CHAPTER - I

INTRODUCTION
1.1 Research publications


3. An analysis of selected demographic parameters in fertility data of Orissa.

   To appear in the Journal 'Demography India', Indian Association for the study of population, New Delhi, India.


5. A Study of Nuptiality Levels and Trends in Orissa.


7. Decision Models to estimate the effect of family planning programme on fertility: Presented at the 16th Annual Conference of Indian Association for the Study of Population, held at Bhubaneswar on Feb., 1993. Also to appear in the Journal 'Statistica', Italy.


10. A Mathematical Programming Model to estimate the Net Migration among Developmental Regions: Presented at the 11th Annual Conference of Indian Society for Medical Statistics and National Seminar on Growing priority for Epidemiological Approaches in Environmental studies, held at Andhra University, Visakhapatnam on October, 1993. Also Communicated to the Journal, 'Sankhya', India.

1.2 Importance of the study

Population plays an important role in the socio-economic development of a nation and hence the study of population is the focus of the increasing attention of the demographers, Sociologists, economists and other social scientists. It is well established fact that the socio-economic development of any country is closely related to its size, structure and pattern of population growth. The alarming growth of the human population, today has posed a very serious problem before the politicians, planners, policy makers, sociologists, economists and other social scientists not only of our country but of the whole world to solve the problems of hunger, poverty and other socio-economic dilemmas.

In general, there are three basic components of population dynamics viz. Fertility, Mortality and Migration. But other three components i.e. Nuptiality, Family planning and Development are also important and are related with the above three basic components of population dynamics. It would be worthwhile to study these points, while considering any study on population of a country. The mortality and fertility are mainly the biological variables in the sense that they operate within the biological frame work, though the social, cultural, economic and political factors do exercise some influence on them. The nuptiality relates to marriage and dissolution in the same way as fertility and mortality to
births and deaths respectively. Whereas family planning is a process by which fertility can be controlled by reducing the births. Anyhow it is related to the basic factor of fertility. Migration, which is an integral part of population planning, is a socio-economic phenomenon which is the result of a complex mechanism involving social, psychological, economic, political, institutional and other determinants. Most of the acute socio-economic and cultural problems of the world today are associated to a great extent, with the fertility and migration. Bogue [16] very rightly stated, "If the problems of the human fertility were not so critical at the present time, It is almost certain that the human migration and the plight of migrants (especially in the developing countries) would be listed as the top priority problems for research and action."

The reduction in mortality, after world War II in most of the developing countries, contributed to the rapid increase in their populations. Among the components of population change, mortality thus plays a vital role of determining the size of population. It also exerts its influence on the age structure of the population though much smaller than fertility. Study of mortality is needed for the analysis of several other demographic phenomenon like nuptiality, fertility and migration; for public health administration and various studies like projection of
population in future, ascertaining changes in characteristics of population, developing plans for housing and educational facilities; managing the social security programmes, providing various services like life insurance policies and commodities for various groups of the population.

Some measures are generally required for studying mortality conditions of a population. Different measures have been proposed for the analysis of mortality. In developing countries where the vital registration system is weak, the principal alternate sources to collect mortality data are, national censuses and national sample surveys. Direct data on deaths are not generally collected in a census, but of late, some indirect techniques have been used to estimate the level of mortality from the age distributions of persons covered by the census or survey. Among the important indicators of morality status of the population are expectation of life at birth and infant mortality. The expectation of life at birth is an indicator of the general level of mortality in a population and is widely used for comparative analysis of mortality situations in different populations. Similarly, the most useful indicators reflecting the general health conditions are infant mortality rates. It is sensitive to the general conditions of life, environmental sanitation and standards of living. Some of the most important economic and social causes which contribute to infant and maternal mortality are poverty,
ignorance, bad housing, venereal diseases, early marriage and psychological, physical and emotional immaturity of the mothers during pregnancy and the neglect of children.

Fertility is the most important factor in the study of population dynamics. The excess of birth over deaths occurring in any human population over a given period of time determines its natural growth. Thus fertility is responsible for the biological maintenance of population being continuously depleted by mortality. It not only affects the size of a population but also affects its age and sex structure. The age composition of population closed to migration is determined by the prevailing fertility and mortality levels of the population in the past. Any change in the level of fertility measures immediately affects the young age population and hence the whole age distribution of the population. With fertility level remaining constant and mortality declining, the more and more children survive longer and the population becomes younger and younger. On the other hand, if any measure of fertility declines, the population necessarily becomes older because of the decrease in the child population. It has been observed that significant increase in fertility to some extent poses a problem on socio-economic development. Similarly, a decline in fertility also pose or creates similar problem. The studies of fertility in many developing countries like India is a major problem due to the
lack of reliable information of birth records. So, it is difficult to find out fertility measures accurately. In recent years, many indirect techniques have been developed for estimating fertility measures. These techniques are particularly useful in situations where reliable estimates by conventional methods are not available. These also serve as useful tools for evaluation purposes by providing alternate estimates which can be compared with those already available.

In exploring the importance of nuptiality studies in general, and for developing countries in particular, we may begin with D.V. Glass's comments [57]:

"For Demographers, here is ample reason to devote more attention to marriage. It is through the intervening variable of marriage that replacement indices become sociologically meaningful. The study of marital patterns and trends in less developed societies is of still greater importance."

First, marital status is an element of population composition which is of considerable importance. It is a significant factor in population dynamics as it affects fertility to a large extent. It has a direct bearing on the computation of reproduction rates. Nonetheless, the effect of nuptiality on other social and economic characteristics such
as school attendance, labour force participation, etc., is also not totally insignificant. In fact, proportions of single are very useful indicators of socio-economic and cultural differences between regions, countries and between different segments of a population.

Second, age at marriage is an important aspect of the study of nuptiality. A paper of Westoff and Ryder [209] has shown that the age at first marriage is the single best predictor of the level of completed fertility. This aspect of nuptiality, therefore, becomes relevant and significant in the context of a population policy which seeks to regulate fertility.

Third, age patterns of marriage have been found to play an important role in determining growth rates of human population. Recently, account has been taken of the effect of different marriage rates of a nuptiality on population growth. The combined effect of a given age structure of mortality, nuptiality and fertility of married and unmarried women on growth rate seem to be significant. In India, almost all the births occur in marriage and changes in age at marriage rates are reflected in the rates of formation of couples. It is, therefore, essential in the analysis of fertility and reproduction of certain periods and generations to consider the rate at which women at different ages marry and the rate at which married women have children.
Much attention has been paid by demographers to explain the variations in fertility in terms of various socio-economic and demographic components. One of the important determinants of fertility is nuptiality. The ages at which men and women marry and the extent to which marriages occur among the single population have important bearing on fertility and population growth. Nuptiality depends upon age, occupation, social class, relative numbers unmarried. Marriages tend to become fewer in times of economic depression. Level of education, particularly for women, is an important factor influencing age at marriage and marriage rates. There is an array of socio-economic and demographic variables which are likely to affect nuptiality. Thus the formulation of an appropriate statistical model showing the effect of a particular variable on nuptiality is, indeed, an complicated task.

Man's enhanced ability at death control has resulted in rapid population growth. Modern medicine, improved sanitation and nutrition have cut death rates throughout the world. This has upset the traditional balance between births and deaths and resulted in rates of population growth unprecedented in the history of man. Most of the additional population will, therefore, have to be contended with limited prospects of adequate food, shelter, education and employment. This makes the task of the Indian Family planning
programme more pressing and urgent. The National Family Planning Programme in India has, during the past four decades, passed through diverse facets of organisation, planning, implementation and strategy to come to the present mass movement characterized by liberal incentives, intensive campaigns and concerted efforts, to meet its demands. The programme has emerged as several methods of birth control programme which can help couples in their endeavour to practise family planning. The inherent motive of this programme is to reduce the level of fertility of a population. The amount or the extent to which the fertility declines can be done through the process of evaluation. Evaluation of the programmes can be organised through different scientific methodologies. Also, much variation on the family planning performance has been observed among different states and different districts of a state. One may, however, ask the question as to why the family planning performance should differ from state to state, district to district, when the organisational set-up for running the programme has been planned uniformly by the Central Government for all the states. The curiosity of researchers in the recent past has led them to analyse the contributions of some socio-economic factors towards the existing variation in the acceptance of various methods among the states, Agarwala [5].
Of the three components of population change migration is most complex and most difficult to analyze, compared to birth and death. Migration is the most volatile component of population change while death rates change slowly and predictably over time, and even birth rates follow fairly stable trends. Migration rates at the smaller and large areal level can change drastically within a very short period of time. Another difficulty is that there is no standard definition of the terms migrant and migration due to its interdependence on time and space.

The nature of migration is different from fertility and morality. Unlike birth and death which are purely biological phenomenon and thus any favourable socio-economic condition may bring desired change. Migration is a two way process—it is a response to economic and social change and is a catalyst to change for those areas gaining and losing migrants. Migration is an essential aspect of economic development and social change. It can be considered as a means of population distribution and equilibrium between economically backward or stagnant areas to prosperous areas. Areas of better economic opportunities such as better employment, facilities, amenities of modern life generally attract population from comparatively economically depressed areas. Migrants usually benefit by their moves and earn more money than before, even at unskilled jobs. Most of the
migrants adopt quickly to new life and help in the transformation of the society from traditional to modern one. In the migration study, internal migration is of direct interest because of its interaction with different aspects of social and economic change and differentiation taking place within the state or country.

The economic development of a country is closely associated with the qualitative as well as quantitative structure of its population and vice-versa. Both the indices, economic development and demographic development are supplementary and complementary, effect directly or in directly each other. The results of development depends on the efficiency, merit and tendencies of the persons involved in it. The impact of man-power on the development of a country expresses that the progress of a country depends on the capability of organising its human resource. No doubt man-power resource is heavy capital of country. But this resource becomes a burden in the absence of right use and appropriate employment. The man power planning is a vital element in national development.

Family welfare in the context of demographic analysis has been well recognized as a very important component of development. When family welfare is considered as an indicator of the quality of life and when a minimum quantum
of health for all is set as a goal of national life then the magnitude and dimensions of the needs depend upon the number and quality of the people therein. Scientific and rational attempts for a planned national life are on the one hand limited by the availability of resources and on the other constrained by the change in the size and quality of the population whose needs are to be commensurate with these resources. Such understanding will provide alarming signals for future exercises in the rationalisation of the human resources planning to an environment of family welfare for sustainable health development.
1.3 Review of literature

The construction of demographic models has proceeded rapidly over the past two decades. Models are used increasingly in preparing, devising and applying new methods for estimating population characteristics from data and increasing our understanding of the dynamics of population growth and change. The purpose of this chapter is to review existing demographic models in order to provide the background for the selection of models that may prove useful in practical application ranging from estimation techniques and bases for evaluation of population policies and the determination of needs for the revision or extension in various ways of existing models.

Our major purpose of models is concise description of some aspects of fertility, mortality, nuptiality, family planning or other related demographic process. If a particular model adequately represents reality, the characteristics of a given population can be summarized by the parameters of the model, thereby facilitating the study of variation among populations or within a population over time. A suitable model may be used to smooth the data, thereby providing better estimates than would result from accepting the data at their face value. When a model is postulated, methods of estimating its parameters must be devised and their adequacy be tested. Both the development and comparison of procedures and the
consideration of kinds of data sufficient for estimation purposes have proved fruitful. In a number of cases, demographers have been able to find, with the help of a model, procedures that employ indirect indices, based on data that would otherwise be considered inadequate for estimating a specified characteristic. Some models have indicated that certain procedures previously thought to provide adequate estimators were not reflecting relevant parameters well, or were serving only poorly to discriminate between alternative values. Models that describe current situations, especially those that contain some theoretical framework for considering future change, may provide some basis for the analysis of population growth or change.

To understand and compare the features of different models, their structural differences and other characteristics will be reviewed briefly. The mathematical approach of models may be either analytic or numeric. Analytic models express assumptions about the individual variables in mathematical forms yielding expressions that summarize the interrelations among the factors or their effect on the dependent variable that is of interest. Solutions for causal models of this type usually are obtainable only if the assumptions are severely restricted and if the causal factors remain unchanged over time. Analytic models may further be either stochastic or deterministic. In numeric model either macro-simulation or
micro-simulation may be employed. Macro-simulation models allow more realistic assumptions regarding causality than have been possible so far with analytic models. Whereas, micro-simulation models are always stochastic, develop a history for each individual in the model population, thereby establishing the population structure. At least some characteristics are treated as being determined by a random device. Many more variables (and their interactions) may be introduced into this type of model.

Recently, Operations Research models have been developed and applied in different fields of demography. Through these models proper management of the procedure can be attained. By proper management we mean that when we are trying to estimate a certain parameter, we should make sure that we have taken an overall view of the system, i.e., not the parameter alone, its relationship with the other correlates as well. Also, the models allow estimation of parameters in the presence of several restrictions on the estimated values itself, as well as on its relationships with other important correlates of the variable. And more important is that we do not ask for more sophisticated data in order to achieve the objective.
1.3.1 Models of mortality

The life table is undoubtedly the first demographic model. The probabilities or proportions dying are assumed to be characteristics of different age groups and usually of different sexes. Mortality rates at different ages have been found to be quite closely related. At least, four systems of model life tables exist, which try to narrow the choice of a life table to those deemed feasible on the basis of examination of mortality risks calculated for actual populations. The following description of the four systems relies heavily upon Brass's work [24].

In the mid-1950s, the first model life tables were developed by the population division of the Department of Social Affairs of the United Nations Secretariat under the aegis of Dr. Valaoras (United Nations), [198]. The tables were constructed as a one-parameter system on the basis of equations regressing the mortality rate in each five-year age group on a quadratic function of the rate in the previous age group and an equation relating mortality by age five to the infant mortality rate. Coale and Demeny [36] published their model tables in mid-1960s. They chose only those empirical life tables that met strict standards of accuracy. Ledermann and Breas [99] carried out a factor analysis of some empirical tables—which were not so rigidly selected for accuracy as were those chosen by Coale and Demeny, but they represented
more developing areas. Ledermann [98] developed a model system consisting of six single parameter sets, each based on the index used for specifying a table, and three two-parameter sets. Carrier and Hobcraft [29] developed tables by using the linear logit transformation of a standard life table probability of surviving from birth to age $P_s(x)$ to generate a system with two parameters. The theoretical analysis by Ledermann and Breas [99] supported by the demographic interpretation of Bourgeois-Pichat [18] showed that a close representation of empirical life tables required five parameters, one of which was sex. Brass [23] developed logit models which are based on the finding of the survivorship proportions from birth to age $x$ in two tables and are linearly related. Preston, Keyfitz and Schoen [161] published some of their empirical cause-specific tables along with the mortality reductions to be expected if each specific cause were to be eliminated. Brass and Barrett [26] have used an extremely simple model in a computer simulation study of measurement problems that arise in the attempt to determine whether child mortality in a family has a volitional effect on the numbers of subsequent births to a couple.

Operations Research Model has also been initiated by Mukherji [125] for mortality analysis.
Besides the above models Preston and Benett [160], Zlotnik and Hill [216] and Trussell [194] have developed different indirect methodologies in mortality analysis.

1.3.2 Models of Fertility

Age patterns of fertility vary among different populations. The variation arises in part from differences in the biological and social factors controlling child bearing within marriage, not only to a great extent from marriage, but also to a great extent from differences in the age pattern of marriage or the establishment of a stable sexual union. However, in different societies that practise little birth control the shape of the fertility distribution may be quite similar, except for differences in the age at which fertility starts. Brass [20] postulated a two parameter polynomial function to describe age specific fertility rates. The parameters reflected the level of quantity of fertility and the earliest age of child bearing. Brass and Coale [21] then suggested a method of estimating fertility from two types of data that can be collected in censuses and surveys. The data tabulated by age of mother are the number of births in the previous year and the number of children ever born. However, Brass procedure estimates the level of fertility from responses by young women to the question on number of children ever born. From the model fertility schedule, Brass calculated the mean age of child bearing $m(a)$ and the ratio of fertility
in the past year for women aged 15-19 to aged 20-24. Empirical regularities have been sought in age-specific fertility for other cases; Romaniuk, alone [170] and with Mitra [122] found that a three-parameter curve, the Pearson Type I curve describes the trajectory of age-specific fertility rate. The parameters can be estimated from total fertility and mean and modal ages of the observed curve.

Coale [34] took note of the natural fertility pattern described by Henery [75], in which there is no voluntary control, and of the characteristic departure from natural fertility that occurs when couples practise voluntary control of marital fertility.

Lesthaeghe's [105] is the effect of nuptiality on fertility which found a pair of nuptiality and marital fertility curves that described situations in which early and near-universal marriage and little voluntary control are producing high fertility.

Coale and Trussell [38] constructed model schedules of patterns of age-specific fertility, when age patterns only are needed. Their tables fit the whole range of observed fertility schedules and extended the range to situations for which rates have rarely been observed accurately. A new method of fitting a fertility curve was devised, based on reports of
parity by marital duration, since it is felt that age is less reliably reported than the length of time since marriage (Coale, Hill and Trussell, [39]).

Lee and Lin [104] proposed an analytical model of marital fertility, based on a simplified biological model of fertility that allows fecundability to decline with parity.

Models that focus on the timing of births within marriage and on the intervals between births have been developed to examine these differences. Louis Henry and Mindel Sheps evolved analytic model relating all factors to birth intervals and number of births according to marital duration.

Models of fecundability and thus of the susceptible period—have been developed by (Gini, [58]; Pearl, [150]; Stix and Notestein, [186]; Henery, [74]). Work with such models has demonstrated that fecundability varies among women in most populations and has considered the method of estimation and types of data that best reflected these differences (Tietze, [190]; Potter, [151]; Potter and Parker, [156]; Sheps, [173]; Majumdar and Sheps, [110]; Menken, [121]; Srinivasan [182], D'Souza [49] & Chakraborty [30]) have developed some models for closed birth interval assuming infinite time of reproduction for all women under study and obtained the estimates of fecundability and change of foetal losses in the
community for which the data relate. Recently, Singh et al. [177]; Pathak [137]; Pandey [144] have derived models for the closed birth interval for women specified by parity and marital duration.

Model of the post-partum period in relation to fertility was developed by Ginsberg [58a] working with data collected in child (Perez and Others, [149]). Srinivasan [182], D'souza [49], Chakrabarty [30], Pathak and Shastry [142] have developed some models for birth interval assuming the component (PPA) to follow some specified probability distribution function. Srinivasan [183] analysed the pattern of PPA through life table techniques.

Macro-simulation models like POPSIM and some others by National Centre for Health, USA., Potter and Sakoda, [157], etc. have been developed for applying fertility analysis. Also Venkatacharya [202], [204] used the simulation of the mean and variance of intervals between successive births.

Micro-simulation models by Ridley and Sheps, [169] permit considerable variation in biological and demographic factors, including certain family planning assumptions. Also micro-simulation models developed by Barrett [9], Barret and Brass [10] and Holmberg [79] play important role in fertility analysis.
Some operations research models have been initiated by Mukerji [126], [128] for the estimation of different fertility measures.

Besides above models, new techniques to estimate the demographic indices from incomplete or inaccurate data are of great importance. Methods developed by Brass [20], Cho [32], Rele [165], Bongaarts [17] and Trussell [195] have contributed much in the fertility analysis.

In India, Researchers like Holla [78], Pathak and Ram [141], Rele [166] and Venkatacharya and Teklu [206] have done intensive work for estimating different fertility parameters by using indirect methodologies.

1.3.3 Models of Nuptiality

Much of the works on nuptiality models have been directed towards finding a function to describe age specific marriage patterns for both sexes simultaneously. A solution is critical if the two-sex population model is ever to be handed well mathematically Mc Farland [119],[120]; Keyfitz [92] and Parlett [147] all review the attempts to model nuptiality when both sexes are explicitly included.

Hajnal [71] described two basic marriage patterns of early and universal marriage. Regarding recent developments of
models for the process of entry into first marriages, mention may be given to Coale [34] and Coale and McNeil [37], Feeney [52] and Hernes [77]. Coale [34] found an uniformity in the first marriage process. He has noted a kind of regularity similar to that in mortality, regarding proportion of females remaining single and in the incidence of their first marriages by different ages. He has given three parameters to know about marriages, which will clear the age patterns of marriage for any population. Using three parameters, he estimated the standard frequencies of first marriage. Later, Coale and McNeil [37] found that a double exponential with the parameters reproduced a wide range of recorded first-marriage frequency distributions. This standard function has been used to estimate population by age and marital status when no cross tabulation was available but separate census counts by age and by marital status existed. They also discussed and analysed the maximum likelihood procedures for estimating the parameters of the model, and proposed a reparameterization of the model in terms of its mean and standard deviation and relate the model to a gamma distribution.

Feeney [52] suggested that the first marriage distribution curve might be a convolution of a distribution describing age at entry into the marriage market and the distribution of delays between entry and actual marriage. He also conjectured that the distribution of delay might be
simple exponential and distribution of time at entry into marriage market is normal. Malaker [111] examined how far the age patterns of female nuptiality in India can be described by simple mathematical models like Log-Normal as suggested by Wicksell [210] and Nydell [132] or by the logistic curve as used by Hyranius. Pathak [135] has applied logistic curve to ascertain the marriage patterns for the period 1961-71. He assumed no abrupt change in the marriage pattern during the period 1961-71.

Sinha [178] made an attempt to discern the nuptiality pattern of a cohort from the cross-sectional data on marital status. Malaker [114] has made an attempt to disaggregate the census based singulate mean age at marriage into their $a_0$ and K components and to examine the interstate variations in SMAM in the light of variations in the parameters.

In India the importance of nuptiality research has been recognised by demographers for quite a long time. Argrawal [212] made some significant contributions towards the study of Indian nuptiality. In 1972, the Economic and Social Council of the United Nations decided to place on the agenda of the World population Conference, 1974, an item on World Population plan of Action (WPPA). To achieve reduction of fertility one of the measures proposed in the Plan of Action was to establish an
appropriate lower limit for age at marriage, for it was taken as an important factor influencing fertility (Concepcion[40]). Again a Seminar of Demographers in New Delhi (1973) recommended that priorities should be given to studies on related factors affecting age at marriage and its effect. Malaker [113] presented the demographic picture of nuptiality through mathematical analysis. Goyal [64] has made a significant contribution to studies on the age at marriage by expanding the work done by Agarwal. Also, it was suggested that socio-economic and demographic factors might help in understanding the differential in age of marriage over states in India. Many scholars like Kirk, [94] observed that economic prosperity leads to larger number of marriages. One of the important variables affecting age at marriage seems to be literacy level of the population. There is considerable variation in the ages by wife's educational level (Majumdar and Das Gupta, [109]).

1.3.4 Models of Family planning

Most nations setting numerical demographic goals have done by designing some reduction of the crude birth rate or growth rate, to be attained within a specified target period. (Watson and Lapham, 1975, [208]). Accordingly it is appropriate to define 'impact upon fertility' as a measurable change in period fertility. Population policies relevant to fertility are conveniently grouped into two classes: family-
planning policies aimed at directly or indirectly fostering the wider practices of some combination of contraception, induced abortion and sterilisation; and a residual class of other policies, includes such policies as delaying marriage, expenditure for disease control, nutritional supplements and governmental action bearing on lactation practices. Bearing late marriage or preference for a sizable number of widely spaced births, the attainment of desired family size tends to occur by the middle of the reproductive period particularly in the developing societies, leaving a risk period when further births are to be avoided. Family building models, even of a crude sort (Potter [151]) have shown that continuity, combined with high effectiveness of contraception is to provide a reasonable assurance of no excess pregnancies. Tietze and Bongaarts [191] estimated total abortion rates required at each level of contraceptive effectiveness in order to realize replacement level fertility under conditions of fairly high fecundity. At much lower levels of sensitivity, the efficiency of abortion increases given a late age of gestation at the time of abortion, proximity to end of the reproductive period, higher rates of spontaneous abortion or lower stillbirth rates (Keyfitz [91]; Potter [153]; Venkatacharya [204] & Williams and Pullum [211]). More particularly, when contraception is absent, abortion becomes quite inefficient, two or three abortions being required to avert a single birth, dependent on fecundity factors. Practise contraception at the continuation
and reacceptance rates observed for that method in the experience of a national family planning programme favouring that same method but than have neither another contraceptive nor induced abortion to turn to (Potter, [152]). With adaption, a family-building model may sometimes be used to test the relative efficiency of quite specific family planning strategies (Potter, Masnick and Gendell, [158]).

Simulation models on family planning programme to achieve the targeted reduction in births, under the best of circumstances were developed by Sarma [172]; Potter [152]; Rao and Others [163]. Simulation of various programmes can aid planners in evaluating alternatives in relation to targets, in selecting reasonable target levels as their goals and in deciding which programme to attempt to carry out (Nortman and Bongaarts [130]; Potter [154] & Mode [123]).

The model work so far undertaken in India can be classified into two types. Model i.e. Computer Simulation Models and Micro-simulation Models. A simulation model developed by Agarwala and Venkatacharya [6] has been used to estimate births averted by the national family planning programme in India during 1956-68, (Agarwala [3]). Also, a micro-simulation model using Monte Carlo technique has been used to obtain a matrix of live birth probabilities to study the impact of sampling error on birth probabilities to study
the impact of sampling error on birth averted estimates (Venkatacharya and Das [205]). The impact of induced abortion on Indian birth rates has also been studied using the same model with appropriate input values (Venkatacharya [204]). Another model has been developed to derive the birth probabilities specific to age, initial susceptibility and duration since initial time (Venkatacharya [203]). Estimates of births averted through the family planning programme operating in India during the period 1956-69 have been obtained using this model (Venkatacharya [203]). A more complex and general simulation model (COMPSIM) has been developed at the International Institute for Population Studies, Bombay on fertility and family planning aspects (Venkatacharya and Others [205a]). Immerwahr [83] has developed a Monte Carlo model to project married women, taking into account the effects of the family-planning programme. Chandrasekaran and et al. [31] have developed a conceptual model related to the estimation of the births averted through the use of contraceptives. Also, Pathak [134] developed a model for estimating births averted through IUCD insertions in India.

The investigator of family planning study has produced many meaningful relationship between different variables and family planning acceptance which gives provocative efforts in this area of research providing a basis

1.3.5 Models on Migration and Development

A number of theories and hypotheses to explain the process of population planning and development in general and through migration in particular have been formulated by various researchers.

The remarks by Lee [100] states that the propensity to migrants may differ significantly among various groups of the society and consequently these may have differential impact of migration. Mangalam [116] has pointed out that in majority of the cases, migration research has been concerned with four basic questions viz. Who migrate? Why do they migrate? What are the patterns of flow and direction of migration? What study of migration differentials of the rural-urban migrants in this thesis provides some clues to the above questions.
According to the model developed by Zipf's [217], volume of migration of particular stream is inversely related to the distance. In other words people are drawn towards the place of destination by gravitational force which reduces the distance. It is believed that population segregation with the concentration of the industrial sector offer more job opportunities to people and they move in search of their livelihood. In fact, the intervening opportunities are the root cause of human migration (Bright and Thomas [27]; Herbele [176] & Stouffer [187]).

L-F-R model of Development was proposed by Lewis [106] and extended by Rains and Fei [163a]. The model is based on a concept of dual economy comprising a subsistances agriculture sector characterized by full employment where 'Capitalist' reinvest full amount of their profit.

The faster growth of the urban population in the developing countries is linked in many complex ways with high fertility and rapid population growth (Salas, Rafael [171]). In the study of urban growth, therefore, it is desirable to ascertain the separate contributions of the natives and the migrants towards the natural increase of the urban population. Migration from rural to urban not only affects the fertility in the place of destination but also in the place of origin either through the separation of the husbands
from their wives or through transfer of small family norm and other relevant ideas of urban to rural places by the return of migrants. Migrants fertility behaviour differ from those of the non-migrants both in the place of origin and destination on accounts of their selectivity, adaption and temporary separations and disruptions in their marital life (Goldstein [60]; [61]).

Blumen, Kogman and Mc Carthy (referred as BKM) quoted from Goodman [62] have done a study relating to the movement of workers among various industrial aggregates in the urban sectors.

Most of the studies done in India indicate the economic considerations to be the main factor behind migration from the villages (Oberai and Singh [133]; Registrar General of India [164]). Unlike in the developed countries, the rural to urban migration in India entails first the migration of males to be followed by their family later on. However, in number to the cities persons (both males and females) migrate to the cities for their livelihood and to support their old parents and siblings in the villages or in the smaller towns (Zachariah [214] & Narain and Gotpagar [129]).

Several efforts have been made to study the relationship between migration and national growth (Zarate and Zarate
These studies however, document the conflicting evidence and conclude that the growth of migrant is higher, lower, or the same as that of the non-migrant depending upon their study design, method of analysis and measures of migration and fertility. Mukerji [127] also initiated the estimation of internal migration at particularly sub-national level by using mathematical programming technique. However, development through population planning using any mathematical technique is an initiation.

Recently there have been increasing attitudes to develop and apply the methods of management in scientific analysis of development. The development of the methodological input for planning in a multi-objective conditioned system is necessary. It is desired here to optimize the single objective of development subjected to the satisfaction of a set of operating constraints. The purpose of the modelling process in a planning system using any mathematical programming technique studies the system fully well in a real life situation. Attempt has been done by few authors Trivedi [193] Charnes and Niehaus [33] to study some of the planning problems in health and academics keeping in view of their objectives, their importance in on going condition, scope of the data and computer availability.
1.4 Objectives of the study

The purpose of this work can be described in three important points.

(a) Development of models and possible extension of some existing models;

(b) Examining the appropriateness of the models for solution and designing of the models and

(c) Applying these models to real world situations and analysing their efficacy.

Keeping above salient points in mind the different problems of the research work alongwith their objectives are laid down here.

The thesis is divided into eight chapters. The first and second chapters are introductory and contain the demography of Orissa with a brief discussion of the demography of India.

The third chapter discusses two important works on the estimation of mortality measures. The first work of this chapter, is to estimate the life expectancies at birth of males and females at district levels of the state of Orissa from vital rates by using a methodology developed by McCann [118]. Here the vital rates i.e. CBRs and CDRs have been estimated by the indirect techniques proposed by Pathak and
Ram [143] and using the concept of stable population theory. In the second part of this work, a Linear Goal Programming model has been formulated to estimate the infant Mortality Rate by age of women in Orissa such that in the specified time period, the rates by age of women follow a given pattern and at the same time the overall infant Mortality Rate lies in a given range. The constraints have been considered taking into the relationship of IMR with the actual number of births and deaths of infants, number of mothers at different age groups and parity of birth. The objective function for LGP is based on limits for these constraints. The credibility of LGP lies in imposing all the constraints simultaneously in the study frame work in a flexible way.

The fourth chapter contains two parts. In the first part of this chapter an attempt has been made to analyse various fertility measures in the fertility data of Orissa. Here, Coale's indices have been estimated to appraise of fertility of Orissa at time intervals. The indirect method developed by Suchindran [188] has been incorporated to estimate the Mean Age at First Birth (MAFB) & Mean age at last Birth (MALB), Mean Inter birth spacing (MIBS) and Mean Reproductive life span (MRLS). The indirect methodology developed by Pandey and Suchindran [146] has been utilised to estimate parity progression ratios of different periods. In this work, different estimates for measuring the speed of fertility
transition of the state by Coale and Trussell model have been found out for different periods. Also two important fertility measures (CBR and GRR) have been estimated indirectly by employing Rele's [165] methodology for the state for 1951-1981. In the second work of this chapter, an attempt has been made to formulate a modified Linear Goal Programming Model for the estimation of Age Specific Fertility Rates (ASFR) for the state of Orissa of the decade 1971-81. The ASFRs have been derived from census age distributions and in addition several restrictions have been imposed simultaneously on the estimated rates so that it truly represents the demographic birth environment.

In the fifth chapter, two important works on nuptiality have been done. The first part of this chapter presents some methodologies for estimating indices of nuptiality and fitted a model by taking proportion of singles for males and females of the state of Orissa. Here the age pattern of nuptiality has been shown with some indicators of nuptiality. Also, to assess the time trend in age at marriage, the methodologies of Hajnal [71], Agarwal [2] and Coale's Standard Curve have been employed to estimate the important parameters of nuptiality. Coale's Nuptiality indices have been found out to show the pattern of nuptiality for different periods. In this part, a marriage probability table has been developed to show the marriage probabilities of the females of
Orissa in different age- groups. In the second part of this chapter, an attempt has been made to design an integrated path analysis model to ascertain the direct, indirect and joint affects of various socio-economic and demographic factors on the age at marriage of the females of rural, urban and rural-urban combined areas of Orissa. Various districts for this purpose have been considered as unit of variation.

The sixth chapter discusses some models to evaluate the family planning programme on fertility and determines the factors effecting on the acceptance of this programme. The first part of this chapter envisaged three methodologies for evaluating the impact of family planning programme on fertility in Orissa. Here three methods i.e. decompositional, component projection and trend analysis have been utilised efficiently to show the impact of this programme on GFR, ASMFR and births averted. In the second part, a study has been undertaken to find out the socio-economic determinants of family planning acceptance in Orissa as reflected in the acceptance of Sterilisation and IUD programmes separately. In view of the objective and scope of this work, the selected variables have been identified by designing two linear multiple regression models from the cross-sectional data on family planning acceptance rates and socio-economic variables. Also, two important hypotheses affecting the family planning acceptance are critically examined.
In the seventh chapter, three important problems relating to migration and development have been undertaken. The first part presents hierarchical clustering technique for classifying thirteen districts of Orissa by considering different indicators of development. Here the analysis has been made by considering single linkage and complete linkage method of hierarchical clustering procedure. In the second part of this chapter a linear programming (LP) model has been designed to estimate the net migration among different developmental regions of the state. It gives scope to the researcher to incorporate some objective characteristics of migration problems independent of researcher's choice. It simultaneously treats all groups between which migration takes place. The use of vast amount and high quality of data are not desired. In the third part of this chapter, an effort has been made for a planning in an environment of family welfare for sustainable health development by using a linear prioritised goal programming technique.

The eighth and the last chapter of this work contains the summary and conclusion, limitations and suggestions for further work on this study along with some possible policy implications.
1.5 Basic Concepts and Important Terminology

The following terminology relating to different chapters of this thesis has been used throughout the present investigation. We have not deviated substantially from the latest document on International Demographic Terminology prepared by the IUSSP (Grebnik and Hill [69]). We have also incorporated some of the important terms on Mathematical Programming discussed in Charnes and Cooper[33a], Ignizio [81] and Lee [101]. For ready reference these are briefly discussed in the following section.

Sex Ratio at Birth: Number of male babies per 100 female babies.

Index of Aging: (Percentage of population aged 60 and over / Percentage of population aged 0-14) x 100.

Birth Order: It refers to the order of live birth to a woman.

General Fertility Rate (GFR): This is a ratio of the total number of live births (B) during a calendar year in a given geographical area to the total number of women (mid-year population) of child-bearing ages (F) (either 15-44 or 15-49 years) in that area.

\[ GFR = \frac{B}{F} \times K \]

or

\[ GFR = \frac{B}{F} \times K, \quad K = 1000 \]
Age-Specific Fertility Rate (ASFR) and Total Fertility Rate (TFR):

ASFR is the number of live births per woman of a specific age group (usually 5-year age groups from 15-19 to either 40-44 or 45-49 years) of the population of a given geographical area during a given year.

\[ \text{ASFR}_i = \left( \frac{B_i}{F_i} \right) \times K, \quad K = 1000 \]

This is defined as the sum of the age-specific fertility rates.

\[ \text{TFR} = 5 \times \sum \text{ASFR}_i \]

Age-Specific Marital Fertility Rate (ASMFR): This is the number of live births (B_i) per married women (MF_i) of a specific age group of the population of a given geographical area during a given year.

\[ \text{ASMFR}_i = \left( \frac{B_i}{MF_i} \right) \times K, \quad K = 1000 \]

Total Marital Fertility Rate: Average number of children that would be born to a married woman if she experienced the current fertility pattern throughout her reproductive span (15-49 years).
Gross Reproduction Rate: A measure of the reproduction of a population expressed as an average number of daughters to be born to a cohort of women during their reproductive age, assuming no morality and a fixed schedule of age-specific fertility rates. More specifically, it is expressed as the sum of age-specific fertility rates for the period multiplied by the proportion of the total births of girl babies.

Net Reproduction Rate: It is the measure of the extent to which a cohort of newly born girls will replace themselves under given schedules of age-specific fertility and mortality rates.

where, $K = 1000$
$D = \text{Number of death in a year}$
$P = \text{Mid-year Population}$

Life Expectancy at Birth: A life table function to indicate the expected average number of years to be lived by a newly born baby, assuming a fixed schedule of age-specific mortality rates.

Natural Rate of Increase: The difference between the crude birth rate and crude death rate, expressed per 1,000 mid-year population.
Survival Ratio: The probability of surviving from one age to an older one, it is often computed for five year age groups and five year time period.

Marriage or Nuptiality Probability: Taken as the ratio of first marriages during a period to the total single population of the same sex at the beginning of the period.

Crude Marriage Rate: Computed as the ratio of the number of marriages occurring in a population during a year to the average population living during the same period.

Singulate Mean Age at Marriage: Measure of mean age at first marriage obtained from a set of proportions single at different ages or in different age groups. Synonym: Mean age at marriage, average age at marriage.

Neo-natal and Post-neonatal Mortality Rate: Number of infants within first month and from one month to one year per 1000 live births in any year respectively.
Natural Fertility: It denotes the fertility of the population in the absence of deliberate birth control.

Contraceptive Prevalence Rate: Percentage currently using contraception, usually based on married or sexually active couples with women in the reproductive age.

Net Migration Rate: The difference between gross immigration and emmigration per 1,000 mid-year population.

Objectives and Objective Functions: Objectives are the direction to do better as perceived by the decision maker. Thus, objectives are the reflections of the desires of the decision maker and they indicate the direction in which the decision maker wants the organisation to work.

Goal: Goals are things desired by the decision maker in terms of a specific state in space and time. Thus, while objectives give the desired directions, goals give a desired (or target) level to achieve. However, in the literature this distinction gets blurred and these two words are used interchangeably. It is better
expressed as an objective in conjunction with an aspiration level. If it is instructed to maximise profit or, minimise cost, then this is an objective. On the other hand, if it is instructed to achieve a certain profit or cost level, then a goal is to be found out, which can take the form of:

\[ \text{Satisfy } f(X) \geq b \text{ or } = b \text{ or } \leq b \text{ depending on the situation.} \]

Constraint: A constraint has exactly the same mathematical appearance as a goal i.e., either one of the inequality or equality types. However, in Goal Programming (GP), a constraint is an inflexible goal, so this relationship may be denoted as a rigid constraint, when a truely inflexible goal is encountered. In single objective mathematical programming, there is no worry about the distinction between the objective and goal or between goal and rigid constraints as this is to deal with only objective and (rigid) constraints.

Feasible Solution: A vector \((x_1, \ldots, x_n)^T \in \mathbb{R}^n\) is called feasible solution to problem (LP), if the constraints are satisfied by the vector. The
set of feasible solution to (LP) is:
\[ T = (x_j, \ldots, x_n)^T: (x_j, x_i, \ldots, x_n)^T \in \mathbb{R}^n \]
and hold at \((x_j, \ldots, x_n)^T\)

A feasible solution may or may not exist.

Optimal Solution: A feasible solution is said to be an optimal solution to the programme (LP), if it gives the minimum value of the objective function provided the minimum value exists. Clearly therefore, an optimal solution may or may not exist.

Single Objective Linear Programming Model: The general problem of linear programming is to optimize a linear function subject to linear equality or/and inequality constraints. In other words, we need to determine the values \(x_1, x_2, \ldots, x_n\) that solve the program:

Minimise \[ Z = \sum_{i=1}^{n} c_i x_i \]

Subject to:

\[ \sum_{j=1}^{n} a_{ij} x_j \leq, =, \geq b_i \quad (i=1, 2, \ldots, m) \]

Where one and only one of the signs \(\leq, =, \geq\) holds for each constraint and the sign may
vary from one constraint to another. Here $C_i$, $b_i$ and $a_{ij}$ are known real numbers.

Goal Programming: Goal Programming (GP) is a relatively new specialisation of multi-objective mathematical programming, which is concerned with decision making problems involving multiple conflicting objectives. It was first introduced by Charnes and Cooper [33a] as a tool to resolve infeasible linear programming (LP) problems in the early 1960s. A text on GP was first prepared by Ijiri [82a] in 1965 and the implementation of GP to a real world problem was first presented by Charnes and Cooper et al., in 1968 [33b].

GP Conversion: The conversion of the base line model into GP model is, in essence, to simplify by converting all the objectives into goals viz aspiration levels.

Thus a maximising objective:

Maximise : $f_i(\bar{x})$

Where $b_i$ is an aspiration level. A minimising objective:
Minimise: $f_j (\bar{X})$

is converted into a goal of the form:

$f_j (\bar{X}) \leq b_j$

by establishing the aspiration level $b_i$.

Finally a distinction is drawn between flexible and inflexible goals. Thus, GP, works on a model consisting solely of goals.

Goal Deviation:

There are three forms of goals:

$f (\bar{X}) \geq b$

$f (\bar{X}) = b$ and

$f(\bar{X}) \leq b$

Since the philosophy of 'satisfying' is used, the decision maker is interested (at least initially) in measuring the non-achievement of each goal. This is unwanted deviation from the aspiration level (i.e., the value of each $b_i$)

Let $d =$ the deviation from the goal aspiration level.

i.e., $d = b - f(\bar{X})$

and since such deviation may be either negative or positive values,
Let $d = d^- + d^+$
Where $d^- \cdot d^+ = 0$
and $d^-, d^+ \geq 0$

Typically, $d_i^-$ represents the under deviation of goal i while $d_i^+$ represents the over deviation.

Achievement Function:

The deviational variables $d_i^-$ and $d_i^+$ provide the decision maker with a way to measure the non-achievement of a goal. There are some approaches to accomplish the solution of a GP model. The approaches can be measured and presented by means of an achievement function consisting of goal deviations. The "goodness" of a solution to any non-trivial GP model depends entirely on one's philosophy as to its measurements.
# 1.6 Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>CDR</td>
<td>Crude Death Rate</td>
</tr>
<tr>
<td>$e_o$</td>
<td>Expectation of Life at Birth</td>
</tr>
<tr>
<td>IMR</td>
<td>Infant Mortality Rate</td>
</tr>
<tr>
<td>NNMR</td>
<td>Neo-natal mortality Rate</td>
</tr>
<tr>
<td>PNMR</td>
<td>Post Neo-natal mortality Rate</td>
</tr>
<tr>
<td>CBR</td>
<td>Crude Birth Rate</td>
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<tr>
<td>GFR</td>
<td>General Fertility Rate</td>
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<tr>
<td>GMFR</td>
<td>General Marital Fertility Rate</td>
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<tr>
<td>TFR</td>
<td>Total Fertility Rate</td>
</tr>
<tr>
<td>TMFR</td>
<td>Total Marital Fertility Rate</td>
</tr>
<tr>
<td>ASFR</td>
<td>Age Specific Fertility Rate</td>
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<tr>
<td>ASMFR</td>
<td>Age Specific Marital Fertility Rate</td>
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<tr>
<td>GRR</td>
<td>Gross Reproduction Rate</td>
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<tr>
<td>NRR</td>
<td>Net Reproduction Rate</td>
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<tr>
<td>SRB</td>
<td>Sex Ratio at Birth</td>
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<td>CWR</td>
<td>Child woman ratio</td>
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<tr>
<td>SMAM</td>
<td>Singulate Mean Age at Marriage</td>
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<tr>
<td>PPR</td>
<td>Parity Progression Ratio</td>
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<tr>
<td>IUD</td>
<td>Intra Uterine Devices</td>
</tr>
<tr>
<td>MAFB</td>
<td>Mean Age at First birth</td>
</tr>
<tr>
<td>MALB</td>
<td>Mean Age at Last birth</td>
</tr>
<tr>
<td>MIBS</td>
<td>Mean Inter birth spacing</td>
</tr>
<tr>
<td>MRLS</td>
<td>Mean Reproductive life span</td>
</tr>
<tr>
<td>LPP</td>
<td>Linear Programming Problems</td>
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<tr>
<td>GP</td>
<td>Goal Programming</td>
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<tr>
<td>LGP</td>
<td>Linear Goal Programming</td>
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</tbody>
</table>
1.7 General Notations

This thesis is divided into 8 chapters. The first chapter is introductory. The second chapter contains the demography of the state. The last chapter is conclusive.

Each chapter is divided into articles and each article is again divided into sub-articles.

Articles are denoted by symbols like 2.1, which means first article of the chapter two. Similarly, sub-articles are denoted by 2.1.2, which means the second sub-article of the first article of the chapter two.

A number in bracket [] indicates the reference at the end of the thesis.

A table is represented by 24(2) which means second table of the first article of second chapter.

An expression denoted by (2.1.2.1) which means first expression of second sub-article of first article of second chapter.

A figure is represented by 2.1(i), which means first figure of the first article of second chapter.