DEVELOPMENT OF POPULATION GROWTH MODELS WITH SPECIFIC REFERENCE TO MAHARASHTRA STATE

A DISSERTATION

submitted in partial fulfilment of the
requirement for the award of the Degree
of
MASTER OF ENGINEERING
in
ELECTRICAL ENGINEERING
(System Engineering & Operations Research)

By

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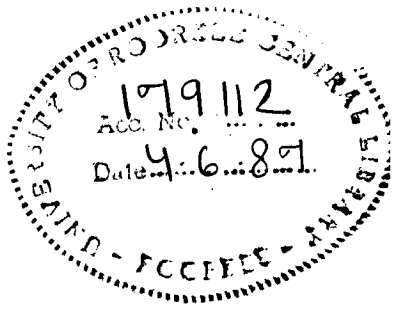

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1986

CERTIFICATE

Certified that the dissertation entitled "DEVELOPMENT OF POPULATION GROWTH MODELS WITH SPECIFIC REFERENCE TO MAHARASHTRA STATE" which is being submitted by Mr. Ravindra Chandrashekhar Balapure, in partial fulfilment for the award of Degree of Master of Engineering in Electrical Engineering (System Engineering and Operations Research) of the University of Roorkee is a record of student's own work carried out by him under my guidance and supervision. The matter presented in this dissertation has not been submitted for the award of any other Degree or Diploma.

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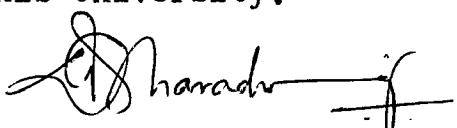

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ACKNOWLEDGEMENT

I am indebted and wish to express my deep gratitude and sincere thanks to Dr. A.K.Pant, Professor, Department of Electrical Engineering, University of Roorkee, for his indefatigable interest and valuable guidance during each and every phase of this work. I admit that learning was never as interesting and easy as it was with Dr.Pant.

I am grateful to Dr. D.G.Bharadwaj, Asstt. Professor, College of Engineering, Amravati for his keen interest and active support. It is difficult to imagine this work without his help.

Special gratitude is due to Shri C.B.Balapure, my father, for his inspiration, encouragement and unflagging support to complete this work.

I am also thankful to my friends Mr.S.S.Umale, Mr. P.S.Pajagade, Mr.S.S.Phaltankar, Mr.P.J.Tayade who helped me to complete the dissertation.

And lastly to Mr.S.B.Umap, for typing the whole thing in record time.

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ABSTRACT

Almost all the developing countries are facing the problem of population growth. The population growth rate is so high that it demands the systematic study of the problem and needs to control the population so that every individual should be brought above the poverty limit line. For developing countries, though this is an impossible task to have sudden control over population growth, these countries are required to plan the long-term population policy.

Of all the countries, India is the one in which it is difficult to predict about the population growth since there are several religions, environmental disparities, a wide variation in earnings and education different castes and so on. Perhaps every state in India has to be treated separately and different strategies will be required to develop the mathematical models. In the present work the most forward state in India i.e. Maharashtra is considered for the population growth study and different mathematical models are put-forth with different strategies.

Solution to these mathematical models is obtained on computer treating this to be a mathematical programming problem. Effect of different variables to control the population growth is studied in detail.

I N D E X

CHAPTER ONE

THE SPOTLIGHT ON THE POPULATION OF MAHARASHTRA

"....to my mind no other factor - not even that of peace and war - is tootremendously fatal for the long- time distinies of democracies as the factor of population."

- Gunnar Myrdal

1.1 THE POPULATION PROBLEM:

Population explosion in terms of available resources is a world wide problem today. All the planned efforts for economic developments are nullified by the rapid increase in numbers. Thomus R. Malthus was the pioneer in drawing the attention of the public to a rapidly growing population in relation to production of foodstuffs in 1824.(12) It is the high growth rate of population which is demanding the attention of enlightened public, organisations - national as well as international and national Governments. By the turn of century i.e. 2000 A.D., world population is expected to double itself and reach gigantic figure of 6000 millions.

India is no exception to this general trend. The population of India touched the 686 million mark in 1981(2) and is currently growing at the rate of nearly 1.1 million persons per month. About 20 million babies are born each year and about 7 million persons die, bringing about a net annual increase in population of 13 million,only a little less than the population of Australia. The accelerating rise of population growth in India has been realised as an obstable to social and economic developments of the country. The increase is contributed by the fast decline in the death rate and the almost stationary level of birth rate. Experience in western countries showed that there was a time-lag of

about seventy years between decline in death rates and birth rates and it took fifty to sixty years for birth rates to balance death rates, even when the decline in birth rates had set in (7).

1.2 ZERO POPULATION GROWTH:

Zero population growth as an urgent goal has caught the public by storm and included in that public, are many biologists, economists, socialogists and demographers.

Zero population represents the state when the rate of growth of a closed population is zero i.e. the rise due to new birth is balanced by the deaths. Zero population growth is then not only simply a desirable goal, but also the only viable situation in a finite world.

Some say the problem will take care of itself as it has in industrial nations with increasing education, greater rights for women and economic growth. However, this approach has had few tangible results since independence, mainly because India does not have the resources necessary for these programmes to reach the entire country. Also, the economic boom in advanced countries occured when their populations were still relatively small.(3).

The Indian economy heavily rests on subsistence agriculture and other extractive industries. Per-capita income and literacy rates are very low. The

population levels are already too large for reduction of poverty on the basis of traditional subsistence agriculture. The only hope of achieving reasonable capita income, literacy rate and health lies in the modernisation of economy which requires heavy investment in production, equipments, transport, education and health. But zero population grown has a meaningful proposal in the immediate future.

1.3 NECESSITY OF STATE-WISE STUDY OF POPULATION GROWTH:

In India, it is very difficult to predict about the population growth since there are several religions, environmental disparities, a wide variation in earnings and education, different castes and so on. Perhaps, every state of India has its own specific characteristics. Every state differs from the other in various manners. India is called as a land of varieties. The soil and climatic conditions in India favour the cultivation of different crops such as wheat in north, sugarcane in north and south, rice in the east and all along the peninsula's coastal strip, jute and tea in north-east, cotton in the west, spices and coffee in south and so on.

Within the states population density varies over a wide range. The average density of India was 216 per square Km in 1981. Kerala and West Bengal had a density above 600 and another three states, Bihar, Tamil Nadu and Uttar Pradesh, above 350 persons per square Km.

The census of India revealed 188 languages and 49 dialects.(2)

Kerala has high literacy rates. Birth rates and death rates are well below the all India average. Maharashtra and Punjab both have high per capita incomes, both being the 'richest' of Indian states. The Maharashtra has a more urban nature than Punjab, being the most urbanised of Indian states. Its level of literacy is considerably higher than Punjab. Uttar Pradesh and Orissa are the two of our poorest states, both essentially rural in nature. Uttar Pradesh has much more density populated and has a lower level of literacy; but has a higher per capita income. Orissa has birth and death rates comparable to all India average while Uttar Pradesh has the highest birth and death rates. A very interesting feature emerges when we contrast U.P. with Kerala. Kerala is even more density populated than Uttar Pradesh, but has strikingly high literacy rate and lower birth and death rates. Kerala has also a higher per capita income. (9).

Therefore, it is necessary to look at the different states individually and from the national population policy in the light of inter-state differences revealed by such a study. It is true that the need for population control is apparent in all the states but the pressures vary, the rates of growth are different, causes and effects have different over-tones and it is not possible to lump all the states together and treat them as an unmixed problem. Programmes, priorities and policies have to be fitted to the regional and state requirements. (12)

Setting up of a specific positive goal is an effective pre-requisite in the fixation of annual targets to be achieved by the states. Up until this new policy, the states were asked to adhere to an invariable uniform target irrespective of the widely disparate conditions present in different parts of India.(14) Setting up of realisable targets must, therefore, take into account several factors. Some of these factors impunging on the goal are:

1)Total area of state,

2)Total population,

3)Fertility and Mortality rates,

4)Literacy level,

5)Social customs, traditions, religious barriers, etc.

6)Communication facilities,

7)Service facilities such as hospitals, dispensaries, primary health centers, medical staff.

8)Special features i.e. large hill areas, industrialisation, urbanisation,

9)Religion wise break up of population,

10)Past performance of Family Planning.

11)General resources,

12)Administration.

In the present work, the most forward state in India i.e. Maharashtra is considered for the population growth study with different strategies.

1.4 THE STATE OF MAHARASHTRA:

The State of Maharashtra came into being on 1 May, 1960 as a result of the bifurcation of the composite Bombay State which had been created in 1956 by combining the old Bombay State with Saurashtra and Kutch, the Vidarbha region from old Madhya Pradesh and Marathwada from Hyderabad. But the pressure of subsequent events forced the composite state to be divided into two separate entitles on a linguistic basis.(14)

1.4.1 PHYSICAL FEATURES:

The territorial limits of Maharashtra are defined by the Arabian Sea to the West, the State of Gujarat to the North-West, Madhya Pradesh to the North, Karnataka and Andhra Pradesh to the South and East.

1.4.2 POPULATION:

In 1981, the territories of the new State, covering about 1,91,353 square kilometers had population of 60 millions. Both in terms of population and area, it is the third largest state in the Indian Union. The average density being 269 persons per square Kilometer is lower than the country as a whole 373 persons per square kilometer. Except the coastal districts and the districts Bhandara and Jalgaon where the conditions have been more favourable to agriculture and the more urbanised districts such as Poona, Sholapur, Nagpur, the rest of the State is rather sparsely populated.

1.4.3 REGIONAL DISPARITIES:

Nearly two-thirds of population derives its livelihood from agriculture and allied activities. There contribution to state income is estimated roughly 33% of the total. Productivity levels are poor by Indian standards. Owing to inferior crop pattern and low yields of the major crops - both of which are attributable to the deficiencies in the climatic and soil conditions in State - the average output per acre was only two thirds of all India level.

The overall comparisons, are rather deceptive, as they hide the fact that the favourable position

of the State in respect of per capita output and the rate of saving is, in very large measures, due to the developments that have taken place in Bombay-Poona belt and its immediate vicinity. This small area has about 9 per cent of the State's population and nearly 40 per cent of its non-agricultural output. If Bombay is excluded from the comparisons, the rest of the State seems to be as backward as other parts of country. In fact, except Thana, Poona, Sholapur and Nagpur which are relatively high up in the scale of urbanisation and industrial development, the per capita output of most other districts is lower than the average for the state. Ratnagiri, Satara, Sangli, Chandrapur, Kolaba and Marathwada districts are specially poor. They have a very low level of urbanisation and none of them have much industrial activity. The per capita net output in these districts is determined primarily by the productivity of land and the density of population. In Ratnagiri, though the per acre output is quite high, the high density of population depresses the per capita incomes; while in Satara and Marathwada districts, favourable land rates is offset by the extremely low productivity of land.

1.5. FAMILY WELFARE PLANNING APPROACH:

The family is a basic social unit. The individual is born, grows up and is matured, educated and socialised in it. An individual's attitude, views, behaviour and actions are, therefore, conditioned by those of the other members of family. The family as a unit, has definate influence over actions of every member and vice-versa. Taking cognizance of the implications of interdependance and inter-action between individuals and family, family planning programme has to take family as a unit and endeavour to motivate it, along with the individual and couple for the purpose.(16)

Individuals and families live in communities, big or small. The smaller the community, the treater the face-to-face relations and the higher the homogeneity in it, the greater is its influence on individuals and families.

Family planning programme, taking family as a basic unit, is a very comprehensive programme. It refers to a wide variety of measures adopted towards enabling the family to grow strong and become effective as a primary and vital unit of society from the social, economic and cultural

points of view. Prevention of conception or birth control, which aims at the avoidance of unwanted children, large-sized families and ill-health of mother caused by frequent and large number of pregnancies, is one of the several measures for promoting family welfare. In our family planning programme, birth control is given overwhelming emphasis as this is more in keeping with our immediate goal, viz. bringing down substantially the rate of increase in our population.

The problem of stabilising population growth was regarded as one of priority from the beginning of the First Five Year Plan in India. The plan stresses the need for stabilising population so that all the developmental attempts would directly improve the level of living of people. A strong impetus should be given to the family planning movement and successive Five Year Plans have allocated more and more funds to strengthen the movement.

In the First Plan in 1951, 21 rural and 126 urban family planning clinics were opened. In 1956, after limited progress under First Plan, the central family planning board was set up and State Family Planning Committees were gradually appointed in each state.(9)

In the Second Plan (1957-62) over 1030 rural and 400 urban family planning clinics were established. Sterilisation was just beginning and in this period 1,22,000 men and women under went operations.

In the successive plans government offered 100 per cent financial assistance to State Governments for training, staff and facilities for sterilisation. Directive measures to reach a birth rate of 25 per thousand by 1984 included raising the legal minimum age at marriage to eighteen for females and twenty one for males; introducing 'population values' in the educational system; drawing all government departments in to 'motivating of citizens to adopt responsible reproductive behaviour', increasing the monetary incentives for sterilisation, offering group incentives to Zilla and Panchayat Samities, teacher, co-operatives, labour in the organised sector and so on.

However, much is to be done in this field, more pronouncely in the rural sector of the population where family sizes are still large.

In this work, Chapter 2 deals with the modelling part for the population projections. The terms Demography, Mortality and fertility have been explained and studied for the Maharashtra State. The choice of fertility control efforts have been made.

The analysis of data comes in chapter 3. The criteria for selecting typical regions of Maharashtra for population projections are enunciated. The errors in census data have been focussed and the method for modification of census data in proper form has been developed. The introduction of decline in future child mortality is presented with the desirability of such measure also has being explained.

The simulation results of the population model for Maharashtra and its selected four regions and Rural Maharashtra are presented in chapter 4 for arbitrary control efforts for fertility and also family planning efforts. The results are given for both cases: assuming constant mortality rates and also for the case of declining child mortality rates.

The whole work is summed up in concluding chapter 5.

CHAPTER TWO

THE POPULATION MODEL

Listen with the ear of your imagination to the little voices of children who will be born in the future. They are saying -

" 'Have you places forus?
Have you food for us?
Have you education for us?
Have you love for us? You called us |' "

- Elise Offesen Jensen

2.1 SYSTEM MODELLING: (7)

To study a system, it is sometimes possible to experiment with the system itself. The objective of many system studies, however, it to predict how a system will perform before it is built. Clearly, it is not feasible to experiment with a system while it is in this hypothetical form. An alternative that is sometimes used is to construct a number of prototypes and test them, but this can be very expensive and time-consuming. Consequently, system studies are generally conducted with a model of the system. Model is not only a substitute for a system, but also a simplification of the system.

A model is the body of information about a system gathered for the purpose of studying the system. In the case of a physical model, the information is embodied in the properties of the model in contrast to the symbolic representation in a mathematical model. Since the purpose of the study will determine the nature of the information that is gathered, there is no unique model of a system. Different models of the same system will be produced by different analysts interested in different aspects of the system or by the same analyst as his understanding of the system changes.

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The simulation is the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behaviour of the system or of evaluating various strategies for the operation of system. Thus the process of simulation includes both the construction of model and the analytical use of the model for studying a problem.

The simulation modelling is, therefore, an experimental, and applied methodology which seeks to:

1. describe the behaviour of system,
2. construct theories or hypothesis that account for the observed behaviour,
3. use these theories to predict future behaviour, that is, the effects that will be produced by changes in the system or in its method of operation.

A good computer model is one which satisfies three criteria to be useful in education and research.(13)

1. It must agree structurally with the actual system but must be modest in size,
2. It's parameter must be estimable,
3. It must fit the computer simulation capabilities.

For an engineer the introduction of model provides link between descriptive and experimental data.

Before formulating the model used in this work, it shall be prudent to examine demography, mortality and fertility in the Indian context.

2.2 DEMOGRAPHY: The Science of Population.

Demography is a science which deals with human populations. Demography is the scientific study of humen populations, primarily with respect to their size, their structure and their development.(8)

During a period as short as one year, the number of births, deaths, arrivals and departures is small compared to the total size of population, which may appear as an almost unvarying whole, where motion but not change takes place. There is no doubt, however, that the population is also the result of these movements, since each one of its members has been born and will die. In whatever way the situation is envisaged, it is certain that there are numerical relationships between the aggregate of inhavitants in a territory at a given moment, and the events births, deaths, arrivals, departures - which make up population change. The study of these relationships is likewise part and parcel of demography.

Birth, marriage and death are ordinary wards designating everyday events that happen to each one of us. Fertility for births, nuptiality for marriages and mortality for deaths are the processes or phenomena that are the real object of our study. Not all the figures provided by observations are usable as such. In most cases one must subject them to detailed analysis in order to interpret them correctly. The analysis can be extended effectively by the use of models, since these shed light on the interaction of phenomena under well defined circumstances and facilitate the search for casual relationships.

2.3 MORTALITY: (8)

Death is a principal "vital event" for which vital statistics are collected and computed. The definition of a 'death' excludes deaths prior to (live) birth. These are so called foetal deaths. There is a great number of measures of mortality based on death statistics. The simplest and commonest measure of mortality is the crude death rate. The crude death rate is defined as the number of deaths in a year per 1000 of the mid-year population. The principal characteristics of a "crude" rate is that all ages are represented in it.

The crude death rate gives only a very general indication of the level of mortality and its changes. There is also need for measures that describe the specific components of the overall number of deaths and the crude rate. Various type of specific death ratios and rates are of interest both in themselves and for their value in the analysis of total number of deaths and the crude rate. Age is also important variable in the analysis of mortality. The age-specific death rate is defined conventionally as the number of deaths of persons of a given age during a year per 1000 of the mid year population at that age. Age specific death rates are usually computed for 5 or 10 year age groups.

India had than in developed countries a very high death rate till the first quarter of this century. Even now the death rates are much higher. As compared with India, Maharashtra state has a slightly less figure of the mortality rates. There has been a decline of about 50 per cent in the death rate during the 30 years period from 1951-1981. The death rate in Maharashtra in 1951 was around 18.1 per cent which came down to around 13 per cent in 1971 and stands at 8.3 per cent in 1981. The crude death rates for the five regions of Maharashtra were:

Aurangabad Division 11.8, Nagpur Division 10.0, Western Maharashtra 8.6, other urban 6.4 and Greater Bombay 5.4. (10)

The rate of natural increase is the difference between birth and death rates. The differentials in the natural increase rate tend to be evened out since a high (low) birth rate goes together with a high (low) death rate. The percentage of natural increase rate was somewhat higher in rural regions, 2.2 in Aurangabad Division, 2.3 in Nagpur Division and 2.0 in Western Maharashtra, compared to the urban zones, 1.8 in other urban areas and 1.9 in Greater Bombay. The rate of natural increase for Maharashtra state was 2.02 per cent during April 1979 to March 1980.

For males and females the age specific mortality rates (ASMR), follow the typical J-shaped curve, with a sharp decline from childhood to adult ages, a gradual increase over adult ages and finally a sharp increase in old age. Urban rates are generally lower than the rural rates. The unweighted crude death rate for males was 8.8 for rural areas, 8.0 for urban areas and 8.5 for Maharashtra. The crude death rate for female in rural areas was 8.2 and in Maharashtra 7.3. However, the crude death rate for urban females was unusually low, only 5.5 compared

to 8.0 for urban males. It is suspected that female deaths might be under-reported to a greater extent than male deaths, especially in urban areas. (10)

Infant mortality rate (probability of death in first year of life) is considered to be a fairly sensitive index of the health condition of country.

2.4 FERTILITY:

The simplest and the commonest measure of fertility is the crude-birth rate. It is defined as the number of births in a year per 1,000 of the mid-year population. It again gives only a very general indication of fertility. Age-specific fertility rate is much more informative. It is defined as the number of births in a year per 1000 of the mid-year population of females of a specific age. These rates are calculated usually in 5 years age groups. (8)

Fertility rates in India are comparatively higher than in developed countries but relatively lower than that of other developing countries, the reasons being universality of marriage, lower age at marriage, limited use of contraceptives, low level of literacy, poor level of living and traditional way of life in rural areas.

In the state as a whole, the crude birth rate for advanced caste Hindus was 26.1, for intermediate caste Hindus 28.6, for scheduled castes and Tribes and backward Hindus 31.4 and for Muslims 34.1. In urban Maharashtra, the birth rates for these four groups were 21.6, 26.0, 23.3 and 32.8 respectively, whereas in rural Maharashtra these rates for four groups were 29.2, 29.4, 33.4 and 35.9 respectively. Thus the rural birth rate for each community is higher than its urban rate. (10) It is affected both by the biological and environmental conditions. Though it is difficult to control the biological causes of infant deaths, the environmental causes, like nutrition and pre-natal care, sanitary conditions, control of diseases to which infants are highly prone, etc. can be controlled and this reflects the health measures undertaken by the community, government and other agencies.

The infant mortality rate in Maharashtra is still high eventhough it has declined by nearly 50 per cent during last 40 years. The infant mortality rates for males and females were 117 and 115 respectively in 1951-61 and it has came down to 71 and 75 in 1980-85. (10)

The age of the mothers, order of birth, time interval between births, etc. also play significant role in determining the level of infant mortality. The shape of the curve of the infant deaths by age of the mother is U-shaped, i.e. it is high when the mother is young, that is, below age 20, fall gradually to a minimum between ages 25-30 and rises again, showly in the beginning and more steeper thereafter. Similar is the case when birth orders are considered. It has also been found that the time interval between births at almost all ages of mother and also the order of births affect the size of the infant deaths.

Muslims had high fertility rates in both rural and urban areas. Schedule Castes and Tribes and backward Hindus had a high fertility rate in rural areas. So, the composition of the population by communities had an effect on the birth rate.

2.5 THE BASIC DEMOGRAPHIC MODEL:

A demographic model of population projections, specially for study of population dynamics in Maharashtra State has been developed. (9)

Population projections means the extrapolations of present demographic data. It does not consider a natural disaster, war, famine, mass migration because there are not predictable. A distinction should be made between projections and forecasts. When most likely

population at a given date is described, then it is a forecast. But if a model is worked out to illustrate certain analytical relationships and on some assumption, then it is nothing but the projections of population. Population projections are prepared for total population of nations, their principal geographic subdivisions, specific locations in them.

The principal uses of population projections relate to government or private planning. In developing countries, it is useful to have a specific goal of public policy related to accelerating their social and economic development. A first step in planning is to study relevant aspects of the population and economy both at the present time and in the recent past.

The population characteristics for a certain span of time have been analysed by a discrete time age model based on following facts and assumptions and which has been used by others± in similar studies.

1. It is assumed that the population system is a closed system. The migration to other states and from other states into Maharashtra is considered negligible.

2. The whole population is divided into different age groups as 0-4, 5-9, 10-14 and so on.

The last age group is of people aged 60 and above. It is obvious that after a given span of 5 years, the population of any age group shall be the population of its previous age group minus the deaths in that groups, except the first and last age groups. The population of the age group of people aged 60 and above after five years will be that of its previous age group minus deaths in that group, added to the population of this very group minus the deaths in the group.

3. In the first age group i.e. 0-4 years, the population will be of the children born during last 5 years. The population of this group will depend on survival of children, female population in different age groups and their fertility.

4. Mortality rates have declined considerably in the earlier decade after independence. The decline has slowed down after 1961. So, mortality coefficient are assumed to be constant through out the duration of our study. A decline in infant mortality rates of first age group has also been introduced.

5. Only female population is considered in the model. The total population can be determined by assuming a suitable male-female ratio.

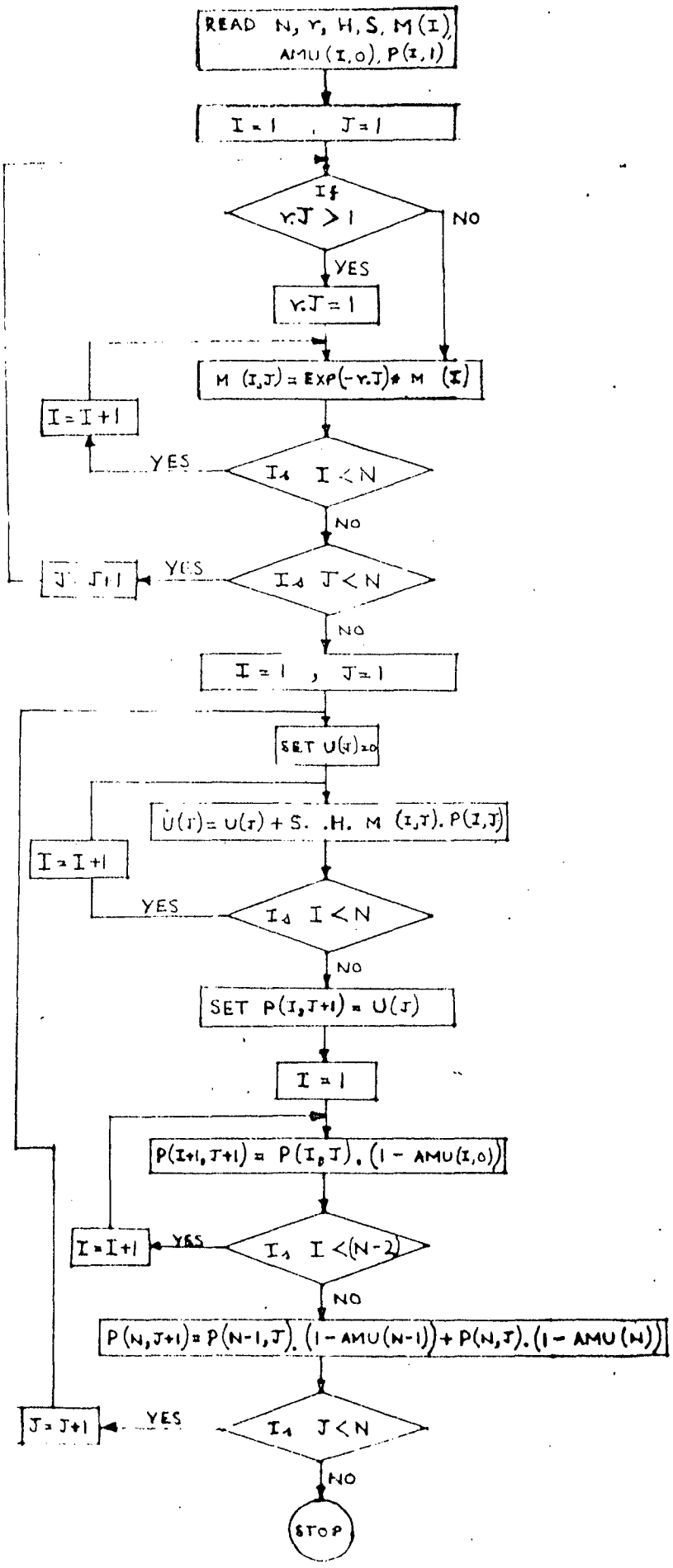


FIG 2.1 FLOW CHART

Double subscripted system is used in the model.

P(i,j) is the population of i^{th} age group is j^{th} year.

'h' is the basic time interval in 'i' as well as 'j' - taken for convenience.

AMU(I) is mortality coefficient, death per unit person (female) at the time interval 'j' and in i^{th} year.

'i' = 1, 2, 3 13

'j' = 1, 2, 3 13

$$P(i+1, j+1) = P(I,J) - AMU(I) \times P(I,J) \quad - 2.1$$

The equation 2.1 has an initial condition as -

$$P(I,J+1) = U(J)$$

For, j = 1,2, ... 13

Here U(I) is the number of children (females) born during the period 'j' and surviving upto end of this period.

The number of children born and surviving during interval 'h' is given by:

$$U(J) = \sum_{j=1}^{N} S.f.h.\ B(I,J)\ P(I,J)$$

B(I,J) is the fertility of a women of age 'I' and at time interval 'j'

S = Survival ratio during + j h to (j+1)h

F = Female proportion of total birth.

S is taken to be equal to 0.94 and F as 0.48 in this work.

A computer programme to calculate population of different age groups has been developed on the basis of above algouthim.

The population model has been simulated for different methods of fertility control.

2.6 FERTILITY CONTROL EFFORTS:

The fertility pattern is the important factor which governs the population growth. It describes the age specific fertility of women. So, to control over population, it is necessary to control the fertility by different control efforts.

2.6.1 EXPONENTIAL DECAY:

In this model fertility decays from an initial value at a rate proportional to the current values. The change in the fertility pattern may be expressed as:

$$X(I) = B(I)\ e^{-rj} \qquad \ldots 2.4$$

X(I) is the fertility of age group 'i' at time interval 'j' and B(I) is initial age specific fertility rate of that group, 'r' is the arbitrary control factor. The characteristic of model is that the level B(I) is divided by a constant factor after a

given interval of time. An increase in value of 'r' means a sharper decrease in the value of X(I) with time. In practice, a lower bound on fertility rates also has to be used. The rate of decrease can not exceed an upper limit which depends on the efforts as well as the social norms. In Maharashtra, the percentage of birth due to first two children was about 37 per cent in 1971 so it is reasonable to expect that the fertility should be reduced with 37 per cent of initial value as the lower bound.

2.6.2 FAMILY PLANNING EFFORTS:

The simple model with uniform decay in fertility is not realistic. It would be more accurate to assume that married couples want atleast a certain number of children. As long as the couples don't have the 2 or 3 children, they want, their fertility shall be roughly the same as that in the natural trend. The birth control efforts shall, therefore, manifest strongly as the later part of fertility pattern.

This can be closely approximated by the expression:

$$B(I,J+1) = B(I,J)\ EXP\ (AM(J) \times (1-EXP(5 \times AK(I-4))))$$

The value of parameter aK has to be selected to match the problem. A value suggested for India is 0.03269.(9) This has been used in this dissertation.

Family planning has been studied in two ways:

1) AM(J), family planning effort has been changed for different time intervals, it is increased from an initial value over five year intervals and then the value is held constant for the remaining period.

2) The family planning effort has been fixed at a level for all time intervals.

2.6.3 MINIMUM AGE AT MARRIAGE:

Age at marriage marks the beginning of the reproductive span of a woman's life. This factor plays an important role in controlling fertility. A shift in the age at marriage can postpone the start of the reproductive span. By increasing the minimum age at marriage the percentage of female population in initial female group goes on decreasing, which naturally effects the population in coming years.

The incidence of widowhood marks the end of a woman's reproductive life in those cases where re-marriage does not take place. In most Indian communities, widow re-marriage is prohibited by the social customs prevailing in that country. It has been estimated that if no woman is allowed to marry upto the age of 20 years, then there will be a reduction of about 16% in the birth rate. (7)

To find out the impact of increase in the minimum age of marriage it is essential to have the percentage of married, divorced, widowed or separated population to determine marital fertility for different age groups. The unavailability of this data for individual regions has resulted in non-inclusion of this important aspect in this work.

CHAPTER - THREE

THE ANALYSIS AND ADJUSTMENT OF DATA

"Today .... no problem is more important to the well-being and happiness of mankind than the limitation of population growth..... The objective of the efforts is not to restrict life but enrich it".

JOHN D. ROCKEFELLER

3.1 THE ERRORS IN CENSUS DATA:

In Census reports, usually, the whole population is divided into different age groups and five-year wise age returns such as 0-4, 5-9 and so on are mentioned. The data available for age-group 0-4 is suspect and also there is a sharp difference in population of 10-14 and 15-19 which also seems erroneous. Generally, the population in age group 0-4 is considered to be the highest of all other age-groups. The general observation is that the population goes on decreasing as the age-groups advances from 0-4 to 5-9 to 10-14 and so on. But in the census report of Maharashtra State, the age-group 0-4 has less population as compared to 5-9. The same defect occurs in middle age-groups also. Even if the migration from other states is taken intoaccount, then also it does not look feasible. The migration occurs in urban regions and generally rural population is somewhat steady. In Maharashtra, the heavy migration is only in Greater Bombay region and that is also in middle-order age-groups. That is why the data of 0-4 age-group is suspect. (18)

This error seems to be due to faulty age reporting by the people. The 0-4 age-group includes the all children who have not completed their 5 years.

That means a age of child is considered as 4 years until and unless it does not complete 5 years. But, this fact has not been understood by many of the people in State and also in India. The people reported the age of child as 5 years even if it had not completed 5 years. Because of this wrong age reporting, shifting of about 20 per cent data occurs which affects the age-group wise distribution pattern.

There is, thus, a need for proper modification of this data. Otherwise the population projections for a long period will not be so cofrect, meaningful and significant.

3.2 MODIFICATION OF DATA:

The age-group-wise population distribution is observed to have a certain definite and specific pattern. There is a rapid decrease in the population in lower age-groups, then in middle age-groups the population is less decrease and again it sharply decreases in the last lower age groups. So, various methods were tried to find out the exact pattern of population distribution.

3.2.1 CURVE FITTING APPROACH:

An attempt has been made to obtain modified age-group-wise distribution of population by various curve fitting techniques.

Firstly, the quadratic curve fitting technique was adopted: The population of 0-4, 5-9, 10-14 are taken in I group and 15-35 in II group and 35-60 in

III group. Then for all the three groups separately quadratic curve is fitted. But it is observed that this curve becomes parallel and somewhat increasing in later age-groups which is not the expected.

Then, secondly, the cubic curve is fitted to the all age-groups. But, this curve also not fulfilled the expectation. This curve decreases more sharply in later age-groups and for last age-group it crosses X-axis, that is, it shows 'negative' population which is obviously an absurd solution.

3.2.2 THE CUBIC CURVE FITTING WITH THE METHOD OF LEAST SQUARES: (19)

It was therefore felt necessary to adopt the method of least squares with a cubic curve for agewise distribution of population, is tried. Because of the method of least squares, the sharpness of cubic curve in last age-groups is eliminated. This cubic curve is found to be the best fit for the population distribution.

Thus, before projecting the population for a long period, the data of age-wise distribution of population is modified by the above mentioned approach.

The error is due to age reporting has been observed in all the census reports, particularly 1961, 1971, 1981. The modification of census data of 1971 by the cubic curve fitting with the use of least squares' approximation method for the different regions in Maharashtra had been given in table 3.1.

3.3 DATA BASE:

The census of India 1981 and sample Registration system 1980 provided the data for use in this work. The age specific fertility rates, age specific mortality rates, female population in different age groups, etc., for the region-wise study of population, are obtained from the Sample Registration Scheme 1980. (2)

The aim of this work is to carry out the population projections for the Maharashtra State and its various regions. The division of the State i.e. Maharashtra into various regions is made on the basis of typical Socio-economic pattern. The four different regions of Maharashtra according to the regional disparities are:

1) Bombay Region,
2) Poona Region,
3) Nagpur or Vidarbha Region,
4) Aurangabad or Marathwada Region.

LEAST SQUARE APPROXIMATION OF 1971 CENSUS DATA

TABLE 3.1

	BOMBAY		POONA		AURANGABAD		NAGPUR	
	Census	Modified	Census	Modified	Census	Modified	Census	Modified
0-4	1158419	1217111	923134	998174	633772	675801	866404	920180
5-9	1188923	1082105	971208	852861	650238	545820	850902	764349
10-14	100725	961984	797741	731138	429573	446479	703387	640791
15-19	729081	854559	508934	629745	276894	372568	427720	544399
20-24	732276	757638	513169	545433	323661	318878	439021	470062
25-29	702494	669031	492097	474912	319425	280200	438690	412672
30-34	606435	586547	420213	414953	274761	251325	390932	367120
35-39	541236	507995	385618	362287	228146	227043	349873	328295
40-44	413720	431185	317818	313653	201913	202146	285932	291090
45-49	341987	353925	265475	265793	142209	171423	233638	250395
50-54	268328	274025	215475	215446	134061	129667	201806	198075
55-59	195247	189294	152857	159353	78364	71666	140246	138097
60+	448270	448270	397416	397416	232156	232156	362689	362689

The outline of four regions of Maharashtra State have been given in Map 1.

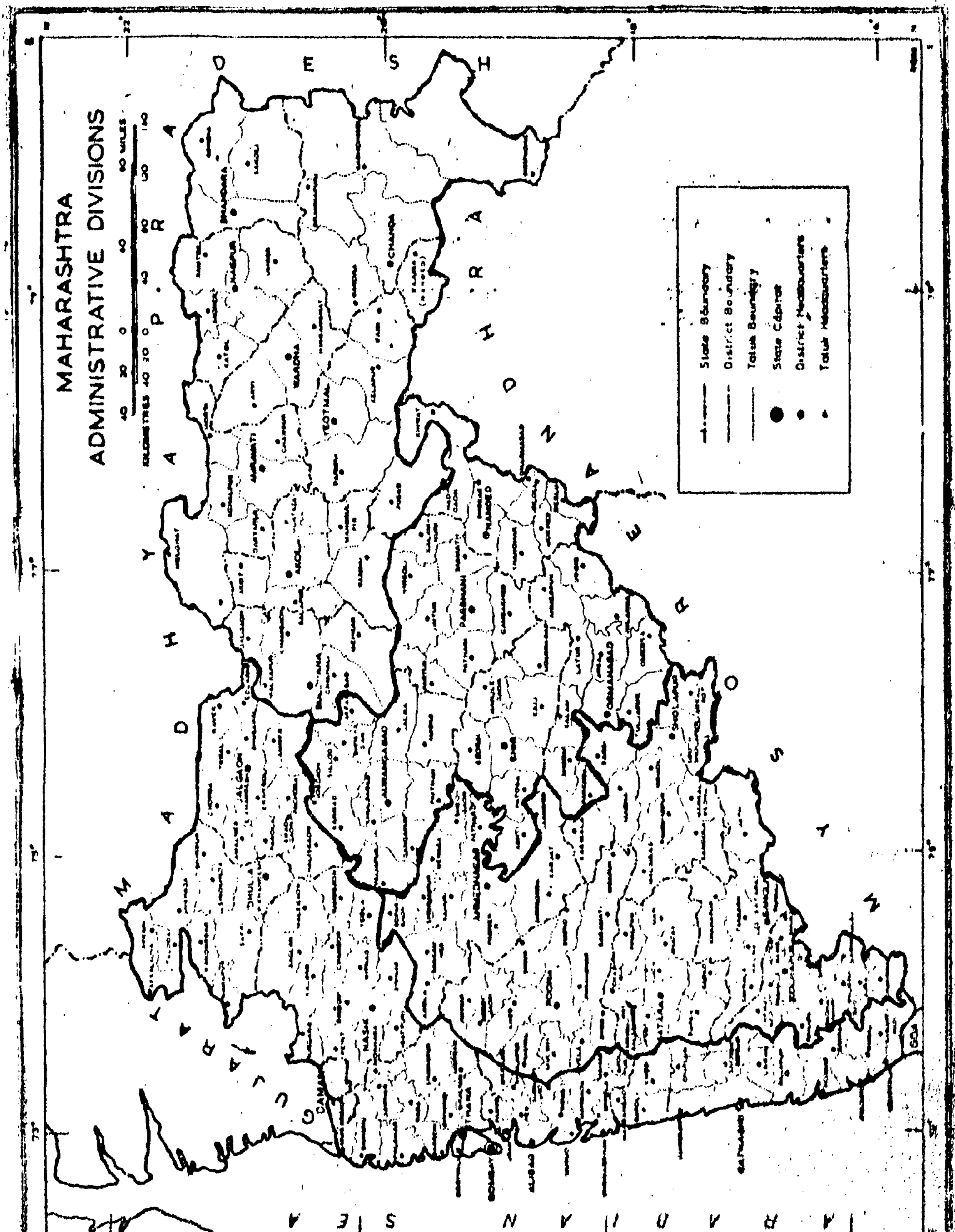
Each region has its own typical characteristics features. For easy to understand, each region is introduced one by one.

3.3.1 BOMBAY REGION:

This region is said to be a pride of Maharashtra, particularly the Greater Bombay District. The comparisons, however, are rather deceptive, as they hide the fact that the favourable position of the state in respect of per capita output and the rate of savings is, in very large measures, due to the developments that have taken place in Bombay and its immediate vicinity. This small area has about 10 per cent of State's population but accounts for over 30 per cent of total output of the state and nearly 40 per cent of its non-agricultural output. If Bombay is excluded from the comparisons, the rest of the State seems to be as backward as other parts of the country. (14)

The Bombay region comes to the west-side of Maharashtra. It includes 7 districts Greater Bombay, Thane, Kolaba, Ratnagiri, Nasik, Dhulka, Jalgaon. The most of the districts are near sea-shores except Nasik, Dhulia, Jalgaon. The Kolaba and Ratnagiri Combiningly forms a typical region, named, Kokan

MAP I



MAHARASHTRA
ADMINISTRATIVE DIVISIONS
KILOMETRES
MILES
State Boundary
District Boundary
Taluk Boundary
State Capital
District Headquarters
Taluk Headquarters
MADHYA PRADESH
ANDHRA PRADESH
MYSORE
GUJARAT
ARABIAN SEA
GOA
JALGAON
DHULIA
AURANGABAD
PARBHANI
NANDED
YEOTMAL
WARDHA
BHANDARA
CHANDA
OSMANABAD
SHOLAPUR
NASIK
AKOLA
AMRAVATI
BOMBAY

region. These districts mostly depend upon the sea for their sources of income.

The crude birth rate for this region is 24.0 which is quite below the average Maharashtra birth rate 28.5 during April 1978 to March 1980. The crude death rate of the region being 6.0 is also quite below the other regions and the average Maharashtra 8.3. The ASFR (age specific fertility rates) are also comparitively the lowestof all other regions.

3.3.2 POONA REGION:

The Poona region consists of 6 districts, namely, Ahmadnagar, Poona, Satara, Sangli, Sholapur, Kolhapur. This region is also high up, relatively, in the scale of urbanisation and industrial development, specially, Poona, Sholapur districts. But still the per capita output of the most other districts is lower than the average for the State. Particularly, Satara, Sangli, Kolhapur have a very low level of urbanisation and none of them have much industrial activity except for the sugar industries. The per capita output in these districts is determined primarily by the productivity of land and density of population.

The crude birth and death rates being 28.7 and 8.6, respectively, nearly same as for the average State. Age specific fertility rates are quite low as compared to other regions except the Bombay region. There is a higher level of literacy in these two regions i.e. Bombay and secondly Poona. This region comes to the South of Maharashtra touching the borders of Karnataka.

3.3.3 NAGPUR REGION:

The north-eastern portions of the state, comprising the basins of Wardha and Wainganga rivers, are known as Nagpur Plains. These basins have the characteristic black soil of the Deccan; more minerals especially coal are found in this region. In fact, this region has the largest known concentration of mineral deposits in the state.

This region has 8 several districts namely, Buldana, Amravati, Yeotmal, Akola, Wardha, Nagpur, Bhandara, Chandrapur. Nagpur and Amravati districts have quite higher standard of urbanisation. But the other districts are quite backward. No other district has a considerable industrial activity and most of the people being 80% of population depends upon the agricultural outcomes. There is a wide-scope of developments in agriculture in these districts.

The crude birth and death rates being 33.2 and 10.0 are comparitively higher than the average Maharashtra and also the other regions. The literacy rates are at lower level.

3.3.4 AURANGABAD DIVISION:

This region lies in the middle of Maharashtra. It consists of five districts, Aurangabad, Nanded,Bhir, Parbhani, Osmanabad. This is the most backward region in comparison with all other regions. None of the above districts is much urbanised and carries industrial activity except Aurangabad.

The crude birth and death rates being 33.7 and 11.8 respectively, are much above the average Maharashtra and other regions. Literacy rates are at lower level. The Age Specific Fertility Rate (ASFR) schedule for the region is the highest. This region has comparitively same characteristics as that of Nagpur region.

The data required for carrying out the population projections is presented in tables 3.2, 3.3, 3.4.

3.4 TREND OF DECLINING CHILD MORTALITY:

The Maharashtra State has an infant mortality rate of 71 and a child mortality rate (0-4 age group) of 30.0. The continuous decay in these rates are observed from since last 40 years. Therefore, it shall be prudent to introduce a decline in future child

TABLE 5.2

AGE SPECIFIC FERTILITY RATES

Age Group	Mahara-shtra.	Nagpur	Auranga-bad.	Bombay	Poona	Rural Maharashtra
15-19	82	90	89	75	80	70
20-24	238	251	242	225	240	298
25-29	190	231	228	173	185	268
30-34	116	169	140	98	112.7	182
35-39	53	89	78	48	56	93
40-44	20	40	36	15	26	37
45-49	5	10	7	4	4	11

AGE SPECIFIC MORTALITY RATES

Table 3.3

Age Group	Maharashtra	Nagpur	Aurangabad	Bombay	Poona	Rural Maharashtra
0-4	28	51.2	53.4	25	31.3	49
5-9	3.7	4.5	5	2.8	3.4	3.0
10.14	2.0	1.8	2.2	1.8	1.8	1.8
15-19	3.0	3.0	2.8	3.3	3.5	3.2
20-24	4.5	4.1	4.2	4.0	4.4	4.5
25-29	4.4	4.0	4.2	4.4	4.4	4.6
30-34	2.4	3.8	4.0	2.2	2.6	5.2
35-39	3.4	4.4	4.0	3.5	3.7	3.5
40-44	4.0	6.5	7.0	3.8	4.2	5.5
45-49	7.4	7.5	7.7	7.1	4.0	6.4
50-54	9.0	13	13.7	7.8	7.5	9.2
55-59	18.7	18	20	18.2	8.0	19.4
60+	.03	.02	.03	.02	.03	.05

AGE-WISE DISTRIBUTION OF FEMALE POPULATION 1961 Table 3.4

Age Group	Maharashtra	Nagpur	Aurangabad	Bombay	Poona	Rural Maharashtra.
0-4	4650864	1049725	717850	1660954	1207073	3170711
4-9	3976688	890192	657441	1419663	1017612	2684087
10-14	3421387	84449	620183	1116943	916024	2335831
15-19	2966531	728024	519880	1030679	812330	1958916
20-24	2593690	619499	431644	930020	706844	1695806
25-29	2284436	519771	355714	815900	601257	1482639
30-34	2020339	445948	302520	718771	517443	1307130
35-39	1782969	395948	268829	641880	455639	1157001
40-44	1553898	354020	242357	565617	400146	1019971
45-49	1314694	313848	217051	485640	346344	883757
50-54	1046930	272596	189303	403790	293726	736079
55-59	732174	186148	127439	263114	197596	564654
60+	3008000	509298	315058	664577	563168	1460000

mortality rates. This has been applied in the work by allowing an exponential decay in the child mortality rates by the relation.

AMU (i,J) = AMU(1) * EXP (-5.* J* d)

AMU(1) = Mortality rate of females of 0-4 age group at the beginning of the period of projection.

AMU(1,J)= Mortality rate of female of 0-4 age group after J^{th} (5 years) interval.

d = Factor controlling the decline in mortality rates.

It has been further assumed that the child mortality rates shall not fall below a lower bound, which is taken to be equal to 50 per cent of current level. Since, exponential of -0.693 is half, 0.693 is put as on a lower bound on the value of 5 * J * d.

CHAPTER - FOUR

SIMULATION RESULTS

"As the tide of population rises higher and higher, it spells less freedom, less mobility, peace, recreation, culture, opportunity, foreign travel, adventureless, of all things that make human life superior to that of an ant"

WRIGHT - Limits of Mankind

4.1 SIMULATION:

Simulation is defined as the technique of solving problems by the observation of the performance of a dynamic model of the system. It is based upon computer science, mathematics and statistics. It is the best technique for the design and operation of complex systems. It can be considered as the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behaviour of the system or of evaluating various strategies for the operation of the system. Thus the process of simulation includes both the construction of model and the analytical use of the model for studying a problem. (5)

The basic demographic model and choice of fertility control have been discussed in previous three chapters. The required data with the proper modification of female population in different age-groups by least squares' approximation method (cubic curve fitting) for carrying out the population projections have been tabulated in tables 3.1 . Based upon these, the effect of various control efforts on the population distribution has been simulated for a period of sixty years in twelve five years interval.

4.2 EFFECT OF VARIOUS ARBITRARY CONTROL EFFORTS:

The effect of different values of arbitrary control efforts on the state of Maharashtra is tabulated in table 4.1 and the trajectories are plotted in figure 4.1. The control effort 'r' for exponential decay in birth rates has been assigned the values 0, 0.005, 0.010 and 0.014. Decline in future child mortality rates has been introduced and the child mortality decline coefficient 'd' assigned values equal to 'r' i.e. 0.000, 0.005, 0.010 and 0.014.

For the four different regions of the Maharashtra i.e. Nagpur, Aurangabad, Bombay, Poona and for Rural Maharashtra, Rural Bombay, the similar projections are carried out.

The corresponding trajectories for these five regions have been plotted in figures 4.2 to 4.8.

The careful observation of the population projections trajectories immerges out the result that with the application of no control, Rural Maharashtra shall be having the highest rate of population increase followed by Aurangabad, Nagpur, Poona and Bombay.

4.3 EFFECT OF FAMILY PLANNING EFFORTS:

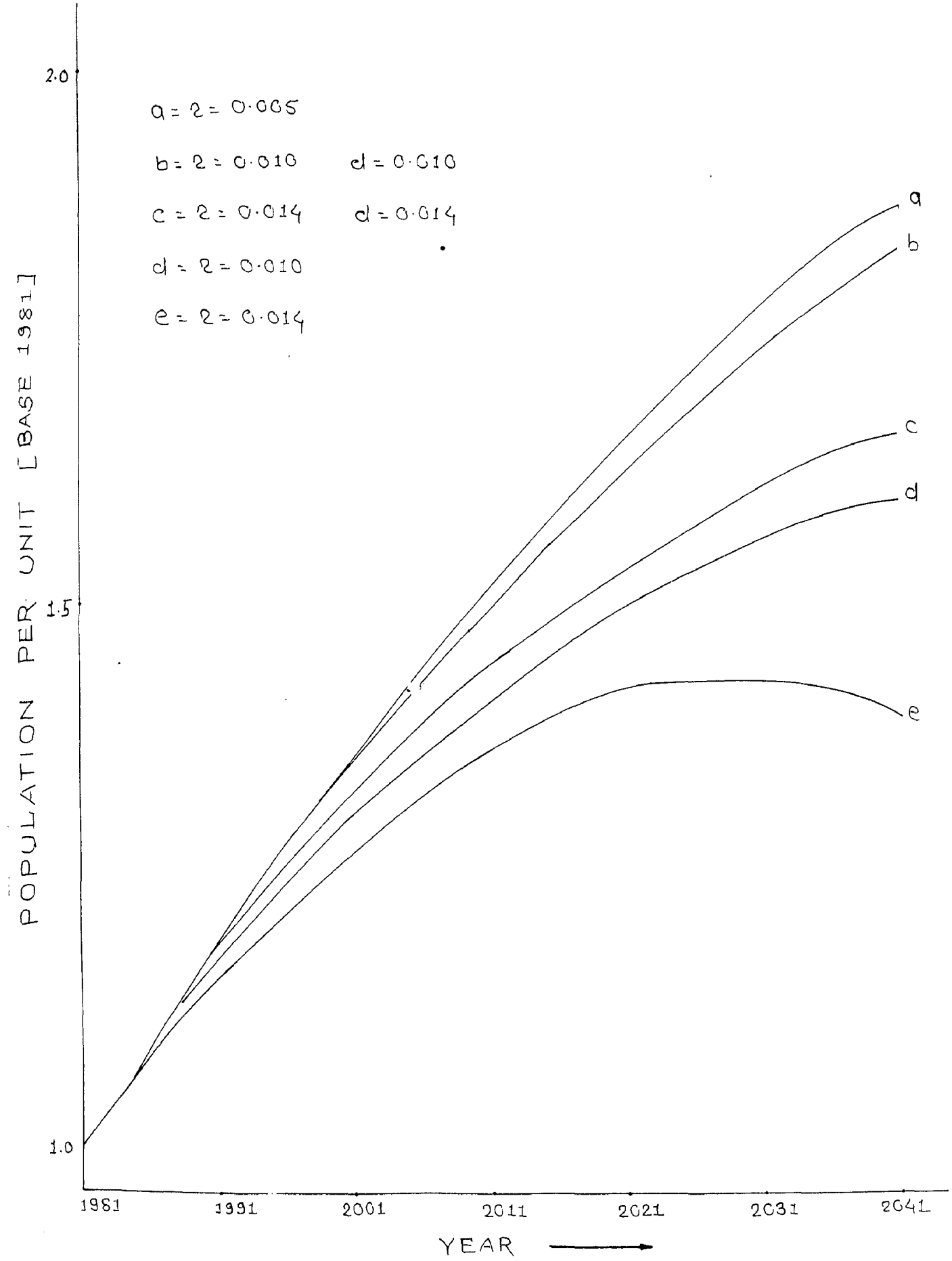
The family planning efforts are able to keep the population in the desirable limits in long term

EFFECT OF ARBITRARY CONTROL EFFORTS ON POPULATION OF MAHARASHTRA TABLE 4.1

Control efforts		1981	1991	2001	2011	2021	2031	2041
Ferti-lity.	Child morta-lity.							
.000	.000	1.000	1.239	1.421	1.65	1.857	2.08	2.292
.005	.000	1.000	1.15	1.24	1.45	1.6	1.75	1.891
.010	.000	1.000	1.13	1.26	1.4	1.51	1.59	1.601
.014	.000	1.000	1.12	1.25	1.35	1.45	1.67	1.425
.005	.005	1.000	1.239	1.421	1.61	1.82	2.02	2.219
.010	.010	1.000	1.13	1.28	1.45	1.57	1.723	1.877
.014	.014	1.000	1.12	1.29	1.425	1.53	1.63	1.660

EFFECT OF ARBITRARY CONTROL EFFORTS ON POPULATION TABLE 4.2

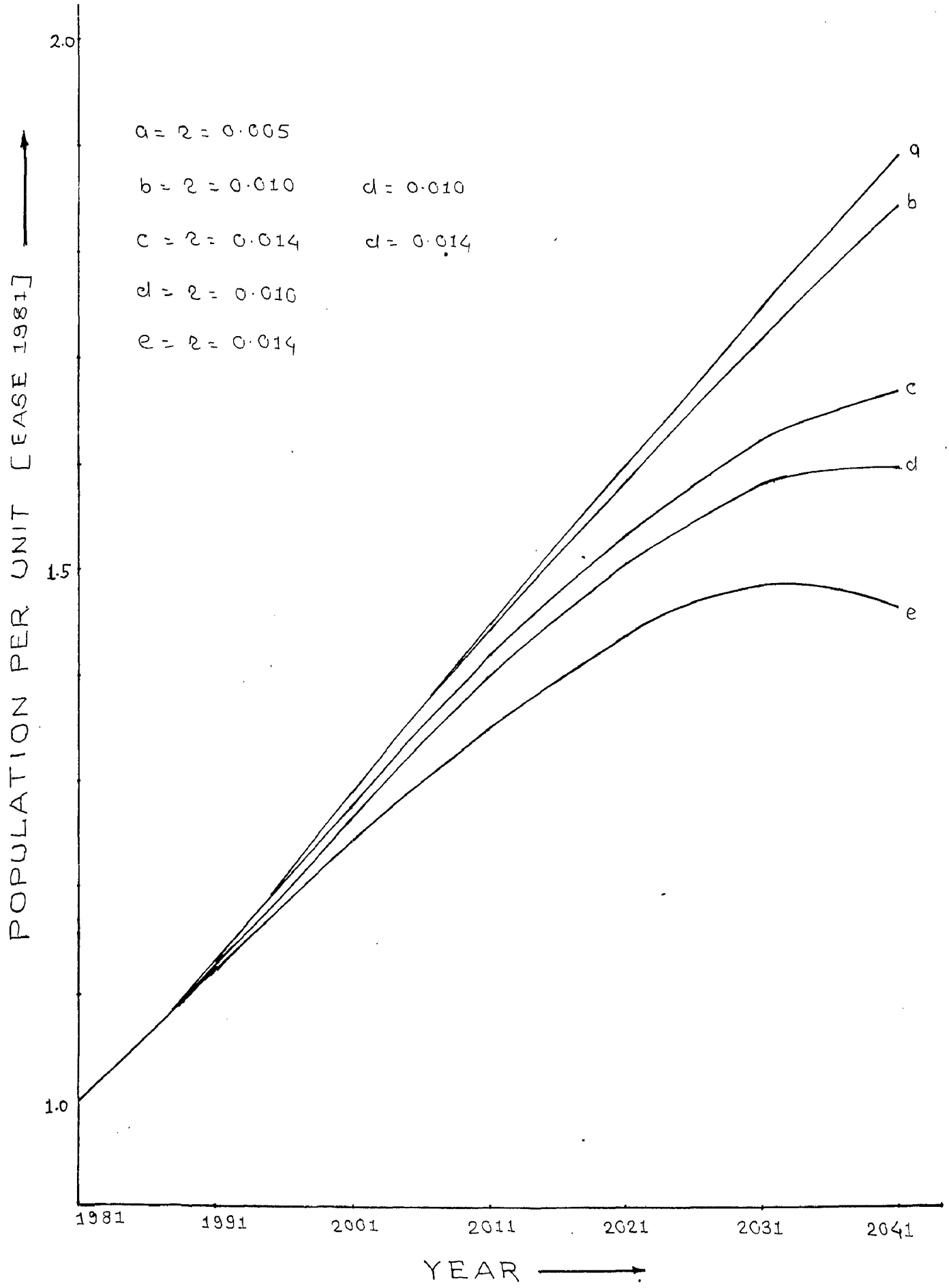
Control effort		Nagpur	Aurangabad.	Bombay	Poona	Rural Maharashtra
Fertility	Child mortality					
.000	.000	2.379	2.401	2.280	2.286	2.898
.005	.000	1.959	1.956	1.882	1.887	1.354
.010	.000	1.622	1.635	1.593	1.605	1.963
.014	.000	1.43	1.443	1.418	1.420	1.727
.005	.005	2.726	2.743	2.208	2.215	3.24
.010	.010	1.989	2.00	1.652	1.670	2.705
.014	.014	1.843	1.861	1.833	1.837	2.353



BOMBAY

ARBITRARY CONTROL

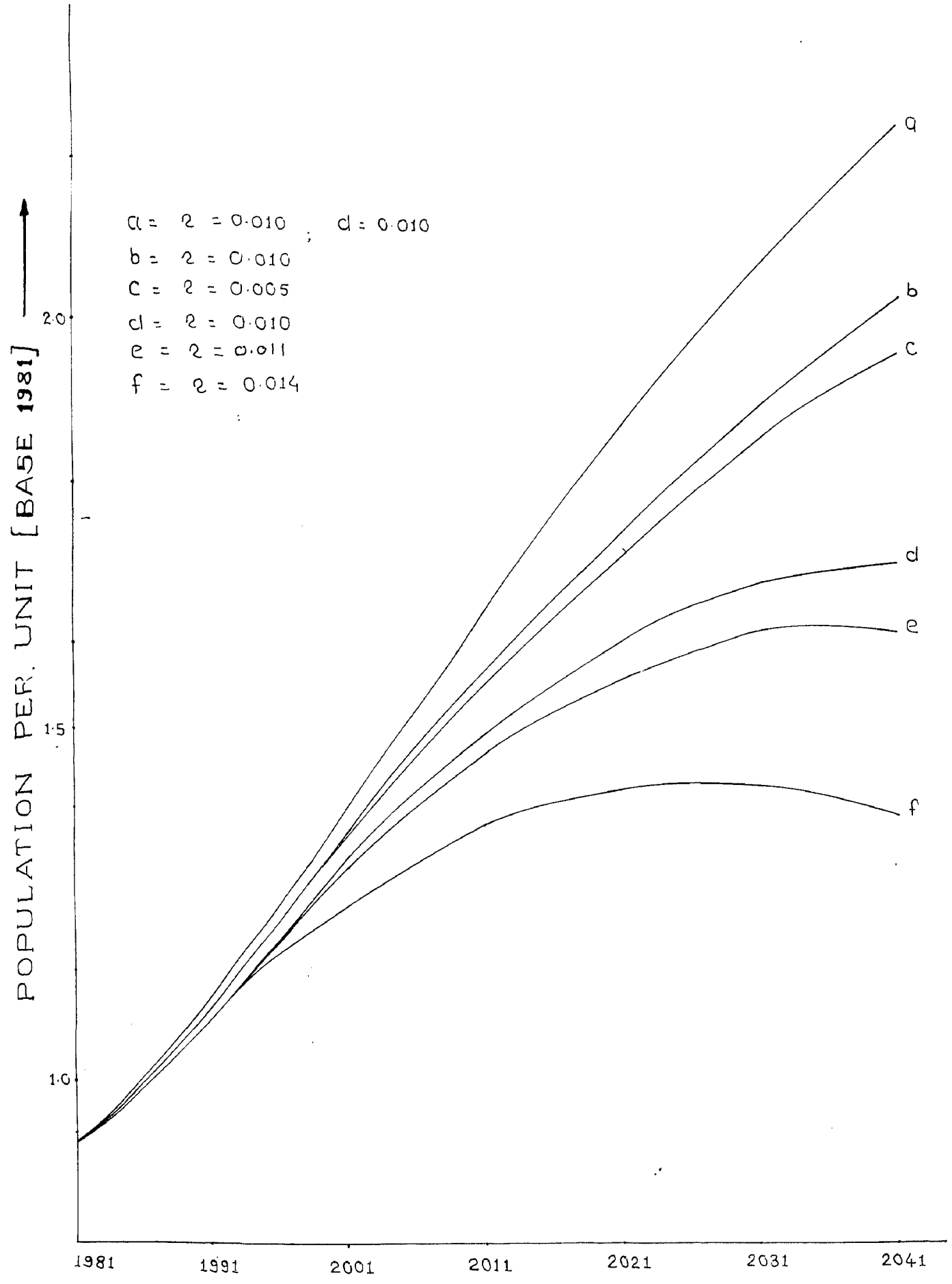
fig. NO. 4.1



MAHARASHTRA

ARBITRARY CONTROL

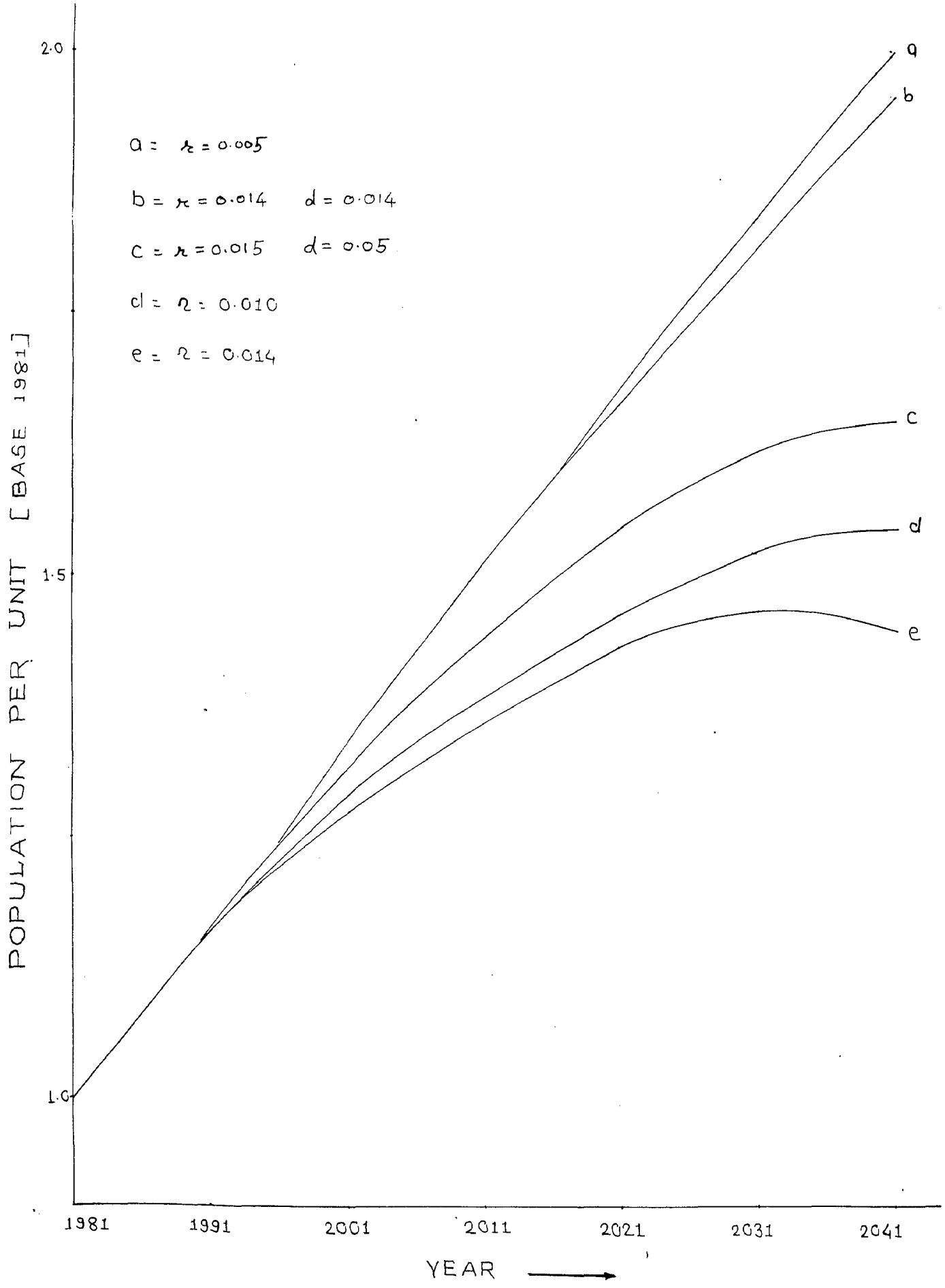
fig NO. 4.2



AURANGABAD

ARBITRARY CONTROL

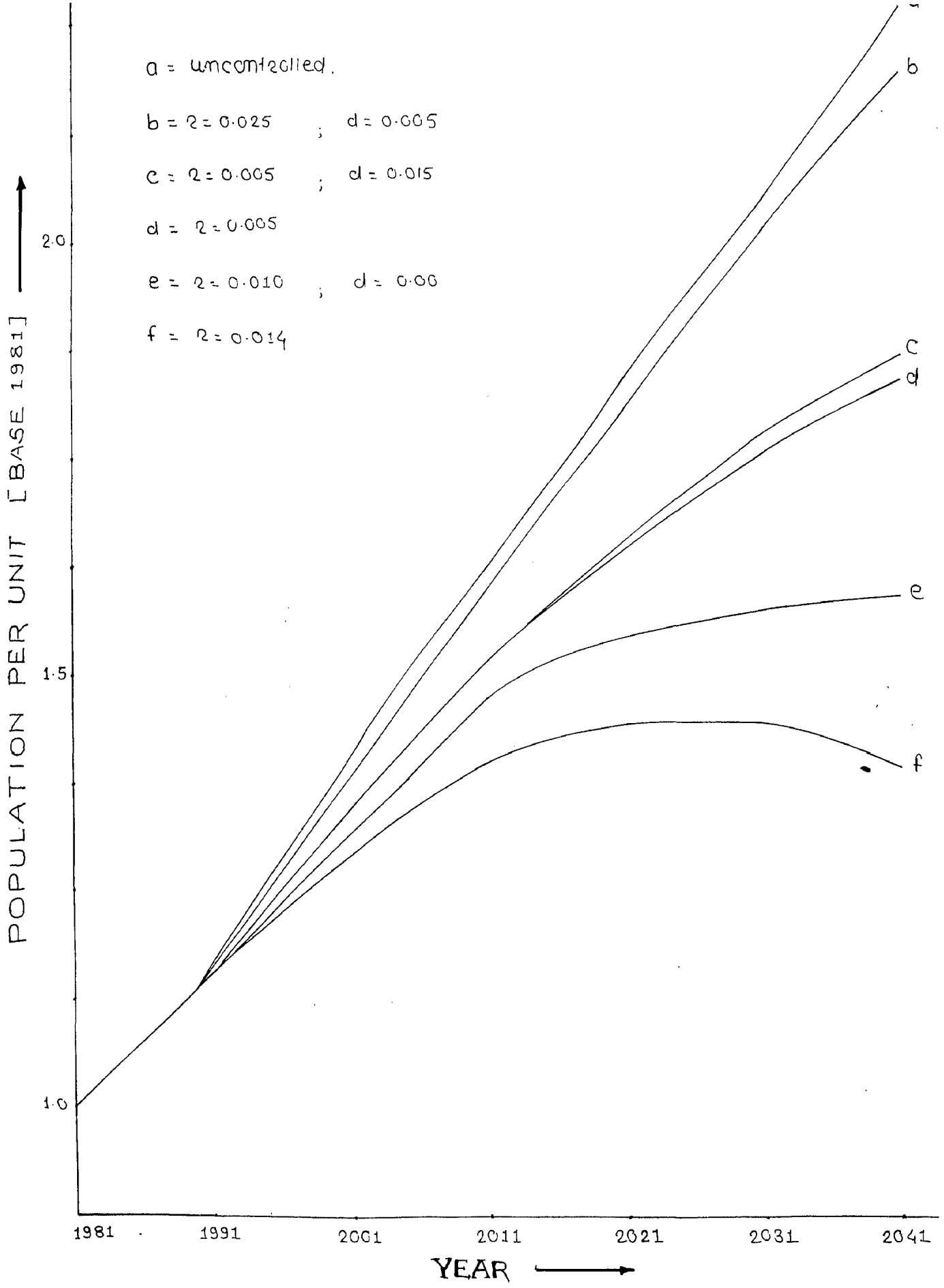
figure. NO. 4.3



NAGPUR

ARBITRARY CONTROL

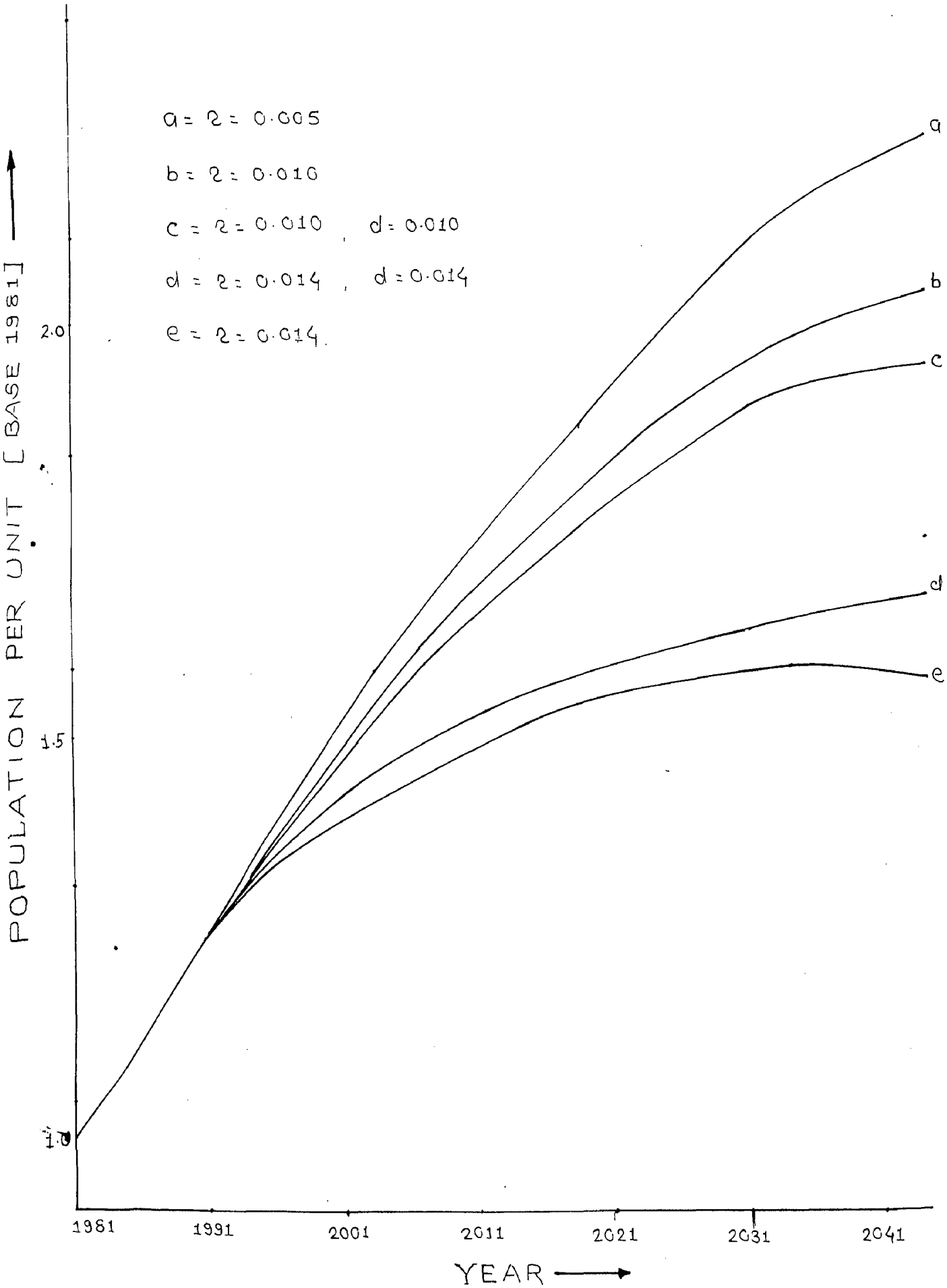
figure NO. 4.4



POONA

ARBITRARY CONTROL

fig NO. 4.5



RURAL MAHARASHTRA

ARBITRARY CONTROL

fig. no. 4.6

policy. These efforts have been studied under two categories:

1. A constant value of family planning effort 'AM' has been used for the pre-determined period of sixty years.

2. Family planning effort has been increased in steps from an initial value for four intervals of five year duration and after 25 years it is held at the constant value attained for such steps.

The population projections by these efforts for the year 2041 for Maharashtra and the four regions are tabulated in table 4.4.

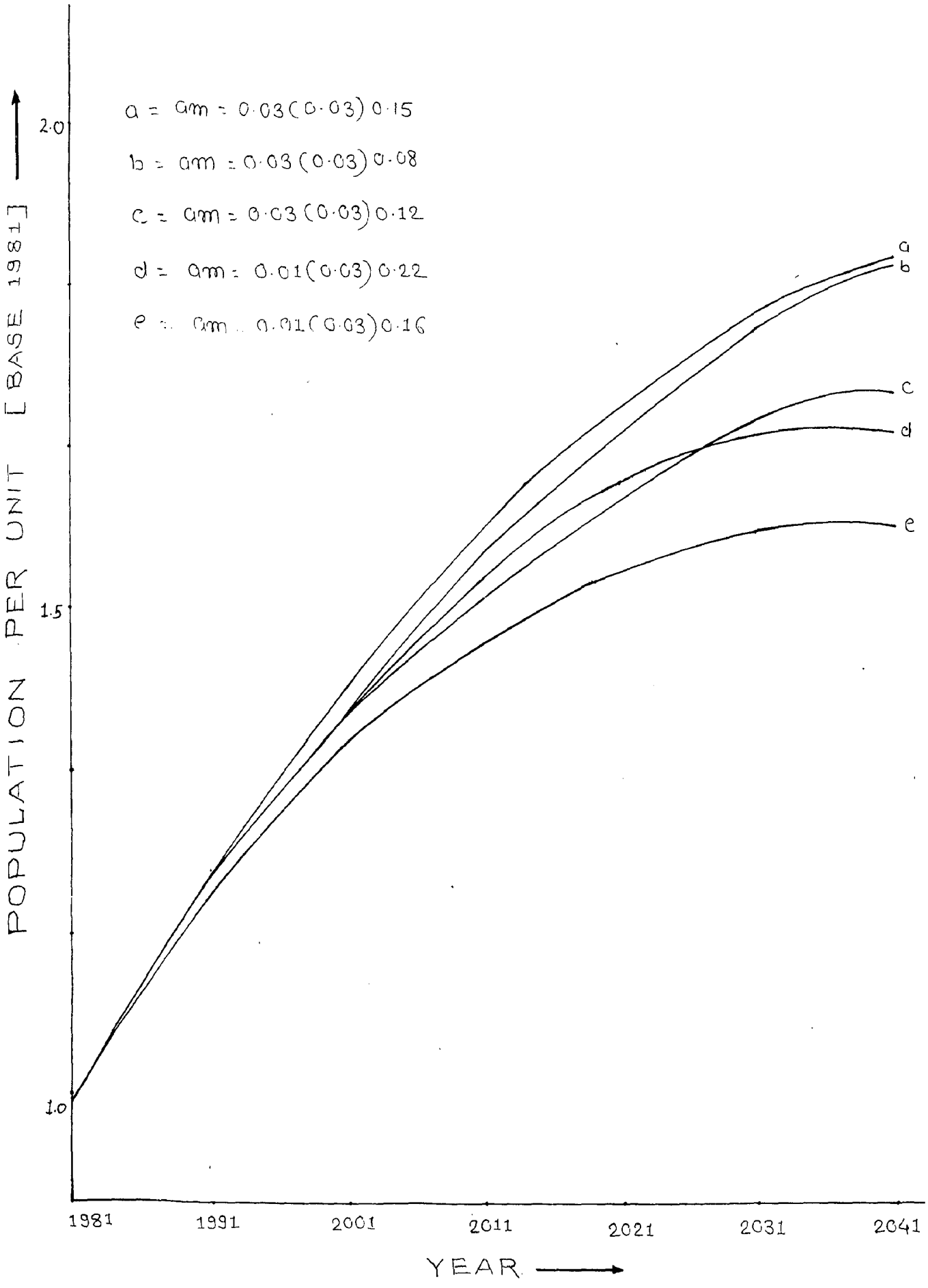
Both the methods for family planning control have been tabulated. The effort .04(.04).20 means that the family planning effort has been increased from .04 to .20 in steps of .04 for four intervals of 5 years and then held constant at 0.2. Child mortality decline is also introduced for two values of d = .005 and 0.010.

The population projection trajectories are plotted for different regions of Maharashtra and Maharashtra in figures 4.9 to 6.4 . Rural Maharashtra and followed by Aurangabad, Nagpur, Poona, Bombay is the order which has been observed from the look at population trajectories.

FAMILY PLANNING EFFORTS

TABLE 4.4

Control AM	Control D	Population in 2041 (per unit 1981 base)					
		Mahara-shtra	Nagpur	Auran-gabad	Bombay	Poona	Mahara-shtra Rural
.02(.02).10	0	1.959	1.991	2.001	1.947	1.949	2.417
.04(.04).20	0	1.745	1.729	1.737	1.733	1.739	2.098
.10(.02).18	0	1.7	1.678	1.685	1.688	1.691	1.953
.08	0	1.841	1.850	1.59	1.830	1.832	2.246
.12	0	1.688	1.664	1.671	1.675	1.679	2.023
.16	0	1.563	1.514	1.524	1.55	1.562	1.843
.10(.03).22	.005	1.772	1.894	1.906	1.763	1.792	2.274
.10(.03).22	.010	1.833	2.033	2.052	1.822	1.863	2.428
.10(.05).30	.005	1.664	1.751	1.765	1.655	1.652	2.099
.10(.05).30	.010	1.718	1.877	1.886	1.706	1.709	2.236
.15(.05).35	.005	1.557	1.616	1.623	1.55	1.545	1.9336
.15(.05).35	.010	1.607	1.727	1.735	1.593	1.586	2.056
.12	.005	1.825	1.969	1.978	1.808	1.816	2.537
.12	.010	1.888	2.115	2.124	1.874	1.856	2.537
.18	.005	1.622	1.7	1.708	1.611	1.616	2.0455
.18	.010	1.674	1.82	1.83	1.659	1.467	2.18
.25	.005	1.469	1.4925	1.501	1.461	1.465	1.770
.25	.010	1.488	1.573	1.582	1.48	1.48	1.879

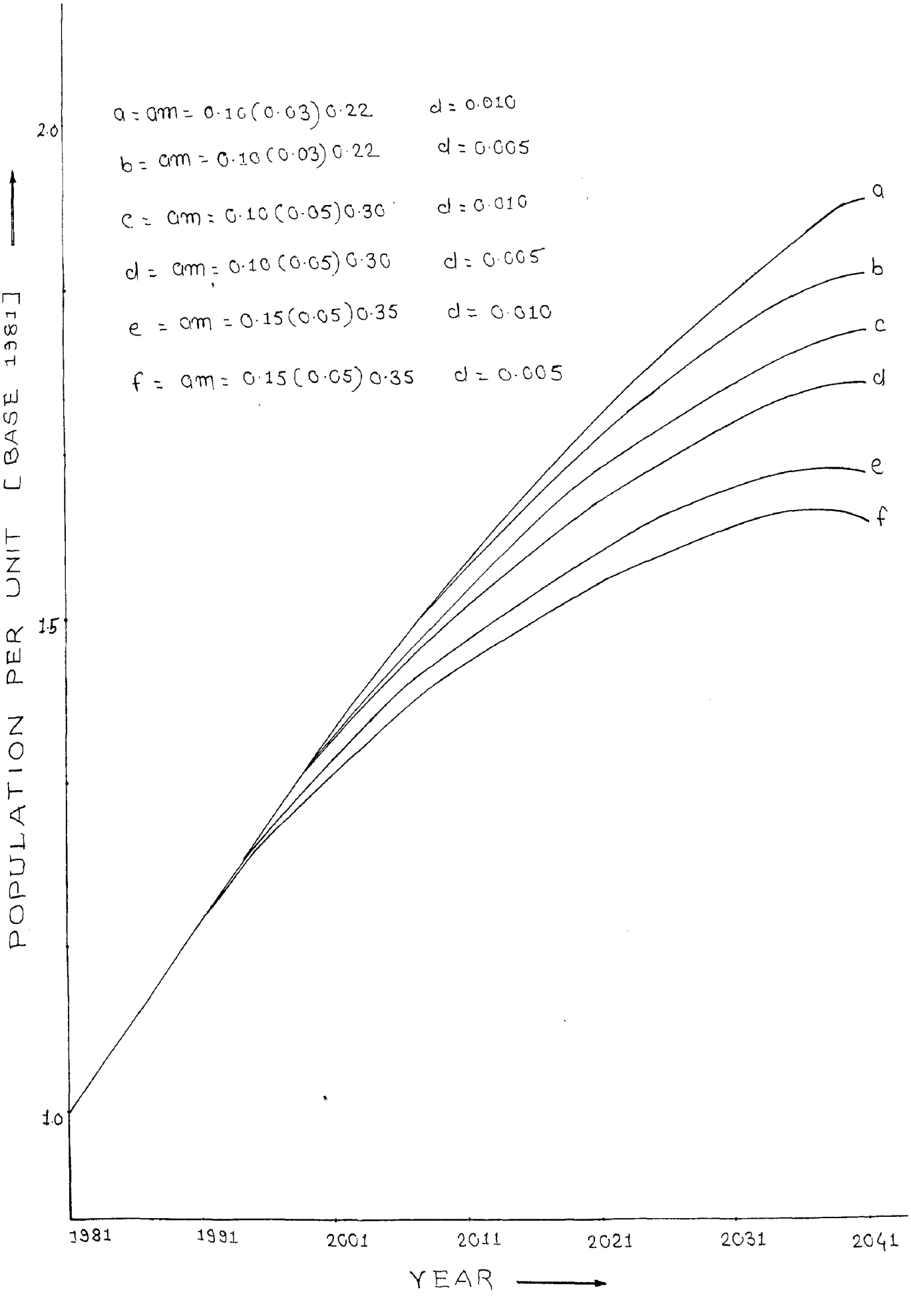


MAHARASHTRA

FAMILY PLANNING CONTROL [A.M.]

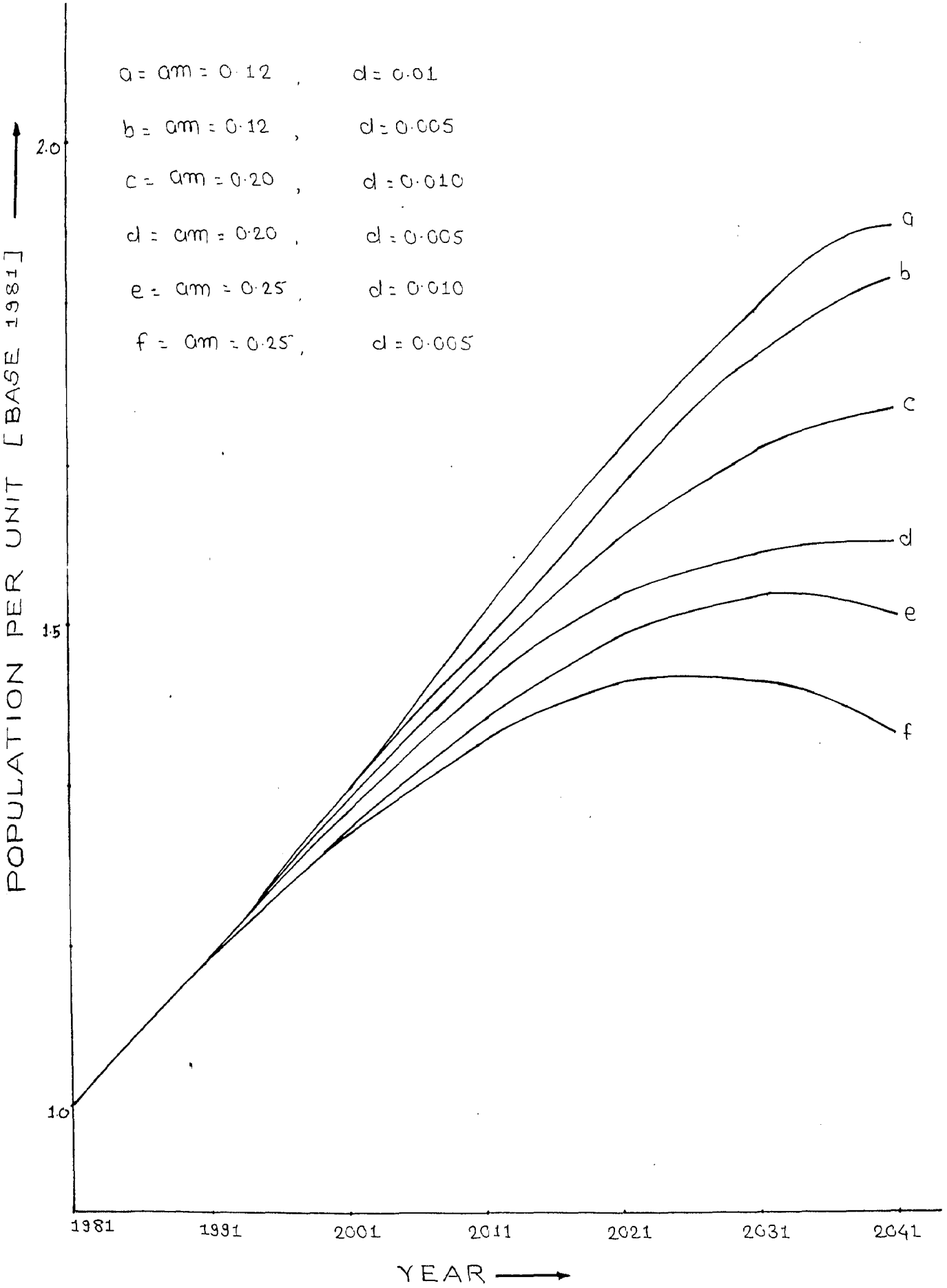
CONSTANT CHILD MORTALITY

fig. NO. 4·7



MAHARASHTRA

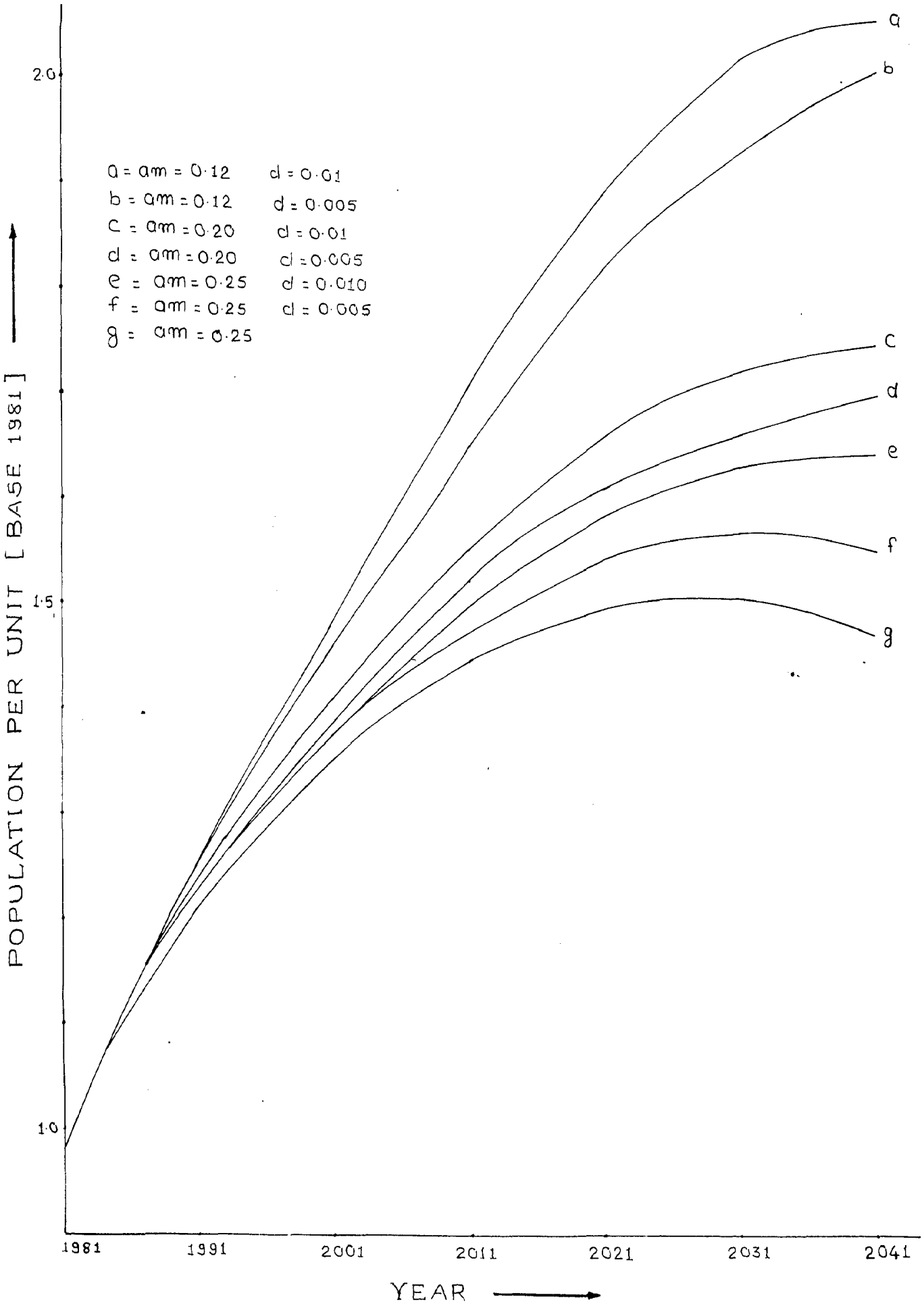
FAMILY PLANNING CONTROL EFFORTS [A.M.]



MAHARASHTRA

FAMILY PLANNING CONTROL CONSTANT [A

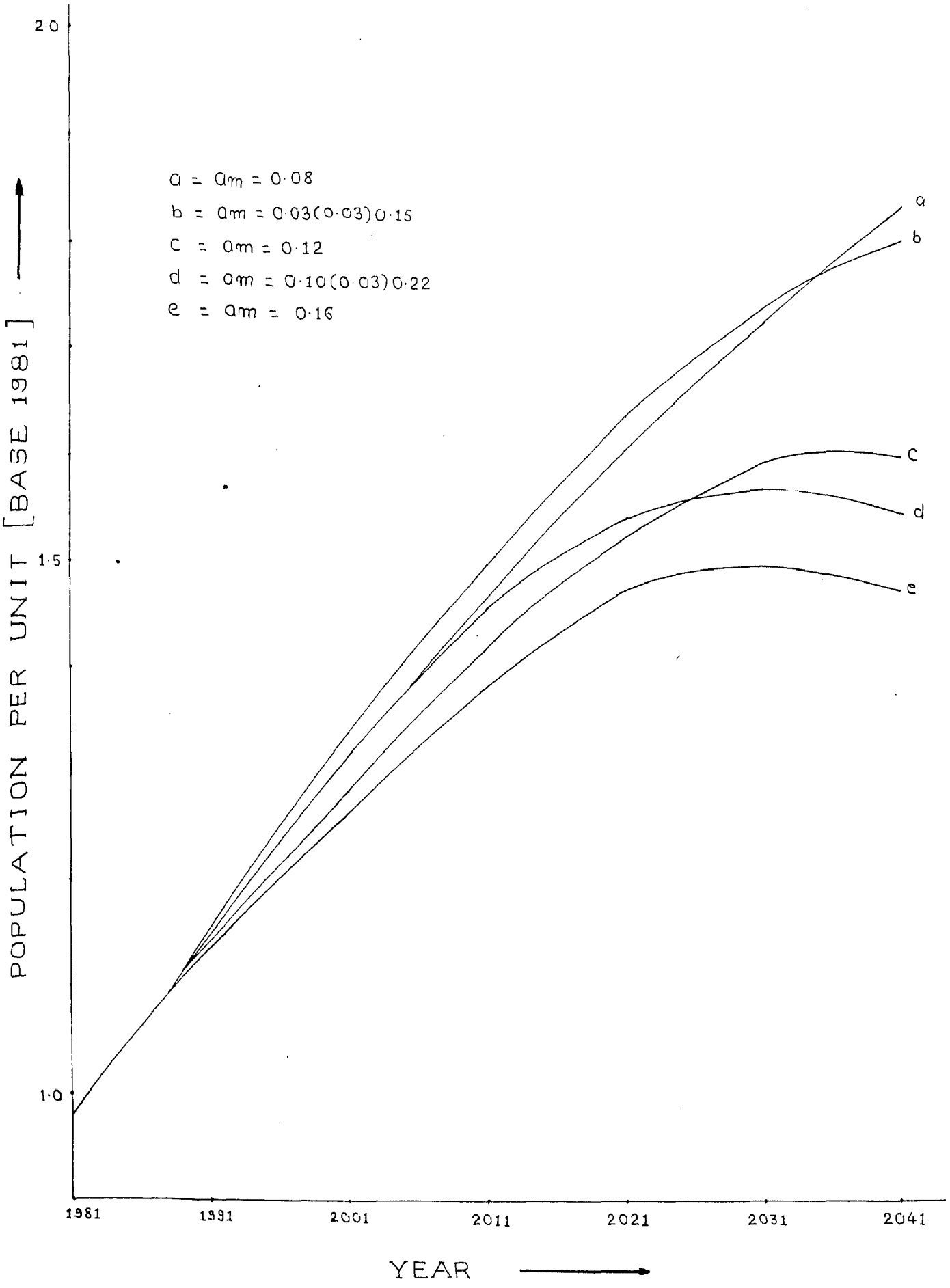
fig. NO. 4.9



AURANGABAD

FAMILY PLANNING CONTROL CONSTANT [A.M.]

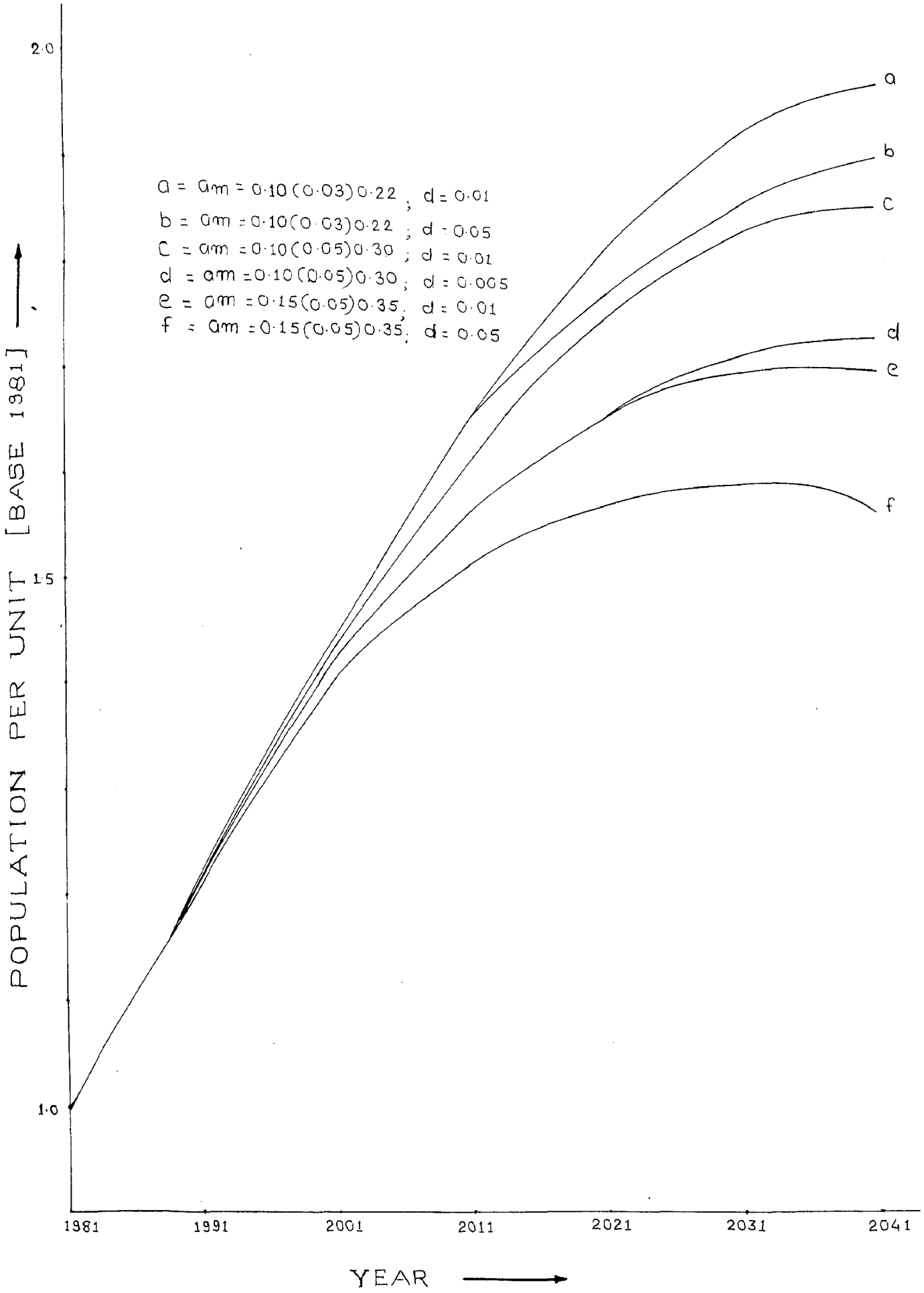
figure NO. 5·0



AURANGABAD

FAMILY PLANNING CONTROL [A.M.]
CONSTANT CHILD MORTALITY

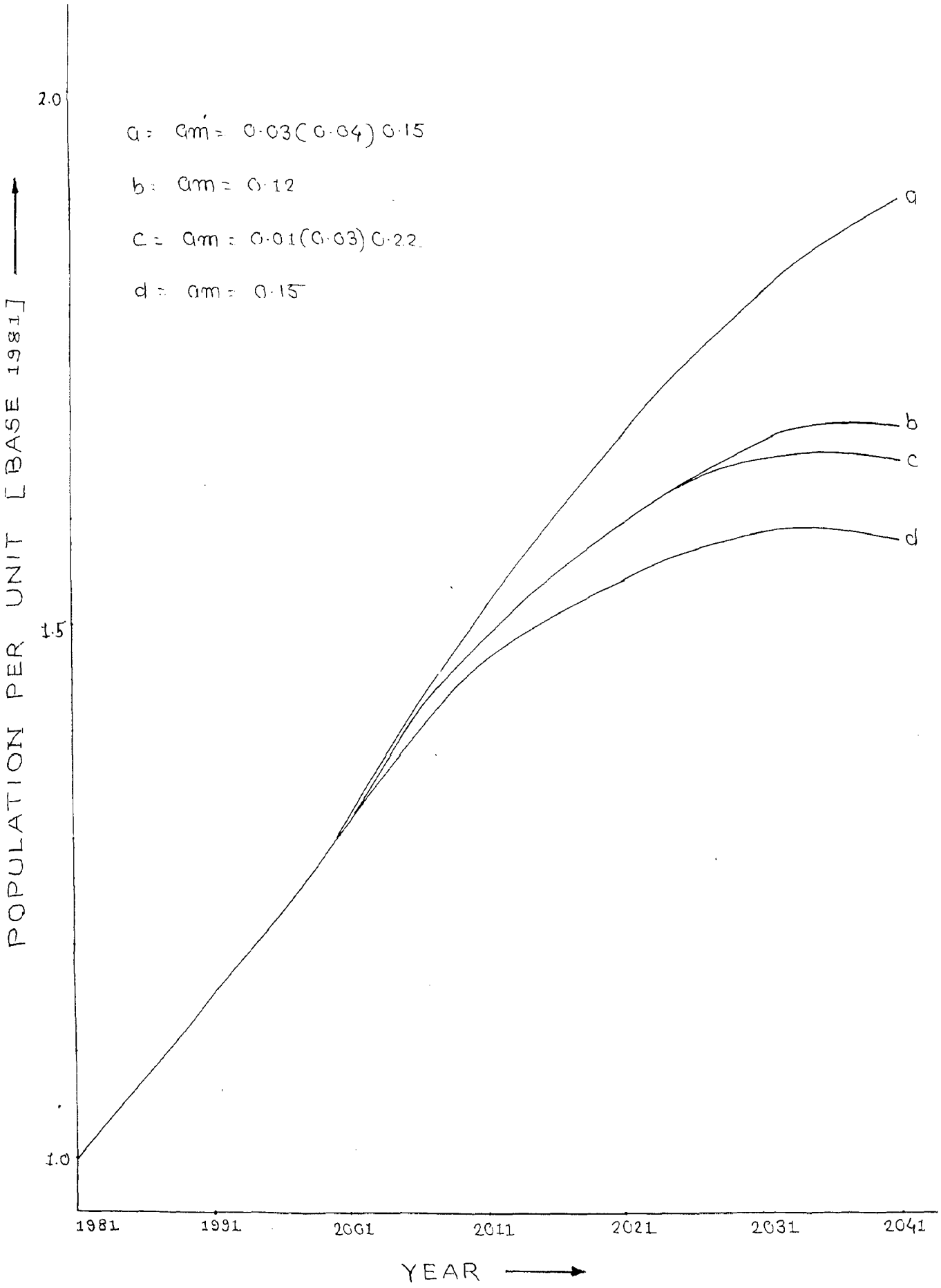
figure No. 5.1



AURANGABAD

FAMILY PLANNING CONTROL [A.M.]

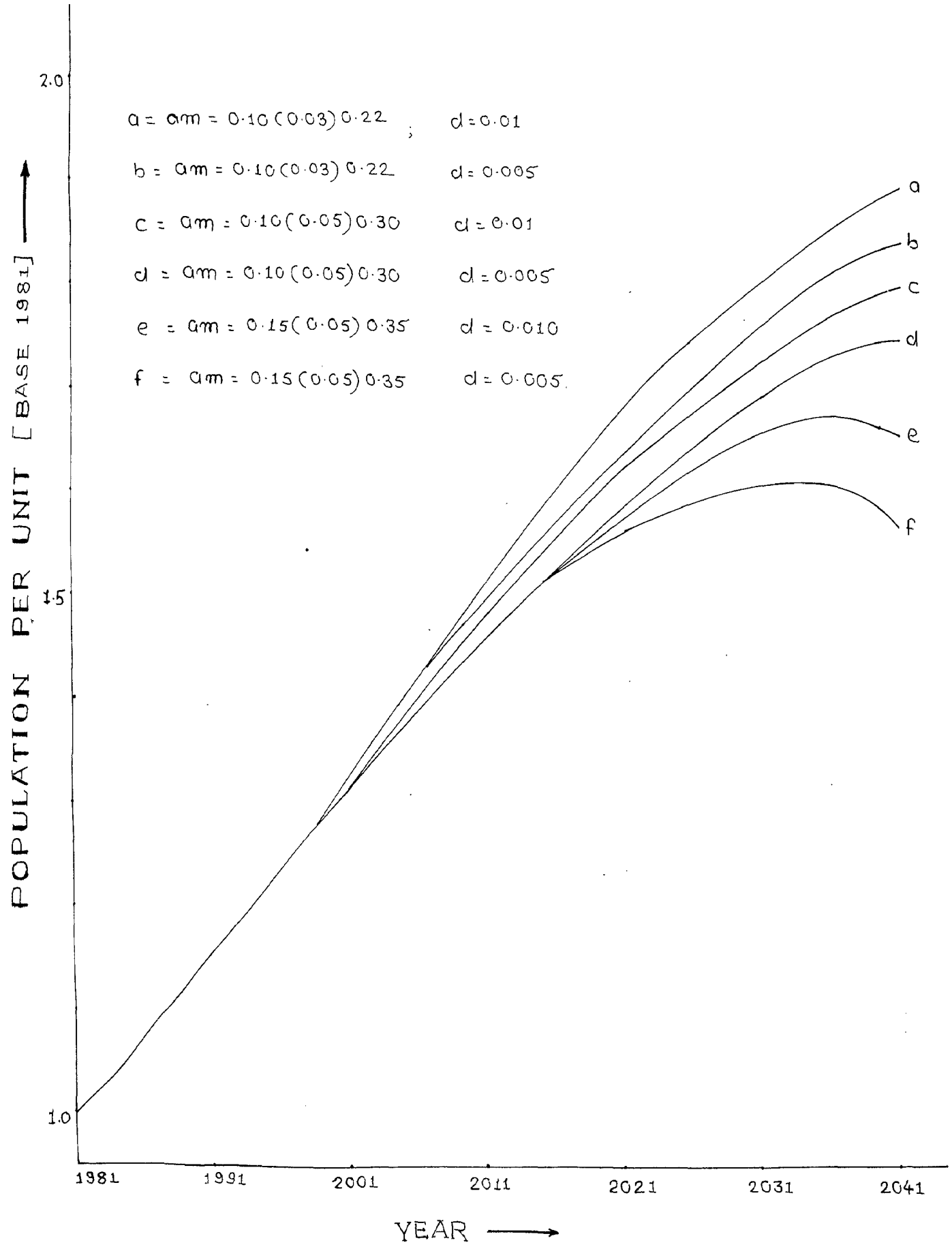
figure NO. 5.2



BOMBAY

FAMILY PLANNING CONTROL
CONSTANT CHILD MORTALITY

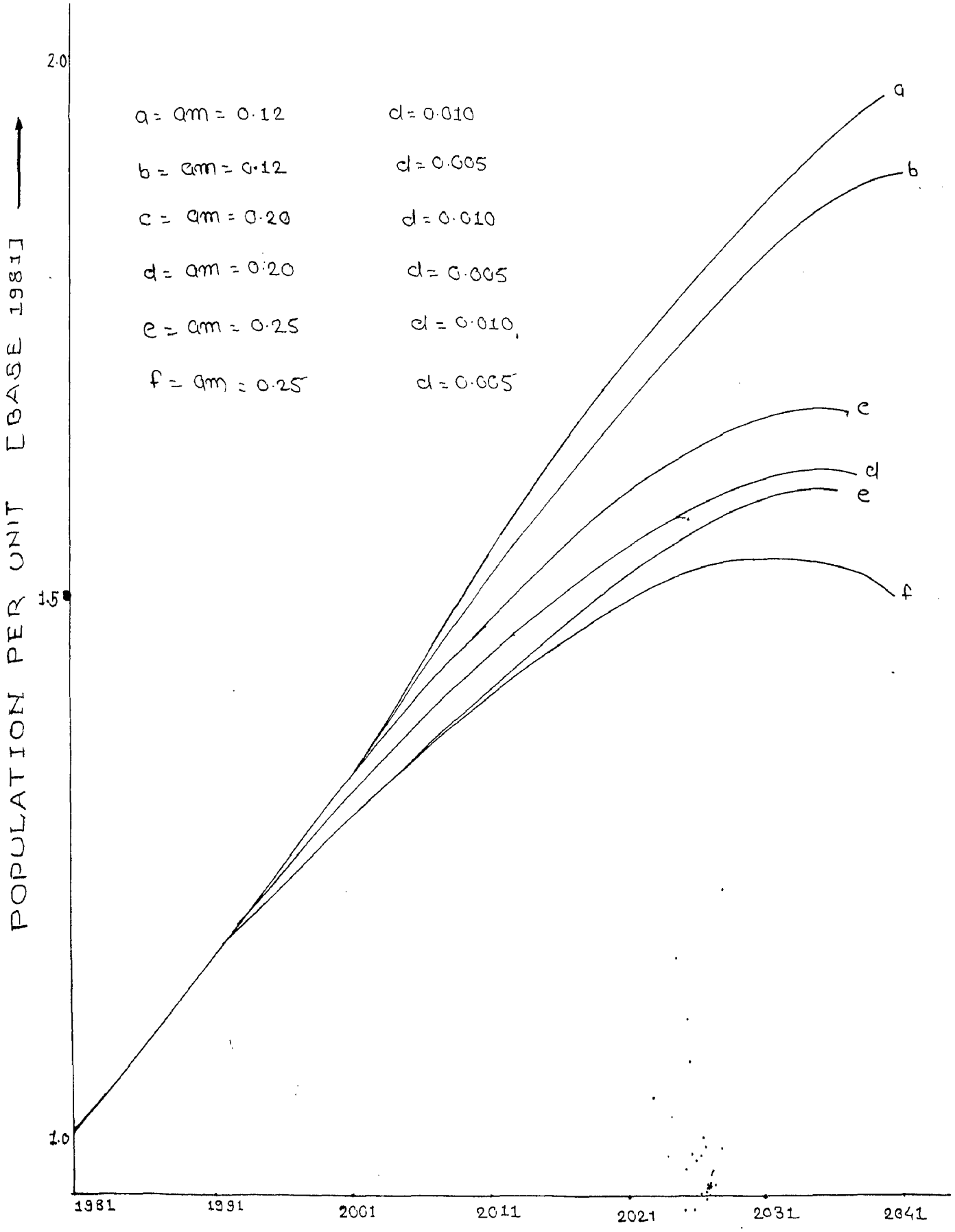
Fig. NO. 5.3



BOMBAY

FAMILY PLANNING CONTROL [A.M]

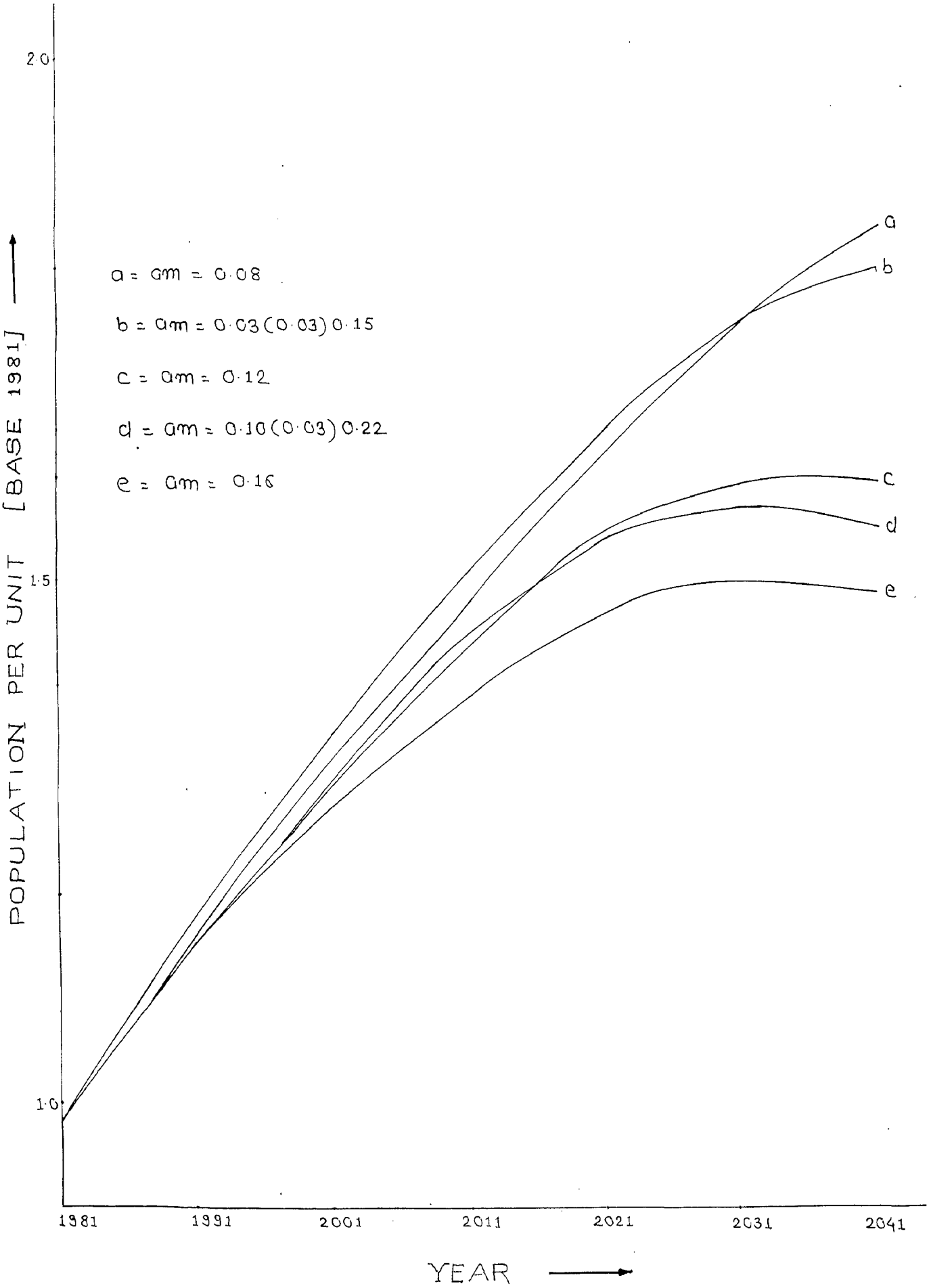
figure NO. 5·4



BOMBAY

FAMILY PLANNING CONTROL CONSTANT [Am.]

fig NO 5.5

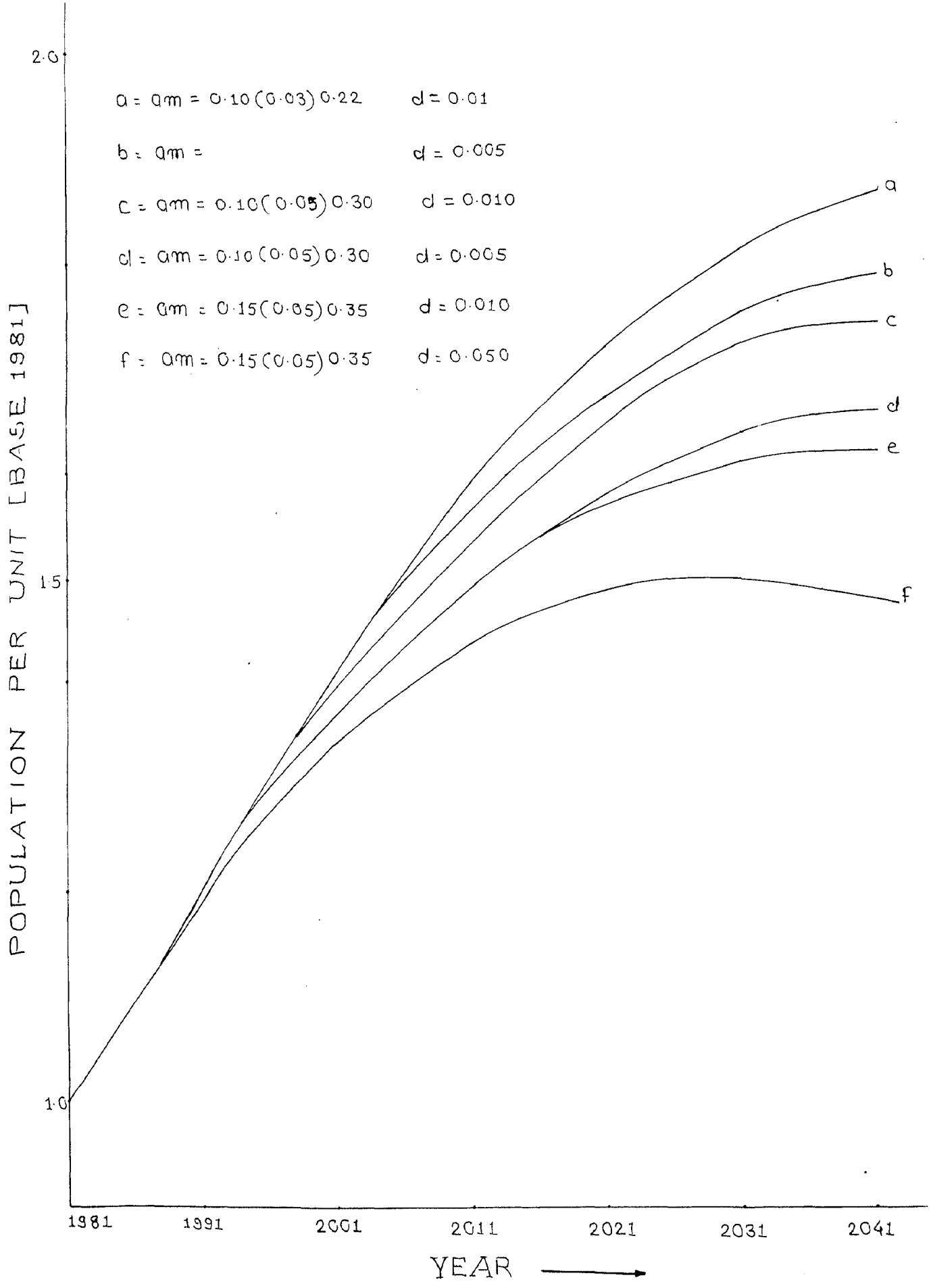


NAGPUR

FAMILY PLANNING CONTROL

CONSTANT CHILD MORTALITY

figure NO. 5·6



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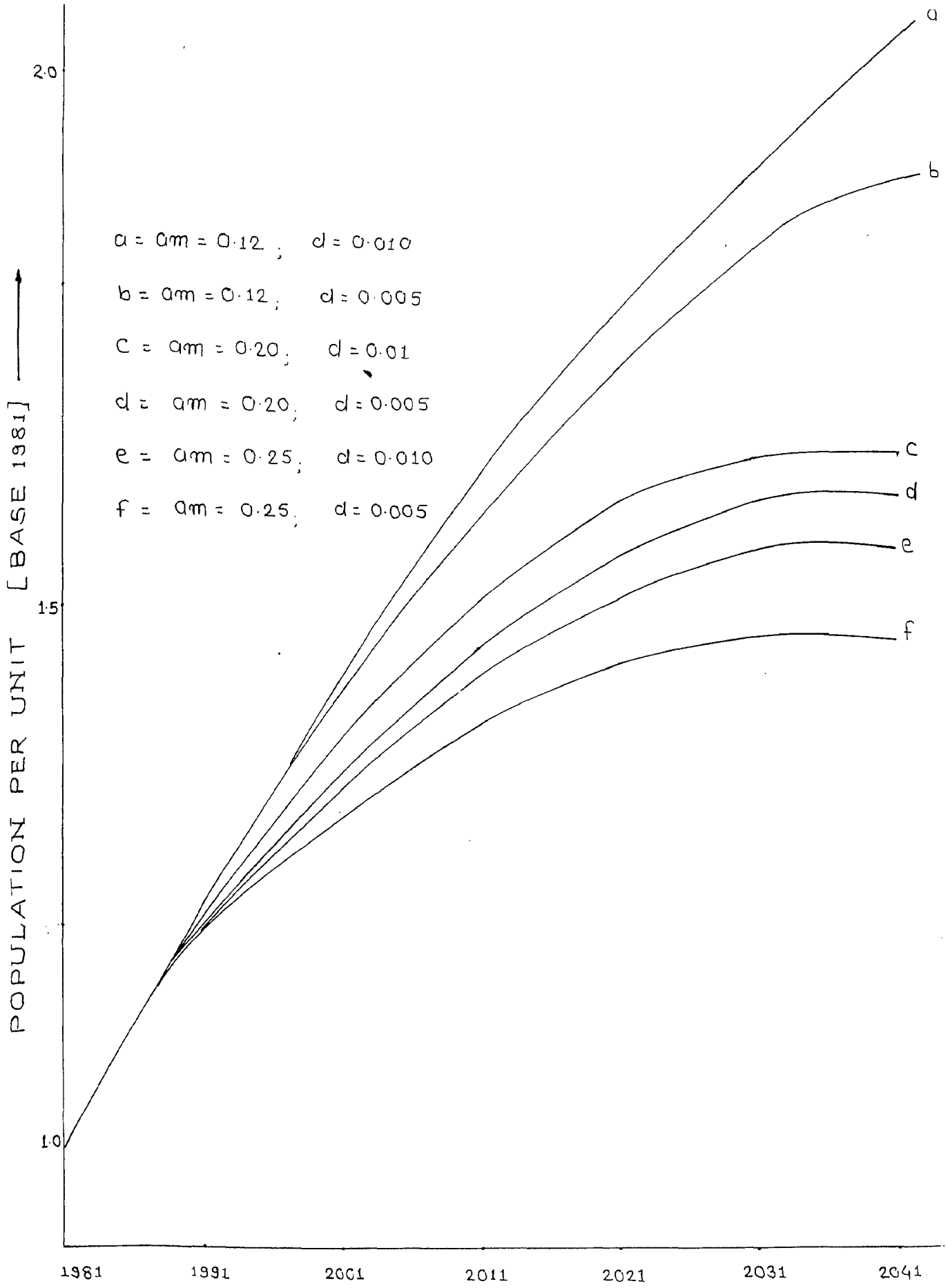
FAMILY PLANNING CONTROL [A.M.]

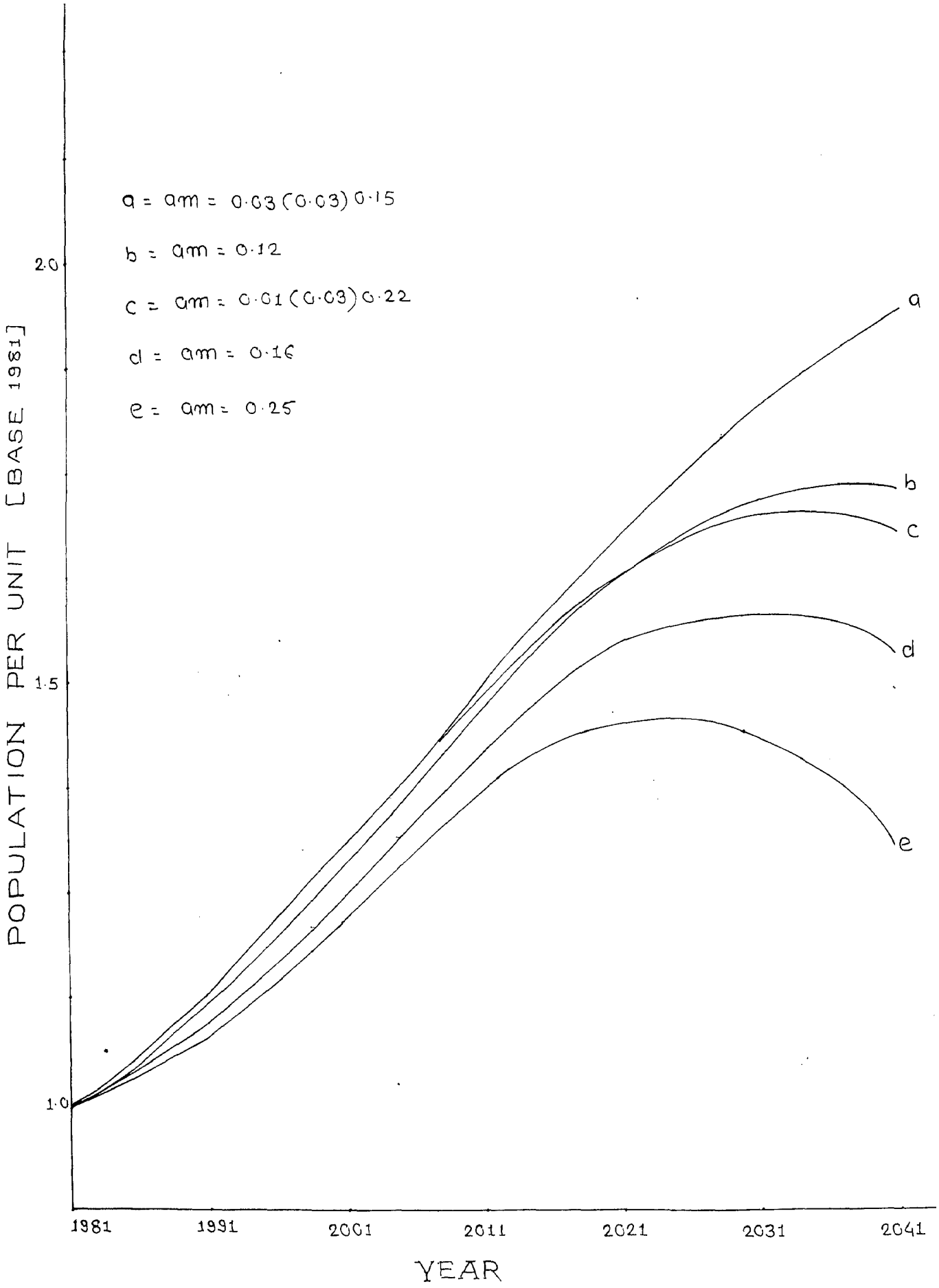
figure NO. 5·7



NAGPUR

FAMILY PLANNING CONTROL CONSTANT [AM]

figure NO. 5.8

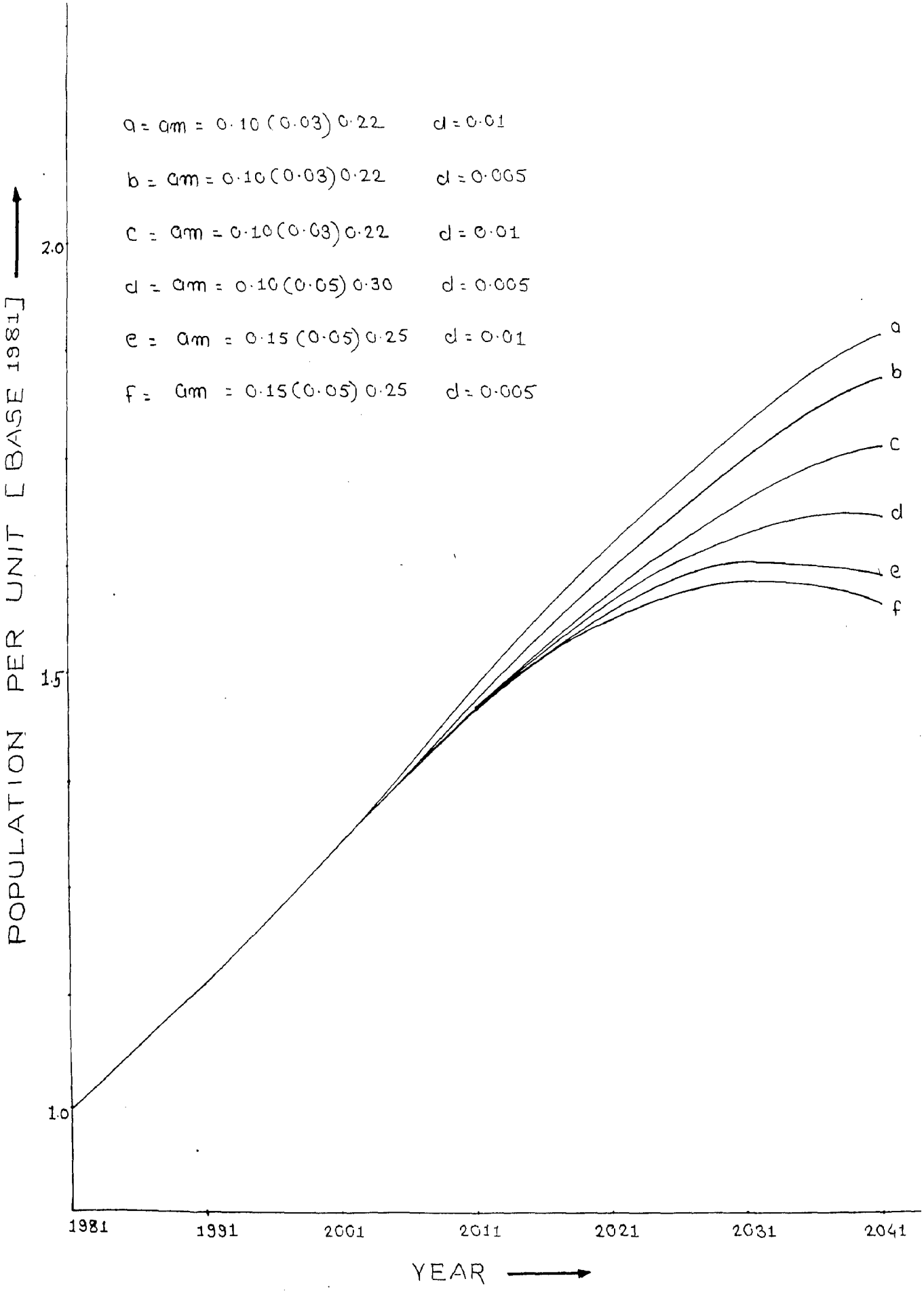


POONA

FAMILY PLANNING CONTROL [A.M.]

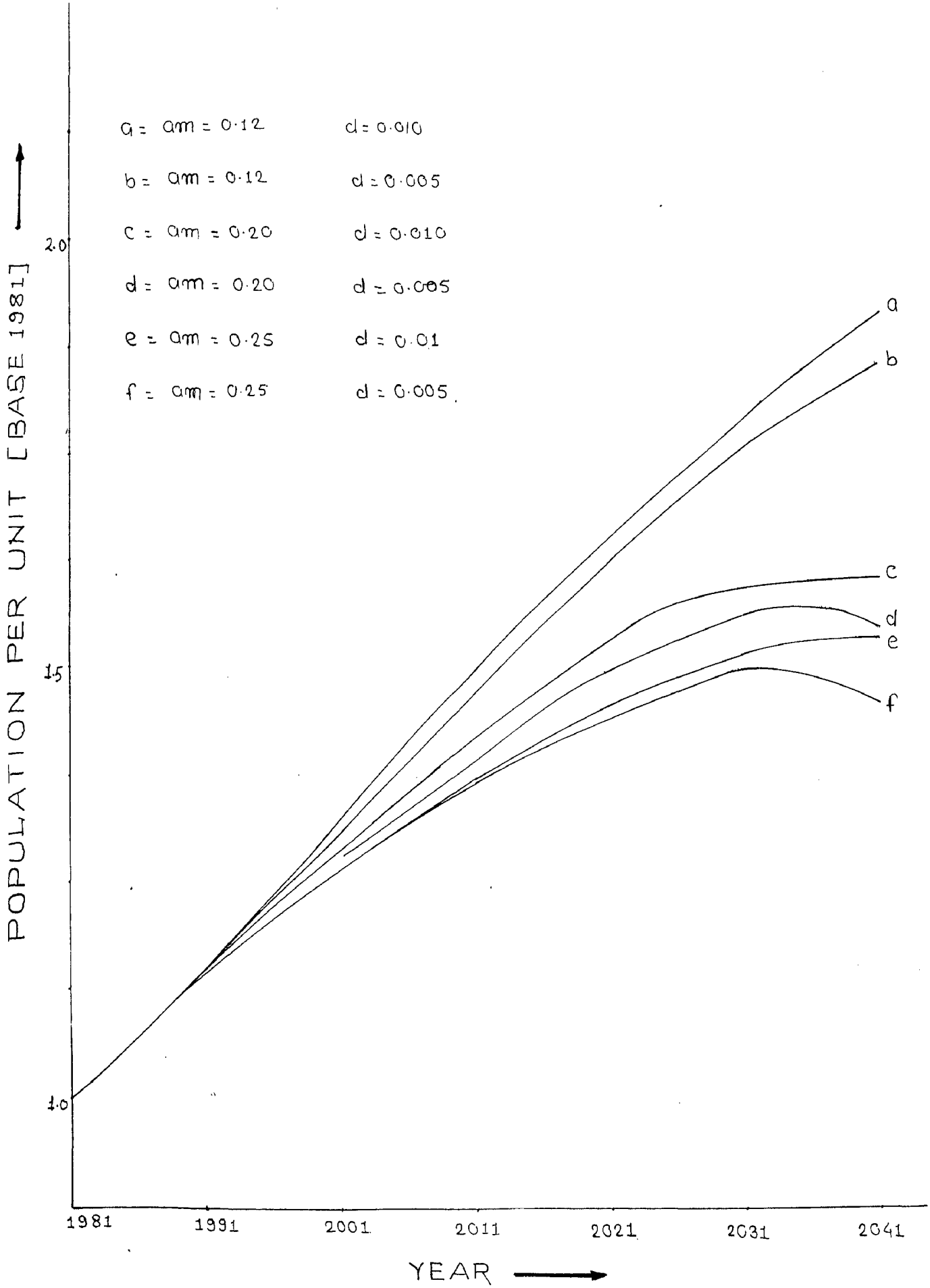
CONSTANT CHILD MORTALITY.

fig. NO. 5.9



POONA

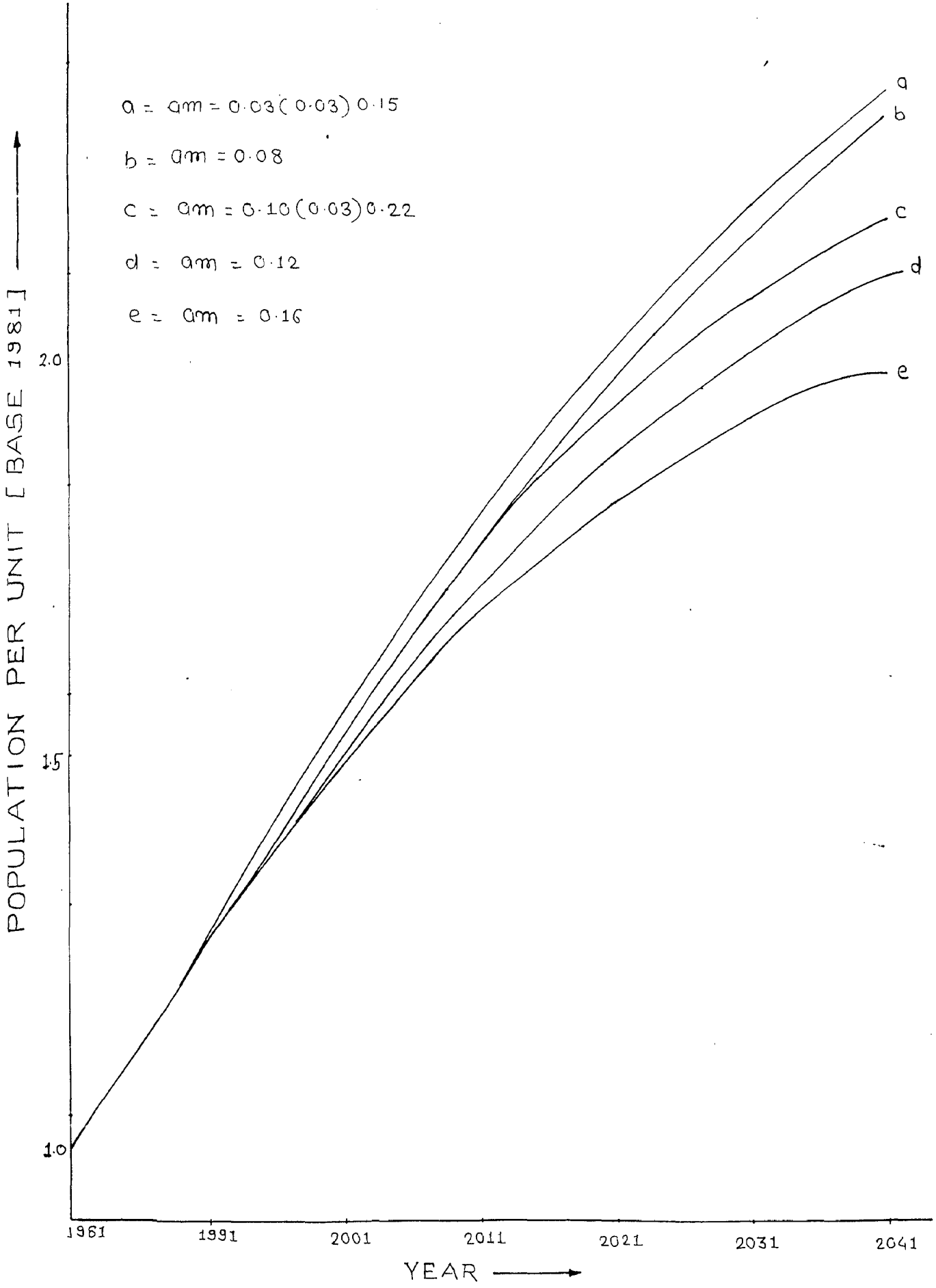
fig. NO. 6.0



POONA

FAMILY PLANNING CONTROL CONSTANT [A.M.]

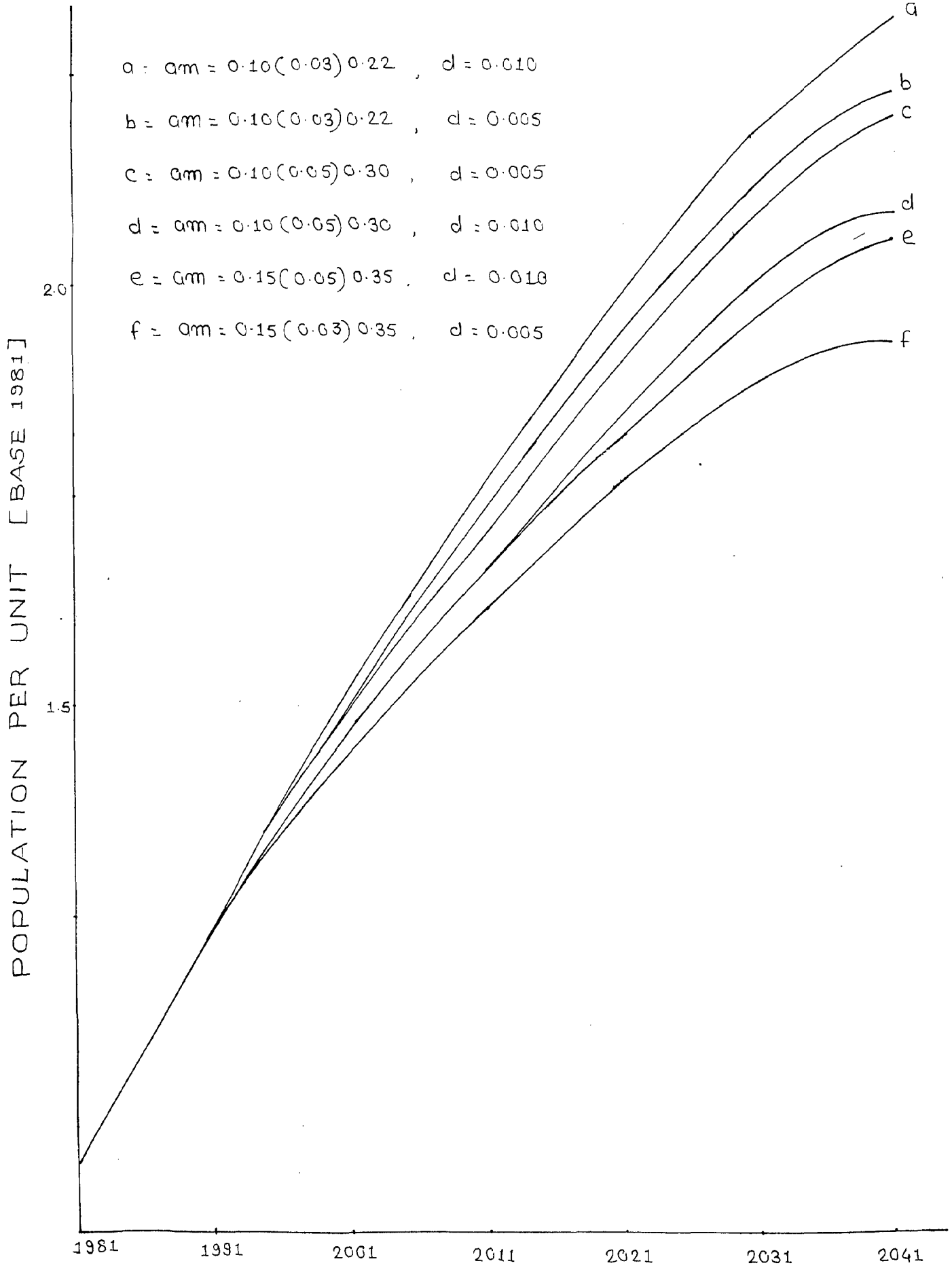
Fig. NO. 6.1



RURAL MAHARASHTRA

FAMILY PLANNING CONTROL [A.M.]
CONSTANT CHILD MORTALITY.

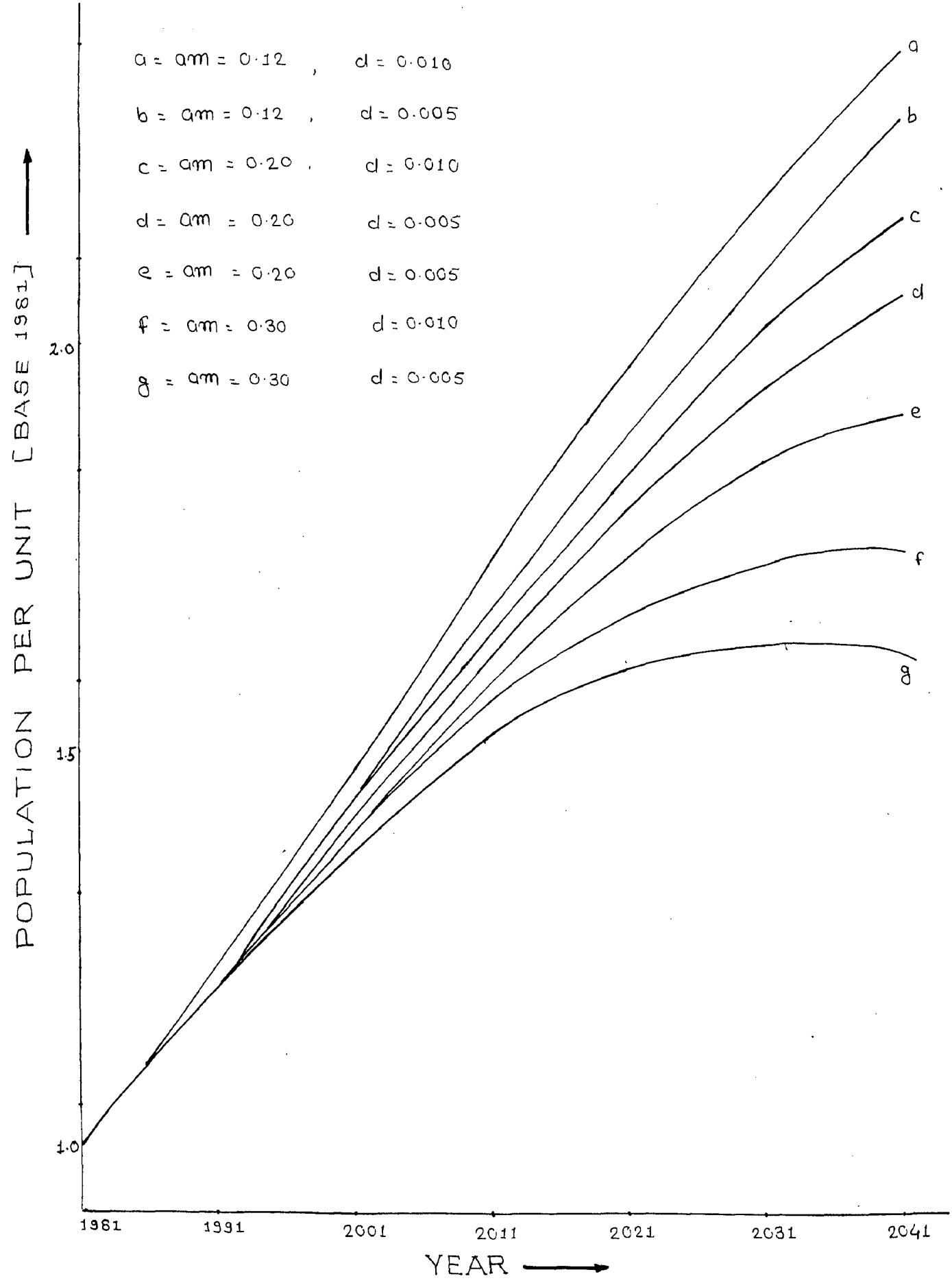
fig. NO. 6.2



RURAL MAHARASHTRA

FAMILY PLANNING CONTROL [A.M.]

fig. no. 6.3



RURAL MAHARASHTRA

FAMILY PLANNING CONTROL CONSTANT [AM]

fig. NO. 6.4

The rural Maharashtra has been observed to have highest rate of population growth the reason obviously being its high fertility and comparatively similar mortality rates to other regions.

CHAPTER - FIVE

CONCLUSION

"The explosion of over-population can be far more dangerous to the maintenance of international peace and security than the atom, hydrogen or cobalt bomb. The already large population of the world which is increasing constitutes today one of the most dangerous pressures, threatening the peace of the world".

BENJAMIN A. GOHEN

5.1 ANALYSIS OF RESULTS:

In previous chapters, the discussion and simulation of results for different methods of fertility control are made. It is clear that a general conscience is necessary to reduce the population level. If we consider the bearing capacity of India as a while to be about 1250-1300 million, then our aim would be to keep the population within this level in future. This means that the population rise should not exceed about 80% of current value.

Some important aspects have been studied about the effect of different fertility reduction measures and their required levels, so not to exceed the bearing capacity of land.

1. Before projecting the population, the most important thing that to be done is to modify the age-wise distribution of female population by least square's approximation method. As described in previous chapters, the error due to wrong age reporting affects the age-wise distribution pattern. The reported populations of 0.4 age group in different censuses can't be reconciled by simply attributing them to reduction in birth rates as has been suggested (Victor Petron).

2. The effect of arbitrary control of fertility pattern a control effort of 0.010 causes a decrease of 9.5 per cent per decade gives a unit population

1.6 times of the present value for Maharashtra as a whole in 2041. If child mortality rates are also decreased simultaneously with a factor of .005 and an increased control effort of 0.014 which causes a decrease of 14 per cent per decade is required for population of 1.85 in 2038. This is an important point to note as decrease in birth rates is very likely to result in reduced child mortality rates.

3. For family planning efforts, the control effort 'AM' of assigned value .08 gives a population of 1.841 times the present one in 2041. If child mortality rates are also reduced simultaneously with control efforts of 0.005 and .010, 'AM' required become 0.12 and 0.14 respectively giving population of 1.825 and 1.840 times respectively.

Family planning is increased in steps as it would be in real life then the control factor has to be increased from 0.04 to 0.20 in five yearly steps of 0.04 and then held constant at 0.20 for achieving a population of 1.745 in 2041. If child mortality rates are also decreased simultaneously, at d = 0.05, it raises the effort to an increase of five yearly steps 0.03 from an initial control factor of 0.10 to 0.22. This achieves a per unit population of 1.772 in 2041. An increase in

'd' to 0.010 increases the level of effort to an initial value of 0.10 increased to 0.30 in steps of 0.03. This gives per unit population of 1.72 in 2041.

Table 5.1 shows the respective control efforts desired for the four regions and for Rural Maharashtra.

5.2 CONCLUSIONS:

The following conclusions have been made on the background of this work:

1. The distortion in the age-groupwise distribution of population has been observed in all the census reports of India particularly, in census 1971 and 1981. This has been analysed and can be said with confidence to be due to the wrong age reporting. This error has been correctdd by adopting a cubic curve fitting to the age-group-wise distribution of population by method of least squares' which gives the smallest mean square error.

2. Since the child mortality rates and fertility rates are strongly correlated, a decline in future child mortality rates has to be assumed together with decline in future fertility rates.

Table 5.1

SUGGESTED CONTROL EFFORTS

Method of Control	Nagpur	Aurangabad	Bombay	Poona	Rural Maharashtra
Arbitrary with child mortality decline factor d = .005	0.015 1.84	0.015 1.86	0.010 1.83	0.010 1.84	0.022 1.73
Family Planning in Steps.	.04(.04).20 1.73	.04(.04).20 1.74	.04(.04).20 1.73	.04(.04).20 1.74	.1(.04).26 1.82
Family Planning constant 'Am'	0.10 1.82	0.10 1.84	0.08 1.83	0.08 1.836	0.16 1.84
Family Planning in Steps with d= 0.005	.10(.05).30 1.75	.10(.05).30 1.76	.10(.03).22 1.76	.10(.03).22 1.76	.25(.05).35 1.7
Family Planning in Steps with d = .010	.10(.05).30 1.727	.10(.05).30 1.755	.10(.03).22 1.862	.10(.03).22 1.823	.25(.05).35 1.8
Family Planning constant 'am' d = 0.005	.18 1.70	.18 1.71	.12 1.81	.12 1.82	.25 1.77
Family Planning constant 'am' d = 0.010	0.18 1.82	.18 1.83	.12 1.87	.12 1.88	.30 1.71

A higher birth control effort is required than for the case of constant mortality rates, a fact which is supported by results obtained.

3. This work raises out a fact that each state should not be considered as a homogenous. There has been observed large variations in population growth pattern from region to region for same control effort.

4. The population increase is considerably high for some regions, typically in Rural Maharashtra as a whole, for a moderate control effort. The population increase has been observed considerably high in rural parts of all regions. This points out to the magnitude of population problem facing to us.

5. Progressive reduction of inter-regional disparities should be a major objective of the country's development programme. But it is obvious that all regions are not capable of attaining the same level, much less the same pattern of development. Broadly speaking, Poona and the eastern portions of Nagpur Division have very good potentialities both for agriculture and industrial development. Greater Bombay, despite several retarding influences, will

continue to be the largest and the most dynamic centre of industrial activity.

The programme for promoting balanced regional growth should be formulated with due regard to the capabilities of different areas. The measures must be dexigned to create the conditions for enabling the resources of each region to be developed to the fullest extent possible.

5.3. SUGGESTIONS AND FUTURE SCOPE OF WORK:

1. In this work, due to the lack of data of married, widowed and divorced females in different regions of Maharashtra, the study of effect of raising minimum age at marriage on population has been impossible to carry out. The raising of minimum age at marriage reduces the reproductive span of woman's life and exercises a controlling influence on population with the altered fertility pattern.

2. On the basis of the results of this work, the necessity of undertaking the population projections for regions-wise divisions of states has been justified. A region must have almost same geographic conditions and same level of living. The results obtained has been very accurate.

3. The inter-regional disparities in incomes and levels of living should be reduced and this should be the major target of the country's development. The efforts should be made for balanced regional growth with due regard to the capabilities of different areas.

4. The census data has been modified in the present case by assuming a cubic curve for demographic profile. It would be worthwhile to investigate this further using other functional forms for this profile.

5. At field level, it would be required to quantify the suggested coefficient values in terms of money and other resource requirements.

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