots P_{2j} \ldots & P_{2n} \\
\vdots & \vdots \quad \vdots & \\
P_{i1} & P_{i2} \ldots P_{ij} \ldots & P_{in} \\
\vdots & \vdots \quad \vdots \ldots \ldots \ldots & \\
\vdots & \vdots \quad \vdots \ldots \ldots \ldots & \\
P_{ni} & P_{n2} \quad P_{nj} & P_{nn}
\end{array}
$$

The state of the system after n moves is described by numbers Pij(n), that is the percentage of the time that   j is the outcome after n moves if the system starts in state i.

As n becomes large Pij(n) approaches $\overline{\pi}$j: that is, all the numbers in a column become identical. The $\overline{\pi}$j's may be computed from $\overline{\pi}$ij = $\sum\limits_{i=1}^{M} \pi$ iPij, where $\sum\limits_{j=1}^{M} \overline{\pi}$j=1,

$\overline{\pi}$j > o   . . . .(2.3.4)

Transient behavior and State Probabilities

Let the probability that the system will ccupy a particular state i, at period k, be denoted by $q_i(k)$. This probability is the state probability. As the system must occupy only one the n possible states at any given period, including period k, then the sum of all q values must equal 1. Thus:

$q_1(k$ + $q_2(k) + \ldots + q_n(k)$ = 1 for every k

That is: $\sum\limits_{i=1}^{n} q_i(k) = 1$ . . . . . (2.3.5)

where: n = number of states

k = number of transitions = o,1,2......

In general therefore, the state probability distribution

$Q(k) = \left[q_1(k), q_2(k), \ldots, q_n(k)\right]$ . . . . (2.3.6)

Thus the probability of $q_1(1)$ together with $q_2(1)$ and $q_3(1)$ form the components of Q(1).

But in Matrix notation : Q(1) is the product of Q(o) and P.

Thus: $Q(1) = q_1^{(1)}, q_2(1), \ldots q_n(1) = Q(o)P$...(2.3.7)

where P is the transition probability matrix of the system.

Similarly: $Q(2) = Q(1)P$ . . . . . (2.3.8)

Thus: $Q(2) = Q(1)P = Q(o)P^2$

In general therefore:

$Q(k) = Q(k-1)P = Q(k-2)P^2 = . . . = Q(o)P^k$ . . (2.3.9)

A major property of Markov chains is that in the long run, the process usually stabilizes: that is the system exist in a steady state or in equilibrium. This phenomenon of equilibrium probabilities is expressed as:

$Q(k) = Q(k-1) = Q(k)P$ . . . . (2.3.10)

But $Q = QP$ . . . . (2.3.11)

which implies the state probabilities at equilibrium remains the same from period to period.

Thus: $Q = (q_1, q_2, ..., q_n) \begin{bmatrix} P_{11} & P_{12} \cdots & P_{1n} \\ P_{21} & P_{22} \cdots & P_{2n} \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ P_{n1} & P_{n2} \cdots & P_{nn} \end{bmatrix}$ . . . (2.3.12)

The key feature of a Markovian Model is its ability to capture probabilistic dependencies between successive events. Determining the steady-state behavior of a Markovian system involves solving a set of linear equations. Consequently the Matrix multiplication in equation 2.3.12 above, then result in a system of n simultaneous linear equations as follows:

$$q_1 = P_{11}q_1 + P_{21}q_2 + ... P_{n1}q_n$$

. . . .

$$q_n = P_{1n}q_1 + P_{2n}q_2 + ... P_{nn}q_n$$

The Limitations of this model are:

(a) For accurate π_j's (equation 2.3.4), the P_{ij}'s must be well determined.

(b) The size of n for $P_{ij}(n)$ to be close to π_j may be quite large; the π_j's are useful only if the requisite size of n is reasonable for the problem at hand.

(c) Difficulties usually arise in the application of Markov chain analysis regarding the development of transition matrix. Historical data can serve this purpose in some cases, while in others, the subjective beliefs of management may be used.

A major property of Markov chains process is thus: "The future, given the present, is independent of the past".

Absorbing Markov chains

A system is said to be in an "absorbing" state if, once there, it cannot exit to some other state. Similarly a state is absorbing if once entered, cannot be left. Practical examples of absorbing states are: A bankrupt business, a river or lake irreversibly destroyed by pollution and sediment, and a building destroyed by fire.

A Markov chain is absorbing if, it has at least one absorbing state or it is possible to reach an absorbing state from any non-absorbing states.

Given a transition Matrix T (where transition proba-
bilities are assumed constant over time)

$$T = \begin{array}{c} \text{From} \\ S_1 \\ S_2 \\ S_3 \\ S_4 \end{array} \begin{array}{cccc} \text{To} & S_1 & S_2 & S_3 & S_4 \\ & \begin{bmatrix} P_{11} & P_{12} & P_{13} & P_{14} \\ P_{21} & P_{22} & P_{23} & P_{24} \\ P_{31} & P_{22} & P_{33} & P_{34} \\ P_{41} & P_{42} & P_{43} & P_{44} \end{bmatrix} \end{array}$$

Assume that states S_1 and S_3 are absorbing states, thus all the
elements in rows S_1 and S_3 are zero save for the one corres-
ponding to the same state which has the value of one.
Thus: $P_{11}=1$, $P1j=o$ for $j= 2,3,4$ and $P3j =o$ save for $j = 3$

The transition Matrix then appears in the following
form:

$$\begin{bmatrix} 1 & o & o & o \\ P_{21} & P_{22} & P_{23} & P_{24} \\ o & o & 1.o & o \\ P_{41} & P_{42} & P_{43} & P_{44} \end{bmatrix} \quad \ldots \ldots (2.3.13)$$

The Fundamental Matrix Formation:

Cross off the rows with the absorbing states (S_1 and S_3
in the above case), then re-arrange the remaining rows and
columns into Absorbing (A) and Nonabsorbing (N).

$$A = \begin{array}{c} \\ S_2 \\ S_4 \end{array} \begin{array}{c} S_1 \quad S_3 \\ \begin{bmatrix} P_{21} & P_{23} \\ P_{41} & P_{43} \end{bmatrix} \end{array}, \quad N = \begin{array}{c} \\ S_2 \\ S_4 \end{array} \begin{array}{c} S_2 \quad S_4 \\ \begin{bmatrix} P_{22} & P_{24} \\ P_{42} & P_{44} \end{bmatrix} \end{array} \ldots (2.3.14)$$

Define the Fundamental Matric (F), where

$$F = (I - N)^{-1}, \quad \ldots \ldots \ldots (2.3.15)$$

the inverse of Identity Matrix less Matrix N.

Thus:

$$F = \left[\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} - \begin{pmatrix} P_{22} & P_{24} \\ P_{42} & P_{44} \end{pmatrix} \right]^{-1}$$

The elements of the Fundamental matrix represent the average number of periods the system will be in each non-absorbing state until it gets absorbed. The sum of the elements in each row of matrix F provide the average number of periods to absorption.

The probabilities of moving from any nonabsorbing state to each absorbing state are given by matrix M.

$$M = F A \quad . \quad . \quad . \quad . \quad . \quad . \quad (2.3.16)$$

That is:

$$M = \left[\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} - \begin{pmatrix} P_{22} & P_{24} \\ P_{42} & P_{44} \end{pmatrix} \right]^{-1} \begin{bmatrix} P_{21} & P_{23} \\ P_{41} & P_{43} \end{bmatrix}$$

Analysis of absorbing Markov chains can provide Manament with answers to at least three important questions:
(i) What is the average number of periods that the system will be in each non-absorbing state before it is absorbed?
(ii) How long is the system expected to stay in non-absorbing state starting from each non-absorbing state?

Such information can be of practical value for management decisions in such areas as: replacement of equipment, marketing, and maintenance. Other relevant areas of application of such information range from queueing theory to production planning, brand loyalty or market share analysis, investment evaluation, new product development, Pest control and ecology, dynamic programming and organization theory among others.

SECTION THREE

RESEARCH DESIGN, MODEL DEVELOPMENT AND VALIDATION

3.1. THE POPULATION

The population of study consisted of all the standard one enrolments in Nakuru Municipal primary schools from 1969 to 1989 (beginning of year). This period of twenty years was chosen because of the major educational policies and developments which took place, and whose effects are felt on enrolment in standard one, in Kenya's urban areas. In 1969 for instance the local (Transfer of Functions) Act, was enacted which transferred the overall responsibility for primary education in the rural areas to the Central Government, while leaving the same in urban areas to the Municipalities. This policy greatly influenced the municipal school systems, and with the unflux of people to the towns, the municipalities had to engage in proper planning and administration of the various resources to meet their local needs, as the central government was no longer responsible directly for the running of primary schools within these areas.

In 1974, there as was a presidential decree which removed school fees for lower primary school (standard one to four). This encouraged many people to send their children to schools consequently enrolment in these classes, especially in standard one sored so high that in some places (like Nakuru) it more than doubled. Such other factors like the gesture by the President in 1979 which introduced milk to primary schools also occurred within this period.

In 1985 a new syllabus was introduced to primary schools
which changed the whole of the education system from the 7-4-2-3
to 8-4-4 system. Such factors may have influenced enrolment
in one way or the other and the last two decades covered by
the study ensures that all these effects are taken into
consideration.

The 1969 to 1989 period gives data for two decades. The
behavior of the system in the last two decades provide a good
indication of the expected behavior for the coming decade.
This period thus provide enough data for standard one enrol-
ment behavior, which can therefore be used to predict enrol-
ment for the coming decade. Finally the 1989 (beginning of
year enrolment) gives the most current data, whose inclusion
in the model made the projections from it more realistic.
This is necessary, because like most forecasting or projection
models, the further away the period to be predicted from the
prediction point, the less realistic the predictions and the
nearer the period to be predicted from the prediction point
the more realistic the predictions are likely to be.

3.2   DATA COLLECTION   METHOD

The data was collected from a secondary source, the
Nakuru Municipal Council records. These records are com-
piled for council school administration purposes. Monthly
returns are sent by the schools to the Municipal Education
office, showing among other things the pupil attendance over
the month for each class. The pupils may not attend classes
due to several reasons:-

Non-payment of school fees, (when standard one pupils paid school fees), sicknesses, death, transfers out of town, transfers within town (to different schools within the same zones or in different zones). In cases where pupils were absent due to non-payment of school fees or sicknesses, they were treated as present, because these are temporary absences. In cases where pupils were transferred out of town (Municipality) or cases of death or drop-outs, they were treated as "absorbed" or as if they entered a non-return state. In cases where pupils shifted between schools in the same zone, such enrolments are really within the same zone and their effects are not felt outside the zone, as such these cases are ignored. Movement out of each zone and into a zone were considered as transitions.

The data collection sheets (Appendices 3,4 & 5) shows how the relevant data was captured. All the data from 1969 to 1988 represent actual enrolment; this is due to the fact that no comprehensive list of the applicants (demand) exists for these years. Furthermore the municipality claims that all the applicants in each of those years were enroled and where these over-numbered the facilities available, temporary measures were taken like converting other rooms for classrooms, employing untrained teachers, or simply doing without some facilities. In other words, the situation was dealt with as it arose. If this is true, then, there was insignificant difference between the applicants (demand) and actual enrolment.

In 1989, however, the application forms sent to the various nursery schools for standard one prospects from the municipality was far below the actual applicants, this was evidenced by the actual requests sent to the Municipal office. Such information while available for 1989 was not available for the previous years as such it was possible to obtain the applicants figures for 1989 that was used to estimate the demand for standard one places in 1990, 1991 and 1992.

The demand estimates are much more useful for planning purposes than the estimated enrolment, because it provides what should be the target for proper allocation of resources rather than what would be the case with the actual enrolment. The three years forecasts were chosen because the shortest planning period (for local government) is three years. Thus it is possible to plan for the three years as part of the usual planning programs rather than for a year.

3.3 DATA ANALYSIS

The data was analysed by building a Markov chain Model of the enrolment, and employing this model in the prediction of future enrolment. The actual process follows.

3.3.1 MODEL DEVELOPMENT :

3.3.1.1 Introduction

Data for actual movement between the zones during any year were not readily available, indeed the documented evidence showed that the movement,

particularly for standard one pupils is negligible.
If such information is used to build the model, it
would not result in a realistic model. It became
necessary therefore, to come up with an appropriate
transition matrix which would be realistic,this is
due to the fact that for a Markov chain Model, the
transition Matrix is the core.

The enrolment for each zone for each year were
arranged in a tabular form (appendix 2).   The
proportion of the enrolment for each zone were then
calculated for every year, from 1974 to 1979 and
from 1984 to 1988. The 1974 was chosen as the base
year to start studying the behavior of the system
for the following reason:-

In 1974 there was a presidential decree which
abolished school fee payment for standard one to
standard four. This decree affected enrolment so
much that it increased from 2,154 in 1973 to 4,359
in 1974 for standard one alone; an increase of 102%.
Indeed the enrolment has never been that high again!
From 1974 therefore a new era started in the primary
school system in which parents paid no school fees
to enrol their children in standard one. It therefore
follows that all schools were the same and parents
could therefore enrol their children only in the
most convenient regions. Before 1974, Price discri-
mination (differential school fees in different

schools) kept pupils only in schools their parents could afford. Indeed some schools were reserved for the very rich, whites, Indians. Such arrangements constrained enrolment to specific regions, and it is possible that parents would send their children to different zones from where they lived. It can therefore be concluded that the distribution of standard one enrolment (behavior of the system) before this period was constrained or artificial. When this barrier was removed, it is expected that the demand for standard one places shifted from the affordable (for the majority of Nakuru resident) to the most convenient regions. The system therefore assumed its own behavior which can safely be represented by a Stochastic Model.

The 1980, 1981, 1982 and 1983 data was left out when building the Model because they were to be used for the Model validation. 1989 data was also left out because this demand is to be used for forecasting for the next decade once the model is validated.

This process was followed for the total enrolments in standard one (boys and girls), for boys only and for girls only. In effect, three different transition Matrices were obtained showing the transition between the zones for boys and girls separately and for the two together.

The assumptions underlying the Markov Chain Model are covered under section two of this study and shall only be referred to, in this section, where applicable.

3.3.1.2 The Model

One of the major properties of Markov chains is that, in the long run, the process usually stabilizes (equilibrium). This phenomenon is expressed in equations 2.3.7, 2.3.9 and 2.3.10; these imply that the state probabilities at equilibrium remain the same from period to period. Therefore at equilibrium, if the current state $Q(o)$ is known and the transition Matrix,T is known, then the future state $Q(k)$ can be predicted.

Since the transition Matix in our case is not known, the transition from state to state is studied for the nine years, in the following manner:

Given that:

$$Q(k) = Q(o)T, \text{ that is}, Q = (q_E, q_C, q_W) \begin{bmatrix} P_{EE} & P_{EC} & P_{EW} \\ P_{CE} & P_{CC} & P_{CW} \\ P_{WE} & P_{WC} & P_{WW} \end{bmatrix}$$

where:

Q is the future state.

q_E is the proportion of standard one enroled in the Eastern zone currently.

q_C is the proportion of standard one enroled in the Central zone currently.

q_W is the proportion of standard one enroled in the Western zone currently.

P_{ij} for i,j = Eastern, Central and Western, represent the probability of moving from the i zone to the j zone.

It is necessary to add here that, $q_E + q_C + q_W = 1$, that is, the enrolment within the Municipality can only occur in either of the three zones. Also, the row vector of the transition Matrix, T, add up to one, thus in every transition, a zone retains a certain proportion while the rest it shifts to either of the other two zones. A shift from the municipality and shifts into the Munici- pality are taken care of by the increases or decreases within the zones. For instance, if there is an influx of people to the Municipality, these will distribute themselves into the various zones as they find conve- nient, as such the proportions in the zones will change. If more people move to the Eastern zone for instance, then the proportion enroled in the Eastern zone shall rise, similarly if there is a major move from the

Municipality from one particular zone, say, the western zone, then the proportions in this zone shall fall accordingly. Otherwise the moves into or out of the Municipality should be distributed equally between the zones if there is no preference of one zone over the others; in which case the proportions remain unchanged.

In most instances the current state, Q(o) and the transition Matrix (T) are known; but Q(k) is unknown. In our case the T is unknown, but the transition from state to state for the nine years (1974-1979, 1984- 1988) were used to arrive at an estimate of the best transition Matrix to be used.

Wolfe and Dantzig (1962) showed that there is an
iteration procedure which when applied result in the
choice of the best Transition Probability Matrix. Since
a Markov chain (system) can be in any one of the
$M(< \infty)$ states and associated with each state $i(i=1,2...,m)$
let Pi be the set of available alternate probability
vectors $(^kPi_1, ^kPi_2, ..., ^kPim)$, $K \in Di$. The idea is
to select one vector out of Pi, in such a way that
when it is used for the one-step transition probabilities
out of state i in the Markov Chain, the ultimate gain
is maximised, assuming that the system stays in operation
for a sufficiently long time. Repeating the iteration
procedure for all the states, $i=1,2,....m$, then a
transition probability Matrix can be assembled for
the Markov Chain which can be considered to be the
best under the given circumstances. The iteration
method used in achieving this result has been shown
to be a special extension of the simplex method of Linear
programming allowing for Multiple substitution (see
Ghellink, 1960).

3.3.1.3   The Total enrolment Model
The transition between 1974 and 1975

$$Q(1974) \begin{bmatrix} P_{11} & P_{12} & P_{13} \\ P_{21} & P_{22} & P_{23} \\ P_{31} & P_{32} & P_{33} \end{bmatrix}^T = Q(1975)$$

Thus:

$$(.378 \quad .362 \quad .259) \begin{bmatrix} P_{11} & P_{12} & P_{13} \\ P_{12} & P_{22} & P_{23} \\ P_{13} & P_{32} & P_{33} \end{bmatrix} = (.383 \quad .356 \quad .261)$$

Similarly the transition between 1975 and 1976

$$(.383 \ .356 \ .261) \begin{bmatrix} P_{11} & P_{12} & P_{13} \\ P_{21} & P_{22} & P_{23} \\ P_{31} & P_{32} & P_{33} \end{bmatrix} = (.374 \ .346 \ .280)$$

This process is done upto the transition between 1987 and 1988. The result is a set of nine simultaneous equations with nine unknowns; which were thus solved to obtain the initial estimate of the transition Matrix. For the total enrolment the initial Matrix obtained was:

$$T = \begin{bmatrix} .52 & .37 & .11 \\ .12 & .78 & .10 \\ .10 & .25 & .65 \end{bmatrix}$$

This matrix reached equilibrium at the ninth transition, that is $T^9 = T^{10} = T^{11} = \ldots\ldots = T^n$ for a very large n. The equilibrium Transition matrix for the Total enrolment is thus:

$$Te = \begin{bmatrix} .095 & .590 & .315 \\ .095 & .590 & .315 \\ .095 & .590 & .315 \end{bmatrix}$$

The transition probability Matrix gives the probability of moving from state Ki to state Kj in one time period (t). Since the transition probabilities above do not depend on t, that is the transition probabilities of moving from one state to the next remain constant over time, the Markov Chain is homogeneous and takes the form of equation 2.3.3. The state space of the Markov Chain above is finite (three) as such it is a discrete Markov Chain.

Pij from the transition Matrix above represent the percentage of time that state j is the outcome if the system starts in state i. The state of the system after n moves is described by Pij(n), that is, the percentage of the time that j is the outcome after n moves if the system starts in state i. As n becomes large (nine in our case) Pij(9) approaches πj; that is all the numbers in a column become identical. In column one, all the numbers are .095, while in Column two, they are .590 and in column three they are .315; also $\sum\limits_{j=1}^{3} \pi j = 1$, $\pi j > 0$ (equation 2.3.4).

3.3.1.4 The Boys enrolment Model

A similar procedure to the one used for the total enrolment is used for the boys enrolment.

With the known states and an unknown transition Matrix, the transition is built from 1974 to 1975, from 1975 to 1976, 1976 to 1977 upto from 1978 to 1979. Also from 1984 to 1985 and so on upto 1988.

$$Q(1974) \begin{bmatrix} P_{11} & P_{12} & P_{13} \\ P_{21} & P_{22} & P_{23} \\ P_{31} & P_{32} & P_{33} \end{bmatrix} = Q(1975)$$

$$\text{Thus: } (.375 \ .351 \ .274) \begin{bmatrix} P_{11} & P_{12} & P_{13} \\ P_{21} & P_{22} & P_{23} \\ P_{31} & P_{32} & P_{33} \end{bmatrix}^{Tb} = (.383 \ .348 \ .278)$$

for 1974-1975

similarly for the 1975-1976

$$(.383\ .348\ .278) \overset{\text{Tb}}{\begin{bmatrix} P_{11} & P_{12} & P_{13} \\ P_{21} & P_{22} & P_{23} \\ P_{31} & P_{32} & P_{33} \end{bmatrix}} = (.382\ .315\ .303)$$

and so on up to 1987-1988 period.

The result is a set of nine simultaneous equations with nine unknowns. These are then solved using the iteration procedure as above to obtain the initial transition matrix

$$\text{Tb} = \begin{bmatrix} .690 & .174 & .136 \\ .220 & .568 & .212 \\ .279 & .249 & .492 \end{bmatrix}$$

The matrix Tb reached a steady state (equilibrium) at the tenth power, so that $\text{Tb}^{10} = \text{Tb}^{11} = \text{Tb}^{12} = \ldots = \text{Tb}^{n}$ for a large n. The equilibrium transition matrix for the boys enrolment is thus :-

$$\text{Tb}_{e} = \begin{bmatrix} .510 & .309 & .181 \\ .510 & .309 & .181 \\ .510 & .309 & .181 \end{bmatrix}$$

To conform with the transition probability matrix property that as n becomes large (ten in this case) $P_{ij}(10)$ approaches π_j; thus all the numbers in a column become identical. In the first column, in this case, the number is .510, the second column has .309 while the third column has .181.

3.3.1.5 The Girls enrolment Model

A similar procedure to the ones already used above
is used for the girls data. The iterations from 1974 to
1975, 1975 to 1976 upto 1978-1979, and also from 1984 to
1985, 1985 to 1986 upto 1988 are followed:

So that:

$$Q(1974) \begin{bmatrix} P_{11} & P_{12} & P_{13} \\ P_{21} & P_{22} & P_{23} \\ P_{31} & P_{32} & P_{33} \end{bmatrix} = Q(1975)$$

Thus: From 1974 to 1975

$$(.382 \ .374 \ .244) \begin{bmatrix} P_{11} & P_{12} & P_{13} \\ P_{21} & P_{22} & P_{23} \\ P_{31} & P_{32} & P_{33} \end{bmatrix} = (.384 \ .364 \ .256)$$

This procedure, if followed upto the 1987-1988 period
result in nine simultaneous equations with nine unknowns. These when
solved provide the initial matrix, Tg.

$$Tg = \begin{bmatrix} .406 & .566 & .028 \\ .110 & .547 & .343 \\ .108 & .030 & .862 \end{bmatrix}$$

Raising Tg to higher powers provided a steady state

transition probability matrix at the thirteenth iteration

thus Tg became steady at the fourteenth power. Thus,

$Tg^{14} = Tg^{15} = Tg^{16} = \ldots Tg^{n}$, for a very large n.   The

equilibrium transition probability matrix for the girls

is thus:

$$Tg_e = \begin{bmatrix} .154 & .234 & .612 \\ .154 & .234 & .612 \\ .154 & .234 & .612 \end{bmatrix}$$

This also conforms to the transition probability

matrix property that as n becomes large(fourteen in this
case), Pij(14) approaches j; thus all the numbers in a column
become identical. In this case, the first column number is .154,
the second column number is .234 while the third column number is .612.

3.3.2 MODEL VALIDATION

3.3.2.1 Introduction

In validating the model, actual enrolment for
1980 (in proportions) are premultiplied with the
transition matrix T, to provide an estimate for
1981, 1981 estimated proportions are also pre-
multiplied with the transition matrix again to
provide estimates for 1982, which is also premultiplied
by the transition matrix to provide estimates for 1983 and
similarly for 1983 and 1984.

A statistical test is then done to compare
the estimated enrolment against the actual enrol-
ment first at 0.10 significance level (90% confi-
dence level) and then at 0.05 significance level
(95% confidence level)

This procedure is followed for all the three
transition matrices (The totals, boys only and
girls only).

3.3.2.2 The Total Enrolment Model

$$
\begin{array}{ccc}
Q(1980) & T & Qe(1981) \\
\begin{array}{ccc} E & C & W \end{array} & \begin{bmatrix} .52 & .37 & .11 \\ .12 & .78 & .10 \\ .10 & .25 & .65 \end{bmatrix} & \begin{array}{ccc} E & C & W \end{array} \\
(.340\ .320\ .340) & = & (.249\quad .460\quad .291)
\end{array}
$$

$$Qe\ (1981) \quad (.249 \quad .460 \quad .291) \begin{bmatrix} .52 & .37 & .11 \\ .12 & .78 & .10 \\ .10 & .25 & .65 \end{bmatrix} = (.214 \quad .523 \quad .263) \quad Qe(1982)$$

$$Qe(1982) \quad (.214 \quad .523 \quad .263) \begin{bmatrix} .52 & .37 & .11 \\ .12 & .78 & .10 \\ .10 & .25 & .65 \end{bmatrix} = (.200 \quad .553 \quad .247) \quad Qe(1983)$$

$$Qe(1983) \quad (.200 \quad .553 \quad .247) \begin{bmatrix} .52 & .37 & .11 \\ .12 & .78 & .10 \\ .10 & .25 & .65 \end{bmatrix} = (.195 \quad .567 \quad .238) \quad Qe(1984)$$

Year	Estimated Proportions			Actual Proportions		
	Ee	Ce	We	Ea	Ca	Wa
1981	.249	.460	.291	.340	.390	.270
1982	.214	.523	.263	.352	.338	.309
1983	.200	.553	.247	.338	.361	.301
1984	.195	.567	.238	.340	.362	.298

A comparison of the estimated proportions against the actual proportions at a 90% level of confidence. This is testing a hypothesis about the difference between two population proportions.

1981

Hypotheses:

Ho: PEe = PEa, PCe = PCa, PWe = PWa

H1: PEe ≠ PEa, PCe ≠ PCa, PWe ≠ PWa

That is the hypothesis that the estimated proportions
are the same as the actual proportions in other words, that
the model predict the proportions with some measure of
accuracy.

Test Statistics:

$$Z = \frac{(Pa - Pe) - 0}{SPa - Pe}$$

Where Pa are the actual proportions

Pe are the estimated proportions

SPa - Pe are the standard error of the

difference between the two proportions.

This is given by $SPa - Pe = \frac{P(1 - P)}{na} + \frac{P(1 - P)}{ne}$

Where P is the pooled estimate of the hypothesized
common proportions, na is a sample size for the actual
proportions and ne is a sample size taken for the
estimated proportions. P is given by $\frac{Xa + Xe}{na + ne}$.

Where Xa represent the actual numbers from the sample
while Xe represent the estimated number from the
sample, for instance if a sample of fifty (50) is chosen
at random then Xa is the actual number from this
fifty inroled in a given zone while Xe is the estimate
(by the model) number enroled in a given zone.

In which case na = ne = 50.

Significance Level: $\alpha = .10$

Decision Rule: If the computed value of the test statistics,

Z, is greater than or equal to +1.645 or

less than or equal to -1.645 we reject the

Null hypothesis (Ho).

Calculations:

Given that: na = 50 (50 is chosen arbitrarily, but since
it is a large number, that is, greater than thirty (30), the
central limit theorem   applies).

Then for the different zones:

	Eastern	Central	Western
X_a =	.34x50=17	.39x50=19.50	.27x50=13.5
X_e =	.249x50=12.45	.46x50=23	.291x50=14.55
P =	$\frac{17+12.45}{50+50}$=.2945	$\frac{19.5+23}{100}$=.425	$\frac{13.5+14.55}{1000}$=.2805

$$SP_{a}-P_{e} = \frac{P(1-P)}{n_a} + \frac{P(1-P)}{n_e} = \frac{2P(1-P)}{50}$$

$$SP_{a}-P_{e} = \frac{2x.2945x.7055}{50} = .091 \quad \frac{2x.425x.575}{50} = .099 \quad \frac{2x.2805x.7195}{50}$$

$$=.090$$

$$Z = \frac{(.34-.249)-0}{.091} \qquad \frac{(.39-.46)-0}{.099} \qquad \frac{(.27-.291)-0}{.09}$$

$$= 1.00 \qquad\qquad = -.707 \qquad\qquad = -.233$$

Statistical Decision:

Since $1.00 < 1.645$, $-.707$ and $-.233$ are greater than -1.645, we do not reject the null hypothesis.

If unpooled estimate of the standard error is used, then

$$Z = \frac{(Pa-Pe)-0}{\sqrt{\dfrac{Pa(1-Pa)}{na}+\dfrac{Pe(1-Pe)}{ne}}}$$

$$Z = \frac{-091}{.0907} = 1.003 \qquad = \frac{-.07}{.099} = -.707 \qquad = \frac{-.021}{.090} = -.233$$

The two methods give the same answer because na=ne, thus pooling does not affect the result.

Administrative Decision

Based on the data from above, we conclude that the two proportions may be equal. These data do not allow us to accept the alternative hypothesis. The model predictions for 1981 are not so far off from the actual proportions; as such the model may be accepted for one transition or for one year estimation.

In testing the same hypothesis at the 95% level of confidence, the test statistics remain the same, however the significance level changes to $\alpha = 0.05$ and the decision rule also changes.

Decision rule

If the computed value of the test statistics, Z, is greater than or equal to + 1.96 or less than or equal to -1.96, we reject the null hypothesis (Ho).

Statistical Decision

Since the calculated values, 1.00, - .707, -.233 all fall within the given range, the decision of not rejecting the null hypothesis is upheld.

Administrative decision remains the same.

1982

Hypotheses:

Ho: PEe = PEa, PCe=PCa, PWe=PWa

H1: PEe ≠ PEa, PCe≠PCa, PWe≠PWa

Test statistics:
$$Z = \frac{(Pa-Pe)-O}{\sqrt{\dfrac{Pa(1-Pa)+Pe(1-Pe)}{n}}}$$

Significance level: $\alpha = .10$

Decision rule: If the computed value of the test statistics, Z, is greater than or equal to +1.645 or less than or

equal to -1.645, we reject the nul hypothesis (Ho)

Calculations

	Eastern	Central	Western
Pa	.352	.338	.309
Pe	.214	.523	.263
n	50	50	50

Eastern

$$Z = \frac{(.352-.214)-0}{\sqrt{\frac{.352(.648)+.214(.786)}{50}}}$$

$$= \frac{.138}{.089} = 1.55$$

Central

$$\frac{(.338-.523)-0}{\sqrt{\frac{.338(.662)+.523(.477)}{50}}}$$

$$= \frac{.185}{.098} = -1.89$$

Western

$$Z = \frac{(.309-.263)-0}{\sqrt{\frac{.309(.691)+.263(.737)}{50}}} = \frac{.046}{.090} = 0.511$$

Statistical Decision

Since one of the calculated values, -1.89 is less than the critical -1.645, we reject the null hypothesis at the significance level $\alpha = 0.10$.

Administrative Decision:

Based on the above data, we conclude that the two

proportions may not be equal, however further tests are to be
carried out below to chech on this decision at a higher
level of confidence.

At a 95% level of confidence, the test statistics
remain the same, but the significance level changes to
α = 0.05 and the decision rule also changes.

Decision rule:

If the computed value of the test statistics, Z, is
greater than or equal to + 1.96 or less than or equal to
-1.96, we reject the null hypothesis.

Statistical decision

Since the calculated values, 1.55, -1.89, 0.511 all fall
within the non rejection range, that is between $\pm$ 1.96, we
do not reject the null hypothesis at the significance level
α =.05.

Administrative Decision

Based on the above data, we conclude that the two
proportions may be equal. The data do not allow us to
accept the alternative hypothesis. The model prodictions for
1982 are not so far off from the actual proportions observed
at the confidence level of 95% as such the model may be
accepted for two transitions or for two year forecast at
95% confidence level.

1983

Hypotheses:

Ho: PEe = PEa,   PCe = PCa,   PWe = PWa

H1: PEe ≠ PEa,   PCe ≠ PCa,   PWe ≠ PWa

Test Statistics

$$Z = \frac{(Pa-Pe)-0}{\sqrt{\frac{Pa(1-Pa)+Pe(1-Pe)}{n}}}$$

Significance level: α = .10

Decision Rule:

If the computed value of the test statistics, Z, is greater than or equal to +1.645 or less than or equal to -1.645, we reject the null hypothesis at the .10 significance level.

Calculations

	Eastern	Central	Western
Pa	.338	.361	.301
Pe	.200	.553	.247
n	50	50	50

$$\text{Eastern} \qquad\qquad \text{Central}$$

$$Z = \frac{(.338-.200)-0}{\sqrt{\dfrac{.338(.662)+.200(.800)}{50}}} \qquad \frac{(.361-.553)-0}{\sqrt{\dfrac{.361(.639)+.553(.447)}{50}}}$$

$$= \frac{.138}{.088} = 1.568 \qquad\qquad = \frac{-.192}{0.098} = -1.959$$

$$\text{Western}$$

$$Z = \frac{(.301-.247)-0}{\sqrt{\dfrac{.301(.699)+.247(.753)}{50}}} \qquad = \frac{.054}{.089} = .607$$

Statistical Decision

Since one of the computed values of Z, −1.956 is less than the critical −1.645, we reject the null hypothesis at the significance level $\alpha = 0.10$.

Administrative Decision

Based on the above data, we conclude that the two proportions may not be equal, however further tests are carried out below to check on this decision at a higher level of confidence.

At a 95% level of confidence the test statistics remain the same, but the significance level changes to $\alpha = .05$ and thus the decision rule also changes.

Decision Rule:

If the computed value of the test statistics, Z, is

greater than or equal to +1.96 or less than or equal to
-1.96, we reject the null hypothesis.

Statistical Decision

Since the calculated values of Z, 1.568, -1.959 and
.607, all fall within the non rejection, range, We fail to
reject the null hypothesis at the α=0.05 level of significance.

Administrative Decision

From the above data, we conclude that the two sets of
proportions may be equal. These date do not allow us to
accept the alternative hypothesis. The model predictions
for 1983 are not significantly different from the actual
observed proportions, the model may be thus used for prediction
of the third year, or the third transition.

1984

Hypotheses:

Ho: PEe = PEa,   PCe = PCa,   PWe = PWa

Hi: PEe ≠ PEa,   PCe ≠ PCa,   PWa ≠ PWe

Test Statistics: $Z = \dfrac{(Pa-Pe)-0}{\sqrt{\dfrac{Pa(1-Pa)+Pe(1-Pe)}{n}}}$

Significance Level: $\alpha = .10$.

Decision Rule:

If the computed value of the test statistics, Z, is greater than or equal to +1.645 or less than or equal to -1.645, we reject the null hypothesis, (Ho) at significance level of $\alpha = .10$.

Calculations

	Eastern	Central	Western
Pa	.340	.362	.298
Pe	.195	.567	.238
n	50	50	50

Eastern

$$Z = \frac{(.340-.195)-0}{\sqrt{\dfrac{.34(.66)+.195(.805)}{50}}}$$

$$= \frac{.145}{.87} = 1.667$$

Central

$$\frac{(.362-.567)-0}{\sqrt{\dfrac{.362(.638)+.567(.433)}{50}}}$$

$$= \frac{-.205}{.098} = -2.092$$

Western

$$Z = \frac{(.298-.238)-0}{\sqrt{\dfrac{.299(.702)+.238(.762)}{50}}} = \frac{.060}{.088} = .682$$

Statistical Decision

Since two of the computed values of Z, 1.667 and -2.092 are greater than 1.645 and less than -1.645 respectively, we reject the null hypothesis at the significance level of $\alpha = .10$.

Administrative Decision

Based on the above data we conclude that the two sets of proportions may not be equal, however, further tests are carried out below to check on this decision at a higher level of confidence.

At 95% level of confidence, the test statistics remain the same, but the significance level changes to $\alpha = .05$, and thus the decision rule also changes.

Decision Rule:

If the computed value of the test statistics, Z, is greater than or equal to +1.96 or less than or equal to -1.96, we reject the null hypothesis.

Statistical Decision

Since one of the calculated values of Z, -2.092 is less than -1.96, we reject the null hypothesis at the significance level $\alpha = .05$.

Administrative Decision

From the above data, we conclude that the two sets of proportions may not be equal. This implies that the model for 1984 or for four transitions has weaker prediction power.

This confirms the suspicion that as the powers keep rising or the further away the predicted point from the starting point, the larger the difference between the predicted and the actual observation.

General Conclusion

The general conclusion for the total enrolment model is that the model should be used with caution especially for long period forecasts. The model works well for the first three transitions and starts to fail at the fourth transition. It is for this reason that the model is used to forcast for only three years. Such forecasts though short for long term planning are long enough for the short term planning purposes.

3.3.2.3   The Boys Enrolment Model

$$
\begin{array}{ccc}
Q(1980) & Tb & Qe(1981) \\
\begin{array}{ccc} E & C & W \end{array} & & \begin{array}{ccc} E & C & W \end{array} \\
(.302 \quad .364 \quad .334) & \begin{bmatrix} .690 & .174 & .136 \\ .220 & .568 & .212 \\ .279 & .249 & .472 \end{bmatrix} & = (.382 \quad .342. \quad .276)
\end{array}
$$

Qe(1981)   Qe(1982)

   E   C   W   E   C   W

$$
(.382 \quad .342 \quad .276) \begin{bmatrix} .690 & .174 & .136 \\ .220 & .568 & .212 \\ .279 & .249 & .472 \end{bmatrix} = (.416 \quad .329 \quad .255)
$$

Qe(1982)   Qe(1983)

$$
(.416 \quad .329 \quad .255) \begin{bmatrix} .690 & .174 & .136 \\ .220 & .568 & .212 \\ .279 & .249 & .472 \end{bmatrix} = (.430 \quad .323 \quad .247)
$$

Qe(1983)   Qe(1984)

$$
(.430 \quad .325 \quad .247) \begin{bmatrix} .690 & .174 & .136 \\ .220 & .566 & .212 \\ .279 & .249 & .472 \end{bmatrix} = (.437 \quad .320 \quad .243)
$$

Year	Actual Proportions			Estimated Proportions		
	Ea	Ca	Wa	Ee	Ce	We
1981	.341	.386	.273	.382	.342	.276
1982	.364	.319	.317	.416	.329	.255
1983	.342	.339	.320	.430	.323	.247
1984	.356	.334	.310	.437	.370	.343

A comparison of the actual proportions against the
estimated proportions first at 90% confidence level then at
95% confidence level. This is a test of the hypothesis about
the difference between two sets of population proportions, the
actual and the estimated.

<u>1981</u>

Hypotheses

Ho: PEe = PEa,   PCe = PCa,   PWe = PWa

H1: PEe $\neq$ PEa,   PCe $\neq$ PCa,   PWe $\neq$ PWa

<u>Test Statistics</u>: $Z = \dfrac{(Pa - Pe)-0}{\sqrt{\dfrac{Pa(1-Pa)}{na}+\dfrac{Pe(1-Pe)}{ne}}}$

<u>Significance Level</u>: α = .10

<u>Decision Rule</u>:

If the computed value of the test statistics, Z, is greater than or equal to +1.645 or less than or equal to -1.645, we reject the null hypothesis.

Calculations

	Eastern	Central	Western
Pa	.341	.386	.273
Pe	.382	.342	.255
na=ne=n	50	50	50

$$Z= \frac{(.341-.382)-0}{\sqrt{\dfrac{.341(.659)+.382(.618)}{50}}} \qquad \frac{(.386-.342)-0}{\sqrt{\dfrac{.386(.614)+.342(.658)}{50}}}$$

$$= \frac{-.041}{.096} = -.427 \qquad\qquad = \frac{.044}{.096} = .458$$

Western

$$\frac{(.273-.255)-0}{\sqrt{\dfrac{.273(.727)+.255(.745)}{50}}} = \frac{.018}{.088} = .205$$

Statistical Decision

Since all calculated values fall within the non-rejection region ($\pm$ 1.645), we do not reject the null hypothesis.

At the significance level $\alpha = .05$: The decision rule changes to greater than or equal to +1.96 or less than or equal to -1.96. Thus even at this level of significance, we do not reject the null hypothesis.

Administrative Decision

Based on the data from above, we conclude that the two proportions may be equal. These data do not allow us to accept the alternative hypothesis. The model predictions for 1981 are not so far off from the actual proportions observed, as such the model is acceptable for one transition or one year prediction.

1982

Hypotheses

Ho: PEa = PEe,   PCe = PCe,   PWa = PWe

H₁: PEa ≠ PEe,   PCe ≠ PCa,   PWa ≠ PWe

Test Statistics: $Z = \dfrac{(Pa-Pe)-0}{\sqrt{\dfrac{Pa(1-Pa)+Pe(1-Pe)}{n}}}$

Significance Level: $X = 0.10$.

Decision Rule:

If the computed values of the test statistics, Z, is greater than or equal to +1.645 or less than or equal to -1.645, we reject the null hypothesis.

Calculations

	Eastern	Central	Western
Pa	.364	.319	.317
Pe	.416	.329	.255
n	50	50	50

$$Z = \dfrac{(.364\ .416)-0}{\sqrt{\dfrac{.364(.636)+.416(.584)}{50}}}$$

$$= \dfrac{-.052}{.097} = -.536$$

Central

$$\dfrac{(.319-.329)-0}{\sqrt{\dfrac{.319(.681)+.329(.671)}{50}}}$$

$$= \dfrac{-.01}{.094} = -.106$$

Western

$$\dfrac{(.317-.255)-0}{\sqrt{\dfrac{.317(.683)+.255(.745)}{50}}} = \dfrac{.062}{.090} = .689$$

Statistical Decision

Since all the calculated values fall within the non-rejection region (± 1.645) we do not reject the null hypothesis (Ho).

At the significance level α = .05, the decision rule changes to greater than or equal to +1.96 or less than or equal to -1.96, thus even at this level of significance (95% confidence level), we do not reject the null Hypothesis.

Administrative Decision

Based on the data from above, we conclude that the two proportions may be equal. These data do not allow us to accept the alternative hypothesis. The model predictions for 1982 are not so far off from the actual proportions observed, as such the model is acceptable for two transitions or for two years' predictions.

1983

Hypotheses remain the same as above.

Test statistics remain the same as above.

Significance Level: α = .10

Decision Rule:

If the computed values of the test statistics, Z, is greater than or equal to +1.645 or less than or equal to -1.645, we reject the null hypothesis.

Calculations

	Eastern	Central	Western
P_a	.342	.339	.320
P_e	.430	.326	.247
n	50	50	50

Central

$$Z = \frac{(.342-.430)-0}{\sqrt{\dfrac{.342(.658)+.430(.570)}{50}}} \qquad \frac{(.339-.326)-0}{\sqrt{\dfrac{.339(.661)+.326(.674)}{50}}}$$

$$= \frac{-.088}{.097} = -.907 \qquad\qquad = \frac{.013}{.090} = .138$$

Western

$$\frac{(.320-.247)-0}{\sqrt{\dfrac{.320(.680)+.247(.753)}{50}}} = \frac{.073}{.090} = .811$$

Statistical Decision

This is upheld as in the above case (1982).

Administrative Decision

The model may be used to forecast for the three years or three transitions.

<u>1984</u>

Hypothesis remain the same as above.

Test statistics remain the same as above.

<u>Significance Level</u>: α = .10

Decision rule remains the same as above.

<center>Calculations</center>

	Eastern	Central	Western
Pa	.356	.334	.310
Pe	.437	.320	.243
n	50	50	50

$$Z = \frac{(.356-.437)-0}{\sqrt{\frac{.356(.644)+.437(.563)}{50}}} \qquad \frac{(.334-.320)-0}{\sqrt{\frac{.334(.666)+.320(.680)}{50}}}$$

$$=\frac{-.081}{.097} = -.835 \qquad\qquad = \frac{.014}{.094} = .149$$

<u>Western</u>

$$= \frac{(.310-.243)-0}{\sqrt{\frac{.310(.690)+.243(.757)}{50}}} \qquad = \frac{.067}{.089} = .753$$

Statistical decision is upheld for 1984 as for 1983.

<u>Administrative decision</u>

From the data above, the model may be used to predict for the fourth year with reasonable measure of accuracy with 95% Confidence. That is the projected proportions are not

so different from the observed proportions.

3.3.2.4   The Girls Enrolment Model

$$
\begin{array}{c}
Q(1980) \\
\begin{array}{ccc} E & C & W \end{array} \\
(.282 \quad .415 \quad .303)
\end{array}
\begin{array}{c}
Tg \\
\begin{bmatrix}
.566 & .406 & .028 \\
.110 & .547 & .343 \\
.108 & .190 & .702
\end{bmatrix}
\end{array}
=
\begin{array}{c}
Qe(1981) \\
\begin{array}{ccc} E & C & W \end{array} \\
(.238 \quad .399 \quad .363)
\end{array}
$$

$$
\begin{array}{c}
Qe(1981) \\
(.238 \quad .399 \quad .363)
\end{array}
\begin{bmatrix}
.566 & .406 & .028 \\
.110 & .547 & .343 \\
.108 & .190 & .702
\end{bmatrix}
=
\begin{array}{c}
Qe(1982) \\
(.218 \quad .384 \quad .398)
\end{array}
$$

$$
\begin{array}{c}
Qe(1982) \\
(.218 \quad .384 \quad .398)
\end{array}
\begin{bmatrix}
.566 & .406 & .028 \\
.110 & .547 & .343 \\
.108 & .190 & .702
\end{bmatrix}
=
\begin{array}{c}
Qe(1983) \\
(.209 \quad ..374 \quad .417)
\end{array}
$$

$$
\begin{array}{c}
Qe(1983) \\
(.209 \quad .374 \quad .417)
\end{array}
\begin{bmatrix}
.566 & .406 & .028 \\
.110 & .547 & .343 \\
.108 & .190 & .702
\end{bmatrix}
=
\begin{array}{c}
Qe(1984) \\
(.204 \quad .369 \quad .427)
\end{array}
$$

Year	Actual Proportions			Estimated Proportions		
	Ea	Ca	Wa	Ee	Ce	We
1981	.340	.395	.265	.238	.399	.363
1982	.340	.360	.300	.218	.384	.398
1983	.334	.383	.283	.209	.374	.417
1984	.323	.391	.286	.204	.369	.427

A comparison of the actual proportions against the

estimated proportions, first at 90% confidence level then at 95% confidence level. This is a test of the hypothesis about the difference between two sets of population proportions, the actual and the estimated.

1981

Hypotheses:

Ho: PEa = PEe,   PCa = PCe,   PWa = PWe

H₁: PEa ≠ PEe,   PCa ≠ PCe,   PWa ≠ PWe

Test Statistics: $Z = \dfrac{(Pa-Pe)-0}{\sqrt{\dfrac{Pa(1-Pa)+Pe(1-Pe)}{n}}}$

Significance Level: α = :10

Decision Rule:

If the computed value of the test statistics, Z, is greater than or equal to +1.645 or less than or equal to -1.645, we reject the null hypothesis (about equality, between the actual and the model predicted proportions).

Calculations

	Eastern	Central	Western
Pa	.340	.395	.265
Pe	.238	.399	.363
n	50	50	50

$$Z = \frac{(.340-.238)-0}{\sqrt{\dfrac{.340(.660)+238(.762)}{50}}} \qquad \frac{(.395-.399)-0}{\sqrt{\dfrac{.395(.605)+399(.601)}{50}}}$$

$$= \frac{.102}{.090} = 1.133 \qquad\qquad = \frac{-.004}{.098} = -.041$$

Western

$$\frac{(.265-.363)-0}{\sqrt{\dfrac{.265(.735)+.363(.637)}{50}}} = \frac{-.098}{.092} = -1.065$$

Statistical Decision:

Since the calculated values above fall within the non-rejection region ($\pm$ 1.645), we do not reject the null hypothesis at the 0.10 significance level.

At the higher significance level $\alpha = .05$, the decision rule changes to greater than or equal to +1.96 or less than or equal to -1.96. The decision above is thus upheld even at this significance level.

Administrative Decision:

Based on the data above, we conclude that the two proportions may be equal. These data do not allow us to accept the alternative hypothesis. The model predictions for 1981 are not so far off from the actual proportions observed, as such the model is acceptable for one transition or for one year predictions.

1982

Hypotheses remain the same as above (for 1981)

Test statistics also remain the same as for 1981.

Significance Level: $\alpha = .10$, $\alpha = .05$

Decision Rule:

If the computed value of the test statistics, Z, is greater than or equal to +1.645 or less than or equal to -1.645 at the 0.10 significance level then we reject the null hypothesis. If the value of Z is greater than or equal to +1.96 or less than or equal to -1.96 at the 0.05 significance level, then we reject the null hypothesis at this significance level.

Calculations

	Eastern	Central	Western
Pa	.340	.360	.300
Pe	.218	.384	.398
n	50	50	50

$$Z = \frac{(.340-.218)-0}{\sqrt{\dfrac{.340(.660)+.218(.782)}{50}}} \qquad \frac{(.360-.384)-0}{\sqrt{\dfrac{.360(.640)+.384(.616)}{50}}}$$

$$= \frac{.122}{.089} = 1.37 \qquad\qquad = \frac{-.024}{.097} = -.247$$

$$= \frac{(.300-.398)-0}{\sqrt{\dfrac{.300(.700)+.398(.602)}{50}}} = \frac{-.098}{.095} = -1\ 032$$

Statistical decision

Since the calculated values fall within the non-rejection region (± 1.645) at the significance level $\alpha = .10$ and also at the significance level $\alpha = .05$ that is $\pm$ 1.96. We do not reject the null hypothesis at both levels.

Administrative Decision

Based on the data above, we conclude that the two proportions may be equal. The model predictions for 1982 are therefore not so far off from the actual observed proportions, as such the model is acceptable for two year transition or for two year projections.

1983

Hypotheses remain the same as above (1982).

Test statistics also remain the same,

Significance Level: $\alpha = .10$, $\alpha = .05$

Decision rules remain the same as above for $\alpha = .10$ and also for $\alpha = .05$

Calculations:

	Eastern	Central	Western
Pa	.334	.383	.283
Pe	.209	.374	.417
n	50	50	50

Eastern

$$Z = \frac{(.334-.209)-0}{\sqrt{\frac{.334(.666)+.209(.791)}{50}}}$$

$$= \frac{.125}{.088} = 1.42$$

Central

$$\frac{(.383-.374)-0}{\sqrt{\frac{.383(.617)+.374(.626)}{50}}}$$

$$= \frac{.009}{.097} = .093$$

Western

$$\frac{(.283-.417)-0}{\sqrt{\frac{.283(.717)+.417(.583)}{50}}} = \frac{-.134}{.094} = -1.426$$

Statistical Decision

Since the computed values of Z fall within the non.
rejection ranges ($\pm$ 1.96), we do not reject the null
hypothesis.

Administrative Decision:

Based on the data above, we conclude that the two
proportions may be equal. These data do not allow us to
accept the alternative hypothesis. The model prodictions
for 1983 are not so far off from the actual observation.
The model is thus acceptable for three years predictions

or for three transitions.

<u>1984</u>

Hypotheses remain the same as above

Test statistics also remain the same.

Significance Level: $\alpha = .10$, $\alpha = .05$

<u>Decision Rule:</u>

If the computed values of the test statistics, Z, is greater than or equal to +1.645 or less than or equal to -1.645 at the 0.10 significance level then we reject the null hypothesis. If the value of Z is greater than or equal to +1.96 or less than or equal to -1.96 at the 0.05 significance level, then we reject the null hypothesis at this level of significance.

<u>Calcualtions</u>

	<u>Eastern</u>	<u>Central</u>	<u>Western</u>
P_a	.323	.391	.286
P_e	.204	.369	.427
n	50	50	50

$$Z = \frac{(.323-.204)-0}{\sqrt{\frac{.323(.677)+204(.796)}{50}}}$$

$$\frac{(.391-.369)-0}{\sqrt{\frac{.391(.609)+369(.631)}{50}}}$$

$$= \frac{.119}{.087} = 1.368$$

$$\frac{.022}{.097} = .227$$

Western

$$\frac{(.286-.427)-0}{\sqrt{\frac{.286(.714)+.427(.573)}{50}}} = \frac{-.141}{.095} = -1.484$$

Statistical Decision

Since the calculated values of Z, fall within the relevant ranges ($\pm$ 1.645 and $\pm$ 1.96), we do not reject the null hypothesis at 0.10. level of significance and at 0.05 level of significance respectively.

Administrative Decision

From the above data the model is acceptable for the prediction of the fourth year or upto the fourth transition, because the two proportions(actual and predicted) may not be different.

3.3.2.5   Conclusion

The three models built in this section for the total enrolment, the boys enrolment and the girls enrolment are validated above. The validation showed that for the latter two, the model may be used to predict upto the fourth year from the prediction point and there would be no statistical difference between the actual and the estimated proportions. For the total enrolment, however, the model can only be used to predict upto the third year from the prediction point

without any statistical difference between the actual and the estimated difference.

It is necessary to note that the tests performed on the model are only statistical and hence have the inherent statistical tests assumptions and limitations.

SECTION FOUR

RESULTS OF THE APPLICATION OF THE MODEL

The Model developed and validated in the last section is used with the demand proportions for 1989 to predict demand proportions for 1990, 1991 and 1992.

4.1 TOTAL STANDARD ONE DEMAND

Demand proportions for 1989:

Transition Matrix

Forecasted Demand Proportions for 1990

Eastern Central Western

$$T$$

Eastern Central Western

$$(.302 \quad .387 \quad .311) \quad \begin{bmatrix} .52 & .37 & .11 \\ .12 & .78 & .10 \\ .10 & .25 & .65 \end{bmatrix} \quad (.235 \quad .491 \quad .274)$$

Forecasted Proportions for 1990:

Forecasted Demand Proportions for 1991

$$T$$

$$(.235 \quad .491 \quad .274) \quad \begin{bmatrix} .52 & .37 & .11 \\ .12 & .78 & .10 \\ .10 & .25 & .65 \end{bmatrix} \quad (.209 \quad .538 \quad .253)$$

Forecasted Proportions For 1991:

Forecasted Demand Proportions for 1992

$$T$$

$$(.209 \quad .538 \quad .235) \quad \begin{bmatrix} .52 & .37 & .11 \\ .12 & .78 & .10 \\ .10 & .25 & .65 \end{bmatrix} \quad (.199 \quad .560 \quad .241)$$

The results of the Model application shows that in 1990 24% of the total standard one demand in Nakuru municipality will be in the Eastern Zone. In the same period, 49% will be in the Central Zone while 27% will be in the Western Zone.

In 1991, 21% of the standard one demand will be in the
Eastern zone, 54% in the Central zone and 25% in the Western zone.

In 1992, only about 20% of the demand will be in the Eastern
zone, 56% in the Central zone while the Western zone will have
24% of the demand.

4.2   THE BOYS DEMAND FOR STANDARD ONE

Demand Proportions for 1989	Transition Matrix	Forecasted Demand Proportions for 1990
Eastern Central Western	T_b	Eastern Central Western
(.323 .340 .337)	$\begin{bmatrix} .690 & .174 & .136 \\ .220 & .568 & .212 \\ .279 & .249 & .472 \end{bmatrix}$	(.392 .333 .275)

Forecasted Proportions for 1990	T_b	Forecasted Demand Propor- for 1991
E C W		E C W
(.392 .333 .275)	$\begin{bmatrix} .690 & .174 & .136 \\ .220 & .568 & .212 \\ .279 & .249 & .472 \end{bmatrix}$	(.420 .326 .254)

Forecasted Proportions for 1991	T_b	Forecasted Demand Proportions for 1992
E C W		E C W
(.420 .326 .254)	$\begin{bmatrix} .690 & .174 & .136 \\ .220 & .568 & .212 \\ .279 & .249 & .472 \end{bmatrix}$	(.432 .322 .246)

The results of the model application shows that in 1990, 39% of
the boys will demand to be enroled in Eastern zone, 33% in the Central
zone and about 28% in the Western zone. In 1991, 42% of the boys will
demand to be enroled in the Eastern zone, 33% in the Central zone and
25% in the Western zone. In 1992, 43% of the boys will demand to be
enroled in the Eastern zone, 32% in the Central zone
and 25% in the Western zone.

4.3   THE GIRLS DEMAND FOR STANDARD ONE

Demand Proportions
for 1989

Transition Matrix

Forecasted Demand
Proportions for 1990:

Eastern Central Western

$$T_g$$

Eastern   Central   Western

$(.285 \quad .427 \quad .288)$ $\begin{bmatrix} .566 & .406 & .028 \\ .110 & .547 & .343 \\ .108 & .190 & .702 \end{bmatrix} = (.239 \quad .404 \quad .357)$

Forecasted Proportions
for 1990:

$$T_g$$

Forecasted Demand
Proportions for 1991:

$(.239 \quad .404 \quad .357\,)$ $\begin{bmatrix} .566 & .406 & .028 \\ .110 & .547 & .343 \\ .108 & .190 & .702 \end{bmatrix} = (.218 \quad .386 \quad .396)$

Forecasted Proportions
for 1991:

$$T_g$$

Forecasted Demand
Proportions for 1992

$(.218 \quad .386 \quad .396)$ $\begin{bmatrix} .566 & .406 & .028 \\ .110 & .547 & .343 \\ .108 & .190 & .702 \end{bmatrix} = (.209 \quad .375 \quad .416\,)$

The results of the model application shows that in 1990, 24% of the girls will demand to be enroled in the Eastern zone, 40% in the Central zone and 36% in the Western zone. In 1991, 22% will demand to be enroled in the Eastern zone, 39% in the Central zone and 39% in the Western zone. In 1992, 21% will demand to be enroled in the Eastern Zone, 37% in the Central zone and about 42% in the Western zone.

SUMMARY   OF   RESULTS

Table 4.1:   Total Demand for Standard One

Zone	Expected	Demand	in	Expected long run Demand
	1990	1991	1992	
Eastern	24%	21%	20%	9%
Central	49%	54%	56%	59%
Western	27%	25%	24%	32% .
Total	100%	100%	100%	100%

Table 4.2: Boys Demand for Standard One

Zone	Expected	Demand in		Expected long run Demand
	1990	1991	1992	
Eastern	39%	42%	43%	51%
Central	33%	33%	32%	31%
Western	28%	25%	25%	18%
Total	100%	100%	100%	100%

Table 4.3:   Girls Demand for Standard One

Zone	Expected Demand in			Expected long run Demand
	1990	1991	1992	
Eastern	24%	22%	21%	16%
Central	40%	39%	37%	23%
Western	36%	39%	42%	61%
Total	100%	100%	100%	100%

SECTION FIVE

SUMMARY, RECOMMENDATIONS AND CONCLUSION

5.1 SUMMARY

The study set out to represent the standard one
enrolment in Nakuru Municipality as a Markovian process
and to use the Markov chain process to forecast the
demand for standard one for the years: 1990, 1991 and
1992. The forecasts are needed for municipal school
administration and planning purposes.

By treating the movement between the different
zones of the municipality as transitions, a Markovian
model of the system was developed which was used to
estimate the future enrolment proportions within the
zones. The results of the study show that for 1990,
about a half of the total standard one demand will
be in the Central zone, while the Eastern and the
Western zones shall share the rest, with the Western
zone demand slightly higher than the eastern zone
demand. More or less the same conditions shall prevail
in the 1991 and 1992, with each successive year's
demand rising in the central zone while the demand for
the other zones fall accordingly. In the long run,
when the system will have reached a stable state,
about 60% of standard one demand will be for the
central zone, 10% for the eastern zone and 30% for
the western zone.

In 1990, about 39% of the boys will demand to be enrolled in the Eastern Zone, 33% in central zone and 28% in the Western zone. These proportions will increase to 42%, remain the same at 33% and increase to 25% in 1991 for the eastern, central and western zone respectively. In 1992, the demand of the boys for the eastern zone will be 43%, 32% for the central zone and 25% for the western zone. Most of the boys demand for standard one will therefore be concentrated in the eastern zone followed by the central zone; which would demand about a third of such places. In the long run, when the system will have reached a stable state, about a half of the boys demand would be for the eastern zone, a third for the central zone and the rest for the western zone.

The demand of the girls for standard one will be 40% in the central zone, 24% in the eastern zone and 36% in the Western zone for 1990. The proportions will change by 1991, so that about 39% of the girls will prefer the western zone, while 39% will prefer the central zone and 22% the eastern zone. By 1992, the western zone percentage will have increased by 42% while the central zone will have dropped to 37% and eastern to 21%. In the long run therefore, when the system will have reached a stable state, most of the girls (61%) or about two-thirds ($2/3$) of the girls would demand to be enroled in standard one in the western zone; followed by the central zone which would be demanded by about 20% or a fifth of the girls.

An interesting observation is that while most of the total demand for standard one places will be concentrated in the central zone, the boys demand for standard one places will be concentrated mainly in the eastern zone while the girls demand will be concentrated mainly in the western zone. The available information does not seem to explain this phenomenon, consequently further research to find why this prenomenon occurs is recommended.

5.2 RECOMMENDATIONS

From the above observations, most of standard one demand will be for the central zone. It has to be noted that the central zone includes the town centre and the busiest parts of Nakuru town. With the observation above, the Municipality has to act fast to be able to meet the standard one demand for this region. One of the possible ways of doing this is to expand the exist- ing schools in this area by, say, erecting storied classrooms, removing structures near such institutions to create room for sportsground and such type of actions that would ensure that adequate resources, about a half needed for standard one, are concentrated in the central zone.

The administrative effort of the Municipal council of Nakuru education department should be concentrated in the central zone, as this is where demand for standard one and possibly the other classes is greatest. Other resources like time, personnel, equipment and money should be apportioned such that the central zone receives more than the other two zones.

For the short planning period (1990-1992),about 50% of the resources should be in the central zone,30% in the western zone and 20% in the Eastern zone. These ratios should be changed in the long-run to about 60% in the Central zone, 30% in the western zone and 10% in the Eastern zone.

One of the possible reasons why the demand for standard one is concentrated near the town centre is that most offices and workplaces are in the town centre itself, parents therefore find it convenient to drop their young children (six or seven year olds) to schools near their offices. The Municipality can discourage this indirectly by allocating no more land in the town centre for offices, so that the the town expands outwards. The Municipal council can also charge higher rates and rents for such areas than the other areas and discourage the coming up of new office structures. Some residential estates within the central zone like the Langalanga area are densely populated than most residential estates within the Western and the Eastern zones. To correct this imbalance, as far as standard one enrolment is concerned, the Municipal can provide safe school transport from such estates to the eastern and western zones, so that fear of transport problems does not force parents to enrol their young children only in schools near their homes.

The recommendations above can be useful both for the short planning period (as the one used in fore-casting with the above Model) or the long planning period. A simple definition of planning is: "deciding in advance what to do, when to do it, how to do it, where to do it and who to do it". Taking this simple definition in relation to the Municipal education department, the "what" may be known, say expand

classrooms for standard one, when?, say for the coming
three years or five years planning period, how? say
by allocating a certain proportion of their budget
to this purpose and by who?, say, calling tenders
from various constructors and whoever qualifies to
get the tender. A difficult question to anwer,usually,
is, where? This is not accidental but is due to the
fact that the Municipality is so large and each
area or even each school needs more resources. Usually
each school sends requests for what it needs. When
going through the Municipal records, one finds so
many requests for each month, some of which are
repeated month after month, implying that they are
never answered in time (if at all). One therefore
realises they are dealing with a typical situation
of limited resources. Like most other towns, Nakuru
faces the problem of allocation of limited resources
among the rivaling needs of its residence, like
education, health,security and housing. The Model
above can help the Municipality in answering this
universal economic question of resource allocation.
By indicating the proportions likely to be enroled
in the different areas, the Municipality can apply
similar proportions to allocate the resources.

The long run (steady state) proportions show
what the position would be in a very long time to
come, if the system is not interfered with. It
shows a possible gross imbalance in the demand

for standard one within the different zones.   This
knowledge can help the Municipality to look for ways
in which to redirect this imbalance before it actually
occurs.   New attractions may be set up in the Eastern
zone for instance to encourage people to move into
this area.   Such actions may help spread out of
people more uniformly and thus spread out development
in the long run.   By trying to identify reasons why
the demand for standard one would shift to the central
zone, the Municipality can then make the Eastern and
western zones also attractive to lure demand into these
areas.

The Model can also be used to allocate more of
those facilities peculiar to girls in the Western zone
and more of those peculiar to boys in the Eastern zone,
thus ensuring that they are allocated where the need
is likely to be felt most.

LIMITATIONS OF THE STUDY

The study was limited to standard one enrolment
and the results may not apply for the other classes.
Certain data for this study were not easy to obtain;
indeed the demand for standard one in the Municipality
has never been recorded in the past.   The only data
kept from 1969 to 1988 were the actual enrolment
within the different zones.   The model was therefore
built with the actual enrolment rather than the
demand.   This limits the study to the extent that

the demand is assumed to behave in a similar way to
the actual enrolment.

Time allocated to the study was too short to
allow for more intensive analysis of the data, and
this contrained the study to some extent.

SUGGESTIONS FOR FURTHER RESEARCH

Any further research could address itself to:

(a) Finding out why the standard one girls and
boys in Nakuru Municipality tend to demand
the Western and Eastern zones respectively.

(b) Finding out how the Municipality can ease
the unequal demand facing the different schools
within the same zones.

(c) Similar studies for the other primary school
classes within the Municipality and even for the
other urban areas like Nairobi.

(d) The whole of education system within a Muni-
cipality for instance, by taking enrolment within
a particular year, say, 1980, until they graduate
in 1988, to find out:

   (i)   actual movements from zone to zone

   (ii)   dropout ratios among the girls, boys
          and the two combined.

   (iii) staying ratios, that is the probability
          that a pupil will graduate from the
          system and such other enrolment related
          factors.

APPENDIX 1

Schools in the different zones

Eastern	Central	Western
Bondeni	Baharini	Freehold
Crater	Flamingo	Harambee Khalsa
Gilani*	Kaloleni*	Heshima
Hyrax	Kimathi	Hill special*
Jamhuri	Langalanga	Kaptembwa
Kisulisuli	Moi	Kariba Road*
Lanet	Mwariki	Kenyatta
Lenana	Ngala special*	Koinange
Lions*		Mama Ngina
Madaraka	Pangani	Mlimani
Menengai	Prairie	Muslim
Nakuru	St. Mary's	Nakuru West
Nakuru East	St. Paul's	Prisons*
St. Theresa's	St. xavier's	St Joseph's
		Uhuru

* Gilani was closed down in 1984 because the area where it was situated was not suitable.

* Lions is a school run by the Lion's club of Nakuru and does not fall under the Municipal Council administration directly.

* Kaloleni was started in 1989

* Prisons was started in 1989

* Ngala is a special school for the deaf

* Hill (or Nakuru Hill) is a special school for the mentally handicaped.

* Kariba Road was started in 1989

APPENDIX 2

Standard one enrolment between 1969 to 1988

YEAR	EASTERN			CENTRAL			WESTERN		
	B	G	T	B	G	T	B	G	T
1969	247	188	435	212	265	477	233	173	406
70	336	306	642	219	252	471	166	142	308
71	303	262	565	280	226	506	236	329	565
72	440	349	789	306	328	634	280	239	519
73	461	425	886	337	366	703	293	272	565
74	829	820	1649	776	804	1580	606	524	1130
75	610	582	1192	554	552	1106	430	383	813
76	661	582	1243	546	609	1155	524	410	934
77	420	352	772	488	342	830	373	520	893
78	418	384	802	480	346	826	428	561	989
79	486	486	972	611	437	1048	501	645	1146
80	582	529	1111	702	780	1482	643	569	1212
81	688	676	1364	780	784	1564	552	527	1079
82	784	676	1460	688	714	1402	682	598	1280
83	666	633	1299	660	727	1387	623	536	1159
84	724	625	1349	679	756	1435	629	553	1182
85	702	651	1353	628	584	1212	963	684	1377
86	634	612	1246	600	606	1206	679	705	1384
87	673	619	1292	669	662	1331	805	725	1530
88	599	583	1182	663	684	1347	963	817	1780

B - Boys

G - Girls

T - Totals

APPENDIX   3

Proportion (of the Totals) enroled within

the zones from 1969 to 1988

YEAR	EASTERN	CENTRAL	WESTERN
1969	.330	.362	.308
70	.452	.331	.217
71	.345	.372	.282
72	.406	.326	.267
73	.411	.326	.262
74	.378	.362	.259
75	.383	.358	.261
76	.374	.346	.280
77	.309	.404	.287
78	.306	.398	.296
79	.307	.397	.296
80	.340	.320	.340
81	.340	.390	.270
82	.352	.338	.309
83	.338	.361	.301
84	.340	.362	.298
85	.343	.333	.324
86	.325	.340	.335
87	.311	.336	.353
88	.274	.313	.413

APPENDIX   4

Proportion of the boys enroled within
the zones from 1969 to 1988

YEAR	EASTERN	CENTRAL	WESTERN
1969	.357	.306	.337
70	.466	.304	.230
71	.370	.342	.288
72	.429	.298	.273
73	.423	.309	.269
74	.375	.351	.274
75	.383	.348	.278
76	.382	.315	.303
77	.328	.381	.291
78	.315	.362	.323
79	.304	.362	.314
80	.302	.364	.334
81	.341	.386	.273
82	.364	.319	.317
83	.342	.339	.320
84	.356	.334	.310
85	.347	.310	.343
86	.331	.314	.355
87	.313	.312	.375
88	.269	.298	.433

APPENDIX 5

Proportion of the girls enroled within

the zones from 1969 to 1988

YEAR	EASTERN	CENTRAL	WESTERN
1969	.300	.423	.276
70	.437	.360	.203
71	.321	.277	.403
72	.381	.358	.261
73	.400	.344	.256
74	.382	.374	.244
75	.384	.364	.252
76	.265	.380	.256
77	.290	.282	.428
78	.279	.268	.435
79	.310	.279	.411
80	.282	.415	.303
81	.340	.395	.265
82	.340	.360	.300
83	.334	.383	.283
84	.323	.391	.286
85	.339	.304	.356
86	.318	.315	.367
87	.309	.330	.361
88	.280	.328	.392

APPENDIX 6

Entries in the body of the table give the area under the standard normal curve from 0 to z.

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549
0.7	.2580	.2611	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

.450 .450
z = -1.64 0 z = +1.64
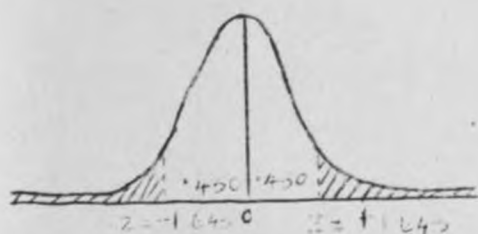
//// Rejection Region at the 90% confidence level

.475 .475
z = -1.96 0 z = +1.96
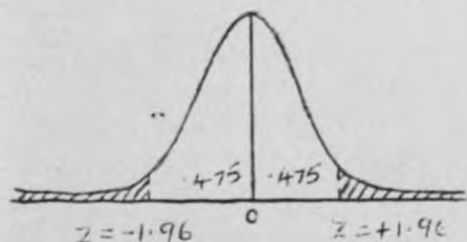
//// Rejection Region at the 95% confidence level.

APPENDIX   7

Demand for standard one in the
different zones in 1989

Totals

	Eastern	Central	Western	Total
In numbers:	1075	1375	1104	3554
As percentages:	30.2%	38.7%	31.1%	100%

Boys

	Eastern	Central	Western	Total
In numbers:	533	562	556	1651
As Percentages:	32.3%	34%	33.7%	100%

Girls

	Eastern	Central	Western	Total
In numbers:	542	813	548	1903
As percentages:	28.5%	42.7%	28.8%	100%

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