APPLICATION OF LAND USE TRANSPORT MODEL FOR MEDIUM SIZED CITY-ALLAHABAD

A DISSERTATION

Submitted in partial fulfilment of the
requirements for the award of the degree
of
MASTER OF URBAN AND RURAL PLANNING

By

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dedicated to

YOGENDRA

CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in dissertation entitiled " APPLICATION OF LAND USE TRANSPORT MODEL FOR MEDIUM SIZED CITY - ALLAHABAD "in partial fulfilment of the requirement for the award of the degree of Master of Urban & Rural Planing submitted in the Department of Architecture & Planning, University of Roorkee, Rorkee, is an authentic record of my own work carried out for a period of nine months from August 1989 to April 1990 under the supervision of Prof. Rattan Kumar, Department of Architecture & Planning, University Of Roorkee, Roorkee and Dr. P. K. Sikdar, reader, Department Of Civil Engineering, University Of Roorkee, Roorkee, India.

The matter embodied in this dissertation has not been submitted by me for the award of any other degree or diploma.

(Dharmendra Kumar Gupta)

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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I am thankful to Shri A. P. Aneja, Chief Town Planner, Allahabad Development Authority for helping me in collecting the data for my work. I again wish to express thanks to my supervisor Dr. P.K. Sikdar for helping me in obtaining some useful data from Consulting Engineering Services, New Delhi. I am also thankful to Dr. G.C. Nayak, Co-ordinator CAD Centre, Civil Engg. Department, for permitting meto use the advanced computer facilities which helped a lot in presenting this work.

At Last I express my thanks to all of my friends for their assistance and encouragement.

ABSTRACT

Urbanisation is inevitable and India is no exception. The large concentration of population in big cities have their probelms as known to all. The recent trend of fast growth in medium size cities makes planners to think seriously about these second order cities. These cities, which have popultin in the range of 0.3 to 1.0 million, have been neglected so far in planning. In most cities of this category, unplanned growth and their implications in transport demand has become a serious concern. Transport needs are function of land use, and with least planning imput in terms of planning a balanced growth, chaotic situations are created which are likely to be more acute in future. Land use transport models are the best tools to derive relationships for better understanding of transport consequences.

In this study the city of Allahabad has been taken as the exapmle of medium size city. The master plan developed by Town and Country Planning Department provided the proposed land use developments. The present land use description for the year 1987 was obtained from the Town & County Planning Department and a study done by Consulting Engineering Services,New Delhi. All travel related information was also avaialble for the present scenerio.

were used. Entire modelling was developed as an interactive package with extensive graphic displays. Thus, both input and model outputs can be presented in terminal of through plotters for easy comprehension, for planners and policy makers. The package has great flexibility in terms of data input and choices of operation. The user friendly package does not demand full understanding of the modelling process for its operation. The beauty of the package is in its capability of testing large number of alternative land use plans for their transport consequences in no time and the presentation of results digramitically . This would remove all inhibition of planners and policy makers regarding planning of medium size cities.

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Lowry model is probably the most popular model due to its operationality, and this model was selected for this study. The model was calibrated for the base year data of Allahabad using similar allocation functions for residential and service allocation. The calibration was done with respect to observed travel while good match of popultion and employment were ensured. The model provided acceptable degree of fit with high correlation.

With the help of proposed Master Plan and other planning controls set up by the Development Authority, alternative land use plans were developed. Using the concept of guided development for transport advantages, the city form was recommended with neighbourhood philosophy. Thus, three alternative plans were evolved. The structural parameters of the economic base mechanism were not changed as they were assumed to be stable. However, density and planning controls were varied. The forecast for Basic employment were used as available form the Development Authority. The calibrated model was run for alternative land-use plans and their transport inplications were compared using the measures like mean trip length and actual pattern of travel generated. While deriving the transport concequencesthe planning controls , like density and holding capacity constraints were applied.

As the calibration and subsequent testing of alternatives require huge computations, computer programs were used. Entire modelling was developed as an interactive package with extensive graphic displays. Thus, both input and model outputs can be presented in terminal or through plotters for easy comprehension, for planners and policy makers. The package has great flexibility in terms of data input and choices of operation. The user friendly package does not demand full understanding of the modelling process for its operation. The beauty of the package is in its capability of testing large number of alternative land use plans for their transport consequences in no time and the presentation of results digramitically . This would remove all inhibition of planners and policy makers regarding planning of medium size cities.

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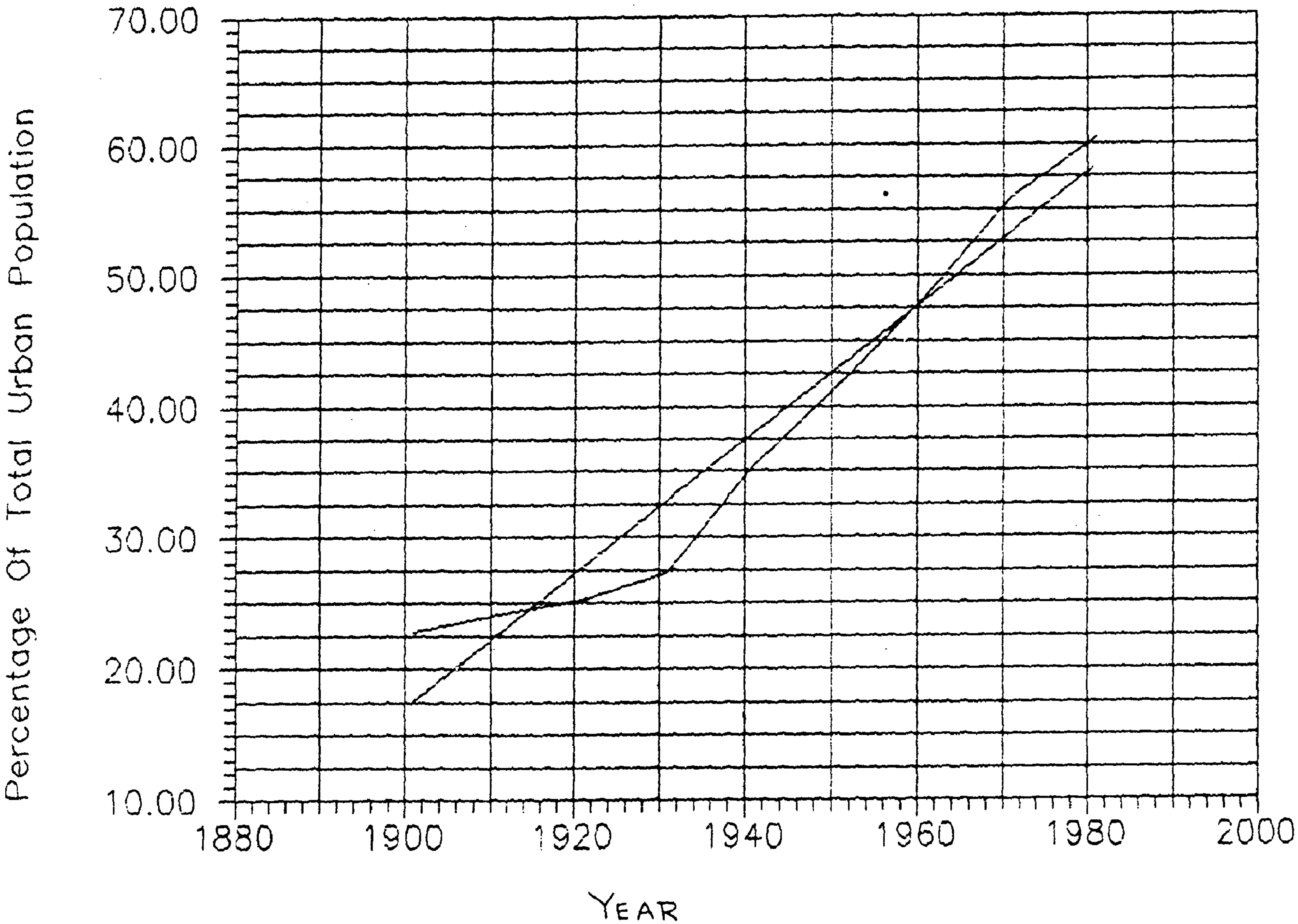

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1. INTRODUCTION

1.1 GENERAL :

Trends of urbanisation in India show a rapid growth of big urban centers. Data reveals that there has always been a major share of urban population in class I cities. Further, the old metropolises are reaching a saturation level. Migration from rural to urban centers, which is the major cause of large population concentration in urban areas, is now being felt by the next order of urban centers. This trend will continue for a long time to come (Fig.1.1). Also,since there is not much being done in the form of planning inputs for these second order urban centers, this will result in the sprawling of the existing urban areas and the growth is bound to be haphazard, mainly in terms of land-useand transportation needs. Problems faced by the larger cities clearly establish a genuine cause of concern for the medium cities. Also, this provides a real timely warning to act and save these urban areas from following the same disastrous course which their larger counterparts had inadvertently followed and got into the mess they are in today.

1.2 TRADITIONAL LAND-USE TRANSPORT PLANNING :

Traditionally transport planning and land-useplanning are considered as packed in two tight compartments. Transport network is planned for a given land-use.

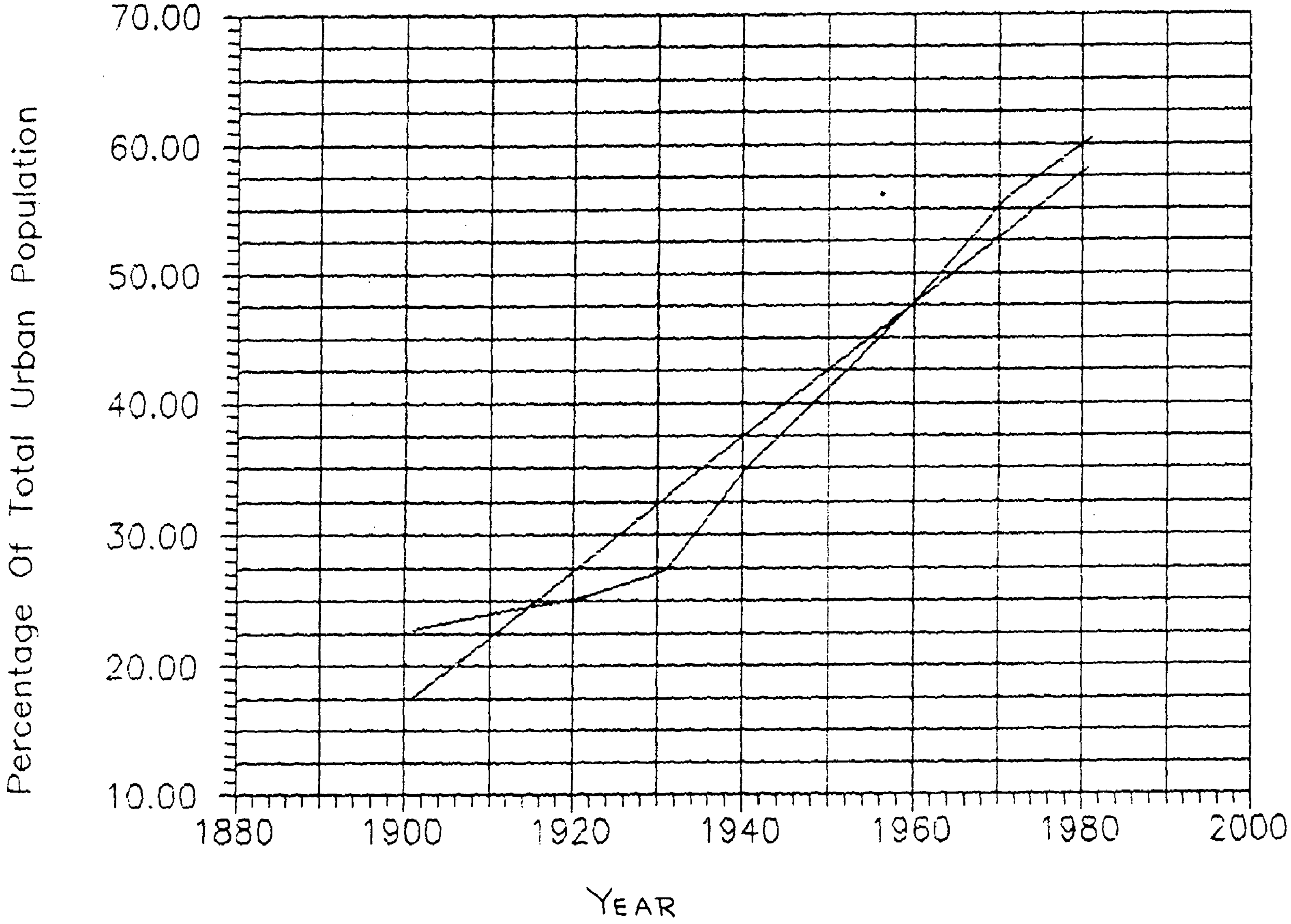

Fig.1.1 Population Growth Trend Of Class I Cities Of India

distribution. No effort is made to see how the land-uses can be manipulated so that the optimum distribution of traffic is obtained. Overall, traffic is a function of land use. To gauge the affect of a land-usedistribution on transportation network alternative land-usepatterns will be required to be evaluated in terms of their transportation requirement. In physical planning, often it becomes difficult to identify whether land-useor transport comes first. Normally, the master plan showing the land-usewith necessary forecasts will be available from planning agencies, which remains as exogenous input for transport planning. Though the suggested land-usemay have been arrived at by looking into the alternative development strategies the choice is never based on desired implication on transport facilities. This was primarily due to lengthening computational requirements. By deploying computers the impact of alternative land-use patterns on transport network can be seen with great economy of time and resources. In this process, detailed network improvement plans can also be developed in relation to the land-use plans.

1.3 RESEARCH PROBLEM :

There is a need to realize the integrity of land-useplanning with the transport planning and to develop such a flexible approach so that a number of alternative land-usedistributions can be evaluated in terms of their implications on transport system. This will require a powerful but operational technique which would require data available at secondary sources. Once developed, this should enable the planners and politicians to make necessary planning decisions for the existing as well as future needs of a city in this regard. Further, this approach will allow policy makers to conceive planning in an integrated way.

The most popular land-usemodel is the Lowry model and it is proposed to use this model in this study for the specific advantages discussed later. The methodology of Integrated land use-transport planning is proposed to be demonstrated using the case of Allahabad City. To make the technique flexible and useable for the medium size cities an easy method for not highly qualified staff will be required. Further, the output from the analysis should be in a most comprehensible format for technical and non-technical policy planners and decision makers and graphic powers of the small personal computers can be suitably used for the purpose of developing an interactive package.

1.4 SCOPE :

Traditional transport planning process consists of four basic steps which include : trip generation, modal split, trip distribution and trip assignment. This process involves a lot of computational work which restricts the evaluation of alternative type of land-usedistribution.

3. To develop an interactive package with extensive graphics for easy comprehension of the results.

4. To predict transport implications for the forecasted land-use distributions under regulations pertinent to density control.

1.6 LIMITATIONS :

1. Only road network shall be considered, because there is no urban railway system. However, for other cities where urban railway system exists this methodology can be equally applied.

2. Only intra city travel shall be considered.

3. Existing land-use shall not bedistributed for reallocation. Predicted land-use activities shall be deployed for generating alternative land-use options.

1.7 ORGANISATION OF THESIS:

Chapter 2 defines the medium size cities, and the study for Allahabad has been justified and Allahabad has been described in detail with all the available data. Literature has been reviewed in chapter 3. Also some operational models are briefly discussed. Chapter 4 is devoted to the selection of the model for the work and its development for Allahabad of their implications on transport system. This will require a powerful but operational technique which would require data available at secondary sources. Once developed, this should enable the planners and politicians to make necessary planning decisions for the existing as well as future needs of a city in this regard. Further, this approach will allow policy makers to conceive planning in an integrated way.

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Further, these techniques have so far been applied onlyfor metropolitan cities. In medium size cities, which with the passage of time are going to face numerous transportation problems, this aspect of planning is generally neglected or almost done intuitively.

The approach suggested in this work will be a flexible one. This will allow the planners to examine travel pattern for any number of land-usedistributions from which land-usegenerating minimum travel demand can be chosen. Attempt will be made to use the minimum possible data and keep the model operational so that its data requirement will be from secondary sources only. Further, this will illustrate as to how these models can be applied to a practical situation. This will certainly be helpful in the planning for transport for any city of similar types.

1.5 OBJECTIVES :

The major objective of the study is to demonstrate the use of Lowry model to derive the transport implications from alternative sets of land-usedistributions. Thus, the detailed objectives are as follows.

1. To calibrate a Lowry type land-use allocation model for Allahabad city.

2. To assess the transport implications of different landuse distributions in terms of amount of travel and the pattern of travel in the city.

with brief description of the calibration process. Preparation of Future Alternative Land use distributions are described in charter 5 and the model developed in previous chapter is applied to see the transport implication of each type of land-use distribution. In chapter. 6 the computer package developed for the work is described in detail with all the facilities available in it. Chapter 7 concludes with the observations made in the study. Also recommendations for further studies has been given in this chapter.

Allahabad falls in the category of medium size cities which faces some transport problem along the major corridors and in the central city. Population of Allahabad in 1987 was 809138(according to TCPD,Allahabad). From the trend of population growth (Fig.2.1) it can be seen that its population is rapidly growing. In 2001 its population is expected to be 12.10 lakhs .Study of this city will show a way as to how the problems of this class of cities can be approached. Seeing the trend of urbanisation in India it can very well be assumed that in future this city is certainly going to face an acute transportation problems requiring distinct planning inputs. This will help in taking policy decisions for future and efficient functioning of the city. Also much of the required land use and travel data was available. All the above reasons stimulated me to choose Allahabad as a study area for the purpose under reference. However, this type of study can be done for any type of urban area.

2.2 LOCATION :

Allahabad is located in Uttar Pradesh(U.P) province in India at the confluence of sacred rivers Ganga Yamuna and mythical Saraswati. Its location in India and UP is shown in Fig.2.2. Fig 2.3 shows its link with the other parts of the country and its nearby cities.

2. STUDY AREA AND IT'S EXISTING CONDITION

2.1 GENERAL:

It has been observed that cities having population less than 3 lakhs, generally, do not have any major transportation problem. On the other hand, twelve metropolitan cities(in India)need special treatment in terms of land use transport planning. The second order cities face an acute problems due to large population concentration, migration vis-a-vis less planning input.

According to Tambe(*) and Patanakar(**) the medium size cities are those which in the population range of 3 to 10 lakhs. There are 57 such cities in India (census of india 1981). Rapid increase in the population of these centers would require large amount of capital investment to provide the services to the inhabitants. To ensure that the limited resources at our disposal are best utilized to provide maximum benefits per unit of investment, it is desirable that we plan expansion of the aforementioned urban communities well in advance. Land- use and transportation network being the most crucial component of an urban community their proper planning would go a long way in conserving the scarce resources and ensuring the optimal use of the same.

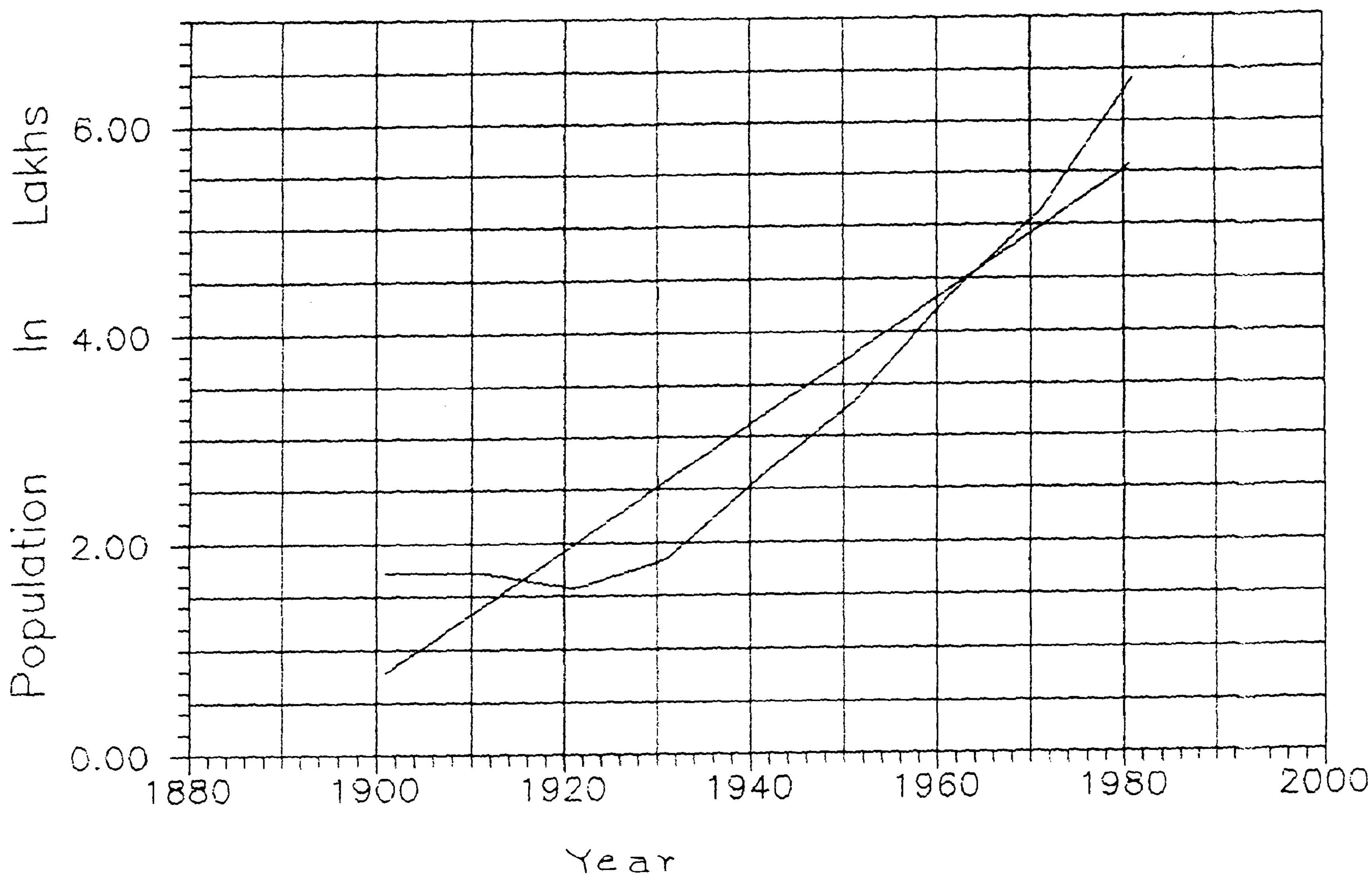

Fig. 2.1 Population Growth Trend Of Allahabad

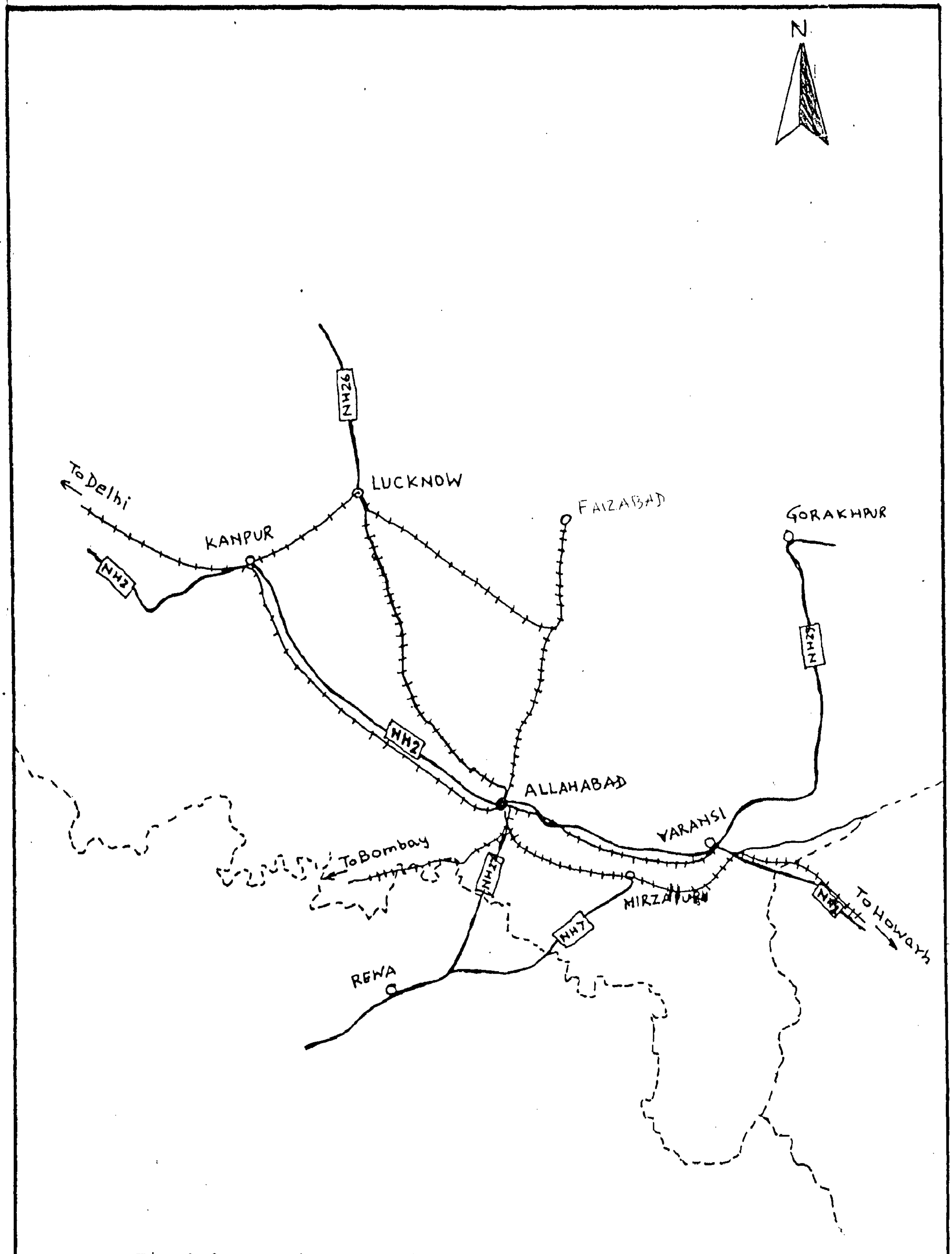

Fig.2.3 Linkages of Allahabad

2.3 HISTORICAL GROWTH :

The genesis of the city could be traced back to the Mughal reign at the end of the XVI century, whence the city had started crystalizing to a permanent physical shape. With the establishment of provincial Head Quarters here under the British regime. Important developments took place in the fields of education, administration, trading and commerce. At the beginning of 19th century A.D. Allahabad was made an important Military station by the Britishers. The transfer of the seat of government and the High Court from Agra in 1956 and 1868 respectively led to the creation of a number of government offices which gave the impetus for the rapid growth of the city. The Municipal Board was created in 1863 for improving the conservancy arrangements and generally promoting the welfare of the city. Allahabad Water Works was Commissioned in the year 1891. The creation of Allahabad Improvement Trust in 1921 for environmental up gradation was a direct consequential measure of the bubonic plaque which hit the city at the onset of the century lowering the population tables drastically. A slight set back to the fast pace of development of the city was observed with the transfer of the seat of government to Lucknow in the late thirties. The city registered a steady growth after independence, boosted by substantial influx of the displaced persons and within two decades population rose by 65% from about 2.01 lakhs in 1941 to about 4.31 lakhs in 1961. The educational and trading fields has been significant over time. The massive congregation of millions of pilgrims from all over the country at the "Sangam" (confluence of three sacred rivers namely Ganga, Yamuna and Saraswati) is witnessed every six years and twelve years; the festive termed as "Ardha Kumbh" and "Purna Kumbh" respectively. Along with these age old traditions, the recent expansion of industrial base of Allahabad and its unique location in the transport network of the northern region, have influenced the socio-economic and physical characteristics of the city. According to 1981 census the area of Allahabad urban agglomeration is 82.18 sq.km. The area of Allahabad Municibpal Corporation is 62.94 sq.km. which has not changed since 1960. Subedarganj railway colony is spread over an area of 0.93 sq.km. and the area of Allahabad Cantt. is 18.31 sq.km. In the Allahabad Master Plan (1967-1991) four major areas had been identified as the potential areas for future growth of urban activities. These were Phaphamau and Jhusi across river Ganga and Naini across river Yamuna and Subedarganj in the west Phaphamau and Naini are within the municipal boundaries of Allahabad.

2.4 Demographic Data :

2.4.1 Demographic Profile

The district of Allahabad is one of the five districts of Allahabad division spread over an area of 7,261 sq.km; it stands 8th in area and Ist in population amongst the 56 districts of the state. In 1951 the district of Allahabad stood sixth in the state in respect of population and it was ranked fourth in 1961 having a population of 24,38,376 persons. As given by 1981 census, the total population of the district of Allahabad is 38 lakhs out of which approximately 30 lakhs persons live in rural aras and 8 lakhs persons in urban areas, bearing a proportion of 80% and 20% respectively. Urbanisaation in the district is 20% which is higher than the state as a whole (17.9%). The total population of Allahabad urban agglomeration is 6.5 lakhs out of which 2.9 lakhs are males and 3.58 lakhs are females. In view of the declining mortality rate and almost constant birth rates we can expect the natural rate of increase to be approximately 15% - 13% per decade.

2.4.2 ZONE WISE POPULATION DISTRIBUTION

On the basis of census data and some data collected by the Town & Country Planning Department, Allahabad,(TCPD) it is seen that Population density varies from approximately 55,000 persons/sq km in zone No. 8 which includes Malviya Nagar, Atar Suiya, and Chock Gangadas to 1995 persons/sq km in zone No. 18 i.e. Sadiyabad.According to the Town & Country Planning Department, Allahabad, the total estimated population of Allahabad Municipal Corporation is 8.1 lakhs. For estimating 2001 population, it sq.km; it stands 8th in area and Ist in population amongst the 56 districts of the state. In 1951 the district of Allahabad stood sixth in the state in respect of population and it was ranked fourth in 1961 having a population of 24,38,376 persons. As given by 1981 census, the total population of the district of Allahabad is 38 lakhs out of which approximately 30 lakhs persons live in rural aras and 8 lakhs persons in urban areas, bearing a proportion of 80% and 20% respectively. Urbanisaation in the district is 20% which is higher than the state as a whole (17.9%). The total population of Allahabad urban agglomeration is 6.5 lakhs out of which 2.9 lakhs are males and 3.58 lakhs are females. In view of the declining mortality rate and almost constant birth rates we can expect the natural rate of increase to be approximately 15% - 13% per decade.

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2.4.3 Demographic Characteristic

Sex composition of the population has changed significantly over the years. Compared to 56% of male population in 1961. It had declined to 45% of the total population in 1981. The average household size is 5 persons per household with a total number of 112,693 households in Allahabad Urban Agglomeration. In 1981, nearly 69% of the total population was literate, which is much higher than the national average and reveals the potentialities of semi-skilled and skilled labour force which is required in the changing economy. A large portion of the literate work force can be employed by the expanding secondary and tertiary sectors of the economy.

Table 2.1

Base Year Population and Density of different Zones

Zone Nos.	Population	1981* Area sq.km.	Density persons/Acre
1	30247	8.24	15
2	17418	5.16	14
3	30130	2.12	57
4	23875	1.44	67
5	31355	0.80	157
6	32035	0.52	247
7	31356	1.56	116
8	37470	0.68	220
9	34339	0.88	156
10	33951	0.80	170
11	18449	1.60	47
12	28003	4.44	25
13	17180	3.16	22
14	14673	2.00	29
15	30586	2.60	47
16	17044	1.12	61
17	18363	3.52	21
18	18485	9.24	12
19	30839	3.72	33
20	39026	2.84	55
21	13936	1.12	50
22	10260	0.48	86
23	23598	0.68	139
24	33426	10.76	14

* CENSUS OF INDIA - 1981

2.5 LAND-USE PATTERN :

The development of Allahabad is largely guided by the physical constraints. The courses of the rivers have limited the expansion of the city along three sides and the only possibility for expansion of the city is along the Ganga loop in the northern boundaries, and towards the west of the city. Besides rivers the existence of a number of railway tracks have divided the entire city in a number of segments. The high embankments of the railway tracks have given rise to poor accessibility between the different segments and thus the entire city could not develop on an integrated pattern.

The existing land-use reveal a wide disparity in the intensity and pattern of land utilization. The Civil Lines area stand out in contrast to the other areas with well organized road pattern, amenities and relatively lower density with larger holdings and accommodating most of the institutions and public offices. While the older parts and parts on the south of the Main Railway line are organically grown and intensively developed with the associated blights and deficiency, the limiting physical factors on the main land have been responsible for the development of Naini, Jhusi and Phaphamu across the rivers Ganga and Yamuna. These places are showing fast developments, out of which Naini has the maximum potentials.

Junhsi and Phaphamau is out side the municipal boundary and excluded from the study area.

The land-use survey of the city was carried out by T C P D which includes the entire area (24.20) sq.m within the Corporation limits. Table (2.2) and Table (2.3) presents the broad land allocations in 1987 and also as envisaged for 2001 A.D. respectively. Since the preparation of Master Plan was on progress only some of the land-use data for 2001 was available . All the data were available through Town & Country Planning Department, Allahabad.

2.6 Transport Network :

Allahabad is well linked with rest of the country by well established rail routes, inter-state highways and air routes. Since the city is surrounded by rivers on three sides, the railways and road bridges across Ganga and Yamuna from the entry points facilitates the movement of passenger & goods, men and material to and from the city. Fig.(2.4) shows the detailed transport network in Allahabad.

Allahabad is unique among the KAVAL towns of U.P. in that it is the only city which handles on one hand the east and west traffic of the Ganga plain and on the other hand links north eastern India with the Deccan. Two National Highways traverse through the city forming important links. National Highway No. 2 also known as G.T. Road

Table No. 2.2

Base Year (1987) Land-use distribution

S. No.	Land-use Category	Area (in Hectares)	Percent
1.	Residential	3014.10	53.7
2.	Commercial(whole sale)	167.50	3.0
3.	Industrial	477.00	8.5
4.	Govt. Establishments	310.00	5.5
5.	Recreational	121.00	2.1
6.	Public & Semi-Public Facilities	306.10	5.5
7.	Degree Level Education	58.00	1.0
8.	Technical Education	208.00	3.7
9.	Health (general)	37.10	0.7
10.	Health (specalised)	3.00	0.05
11.	Utilities	31.00	0.6
12.	Railway	582.40	10.3
13.	Bus Terminal	3.00	0.05
14.	Truck Terminal	37.00	0.70

Source: Town & Country Planning Department, Allahabad.

Incomplete?

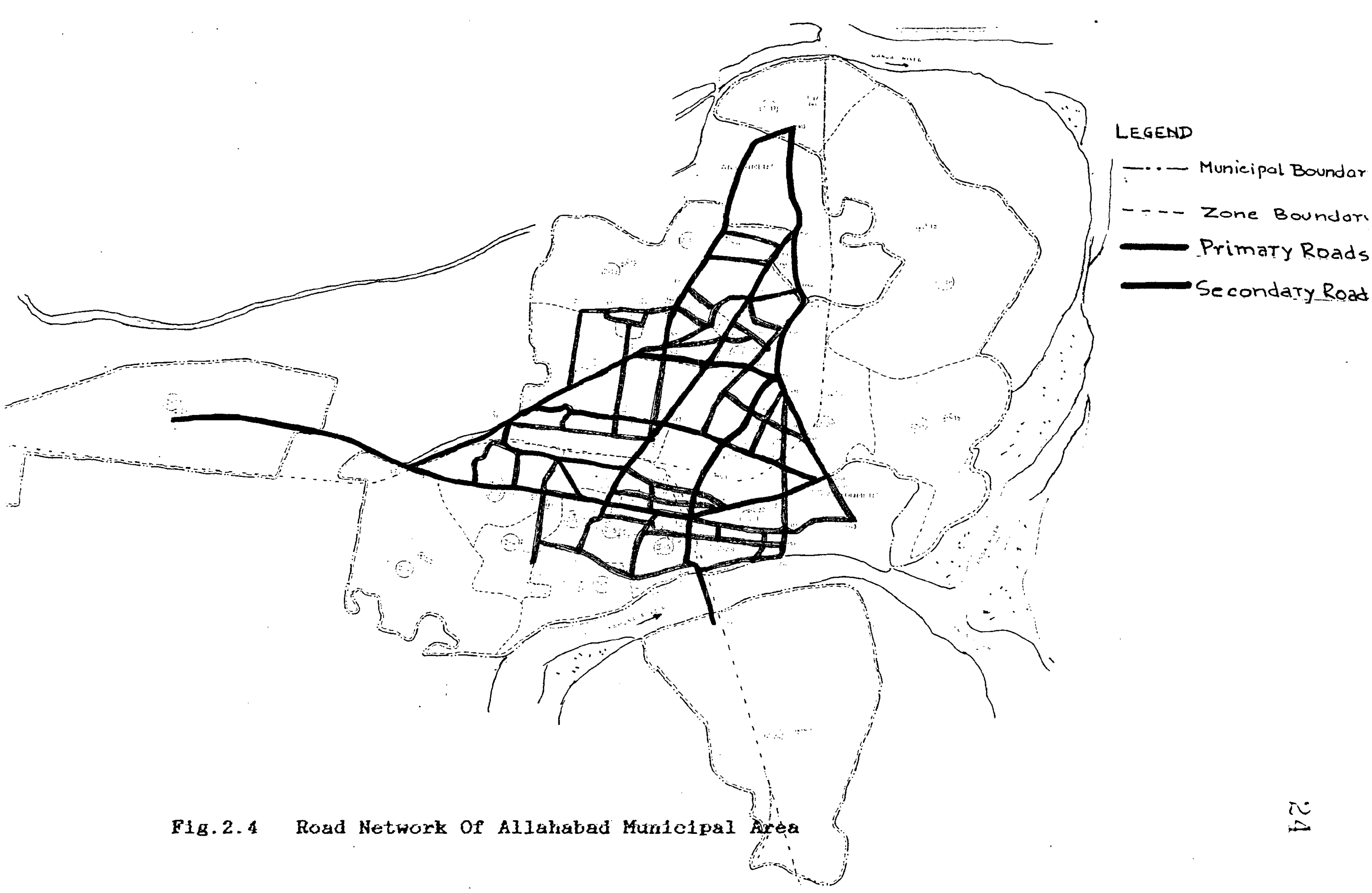

Fig.2.4 Road Network Of Allahabad Municipal Area

connecting Delhi to Calcutta passes through the heart of Allahabad city. National Highway No. 27 connects Northern India with Deccan passing through South Western region of Allahabad.

The establishment of the military cantonment during 19th century, necessitated construction of new roads, railways and bridges. The city area, north of railway line was developed during this era in a grid iron pattern. The rest of the city area are served by an inefficient road network of irregular pattern.

A link between the Civil Lines and the Fort is provided by the east west extensions of Mahatma Gandhi Marg. The important settlement of Katra, Colonelganj is linked by the Jawaharlal Nehru Road to the holy confluence and the Fort. The Triveni Road is another important approach road to the sangam. Other east-west alignments are formed by Kolhantola Street, Panchkroshi and Shankar Lal Bhargava Road which run parallal to G.T. Road and Triveni Road. Apart from these, the other important east-west alignment are Leader Road, Maharshi Dayanand Marg, Zero Road, Beni Bandh Road, and the Yamuna Bank Road. The main roads of the city running north-south and linking the G.T. Road with the Yamuna river are the Noorullah, the Attarsiya-Kalraha Ghat, the Sheo Charan Lal, the Tilak, the Ganeshwatica and the Laxmi Narain Road. The Johnstonganj and the Kamla Nehru Roads connect chowk with Katra which is an important neighbourhood centre of the city. The roads linking chowk to the district court and the University are the Motilal Nehru Road, Kulbhaskar Ashram and Swami Vivekananda Road.

The shortest path time and distance matrices of interzonal travel. The total trip matrix was also available which include travel between each pair of zones combined for all purposes. Since the land-use transport model used (Lowry model) has interaction in the form of travel for work and retail shopping purposes, the calibration process would require a trip matrix representing these travels only. Thus, assuming that work and shopping comprises 65% of travel in a medium size city, the trip matrix available was sliced for use in study.

2.7 TRAVEL PATTERN :

Traffic zones, required for planning purpose were delineated by the Allahabad Development Authority on the following basis:

i) As far as possible, the traffic features zone include homogeneous population and landuse groups.

ii) Certain important topographic features, such as ,railway lines ,river, nallahs and roads were used as zone boundaries, as such physical barriers exert a profound effect on travel patterns particularly with respect to within city trip.

iii) Zone boundaries are made to conform to administrative boundaries such as municipal wards, as far as possible. Since data for population, employment and other factors affecting travel generation are generally compiled for these administrative units, it becomes convenient to relate travel with these factors. Thus, twenty four traffic zones were formed for Allahabad as shown in Fig. 2.5.

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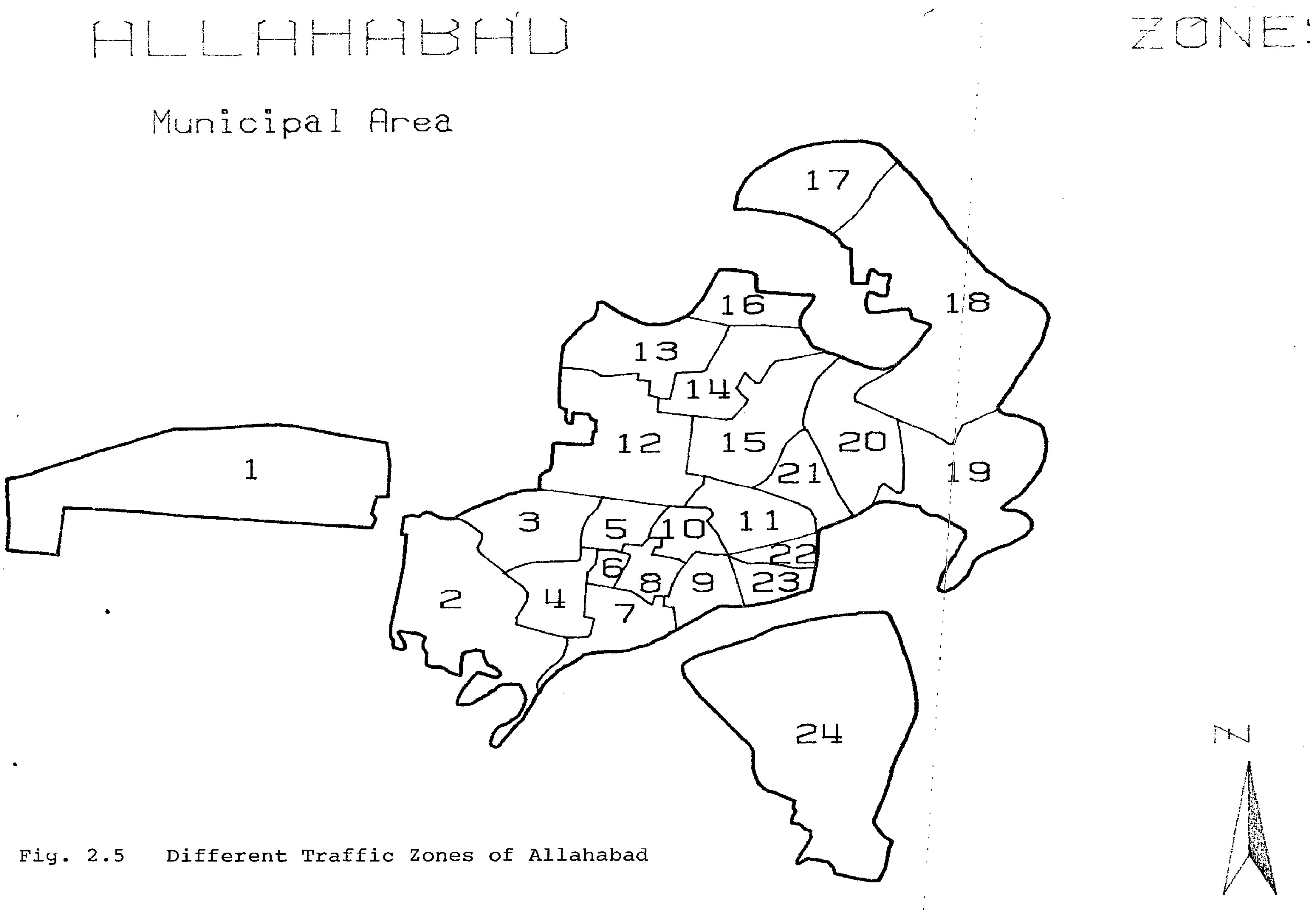

Fig. 2.5 Different Traffic Zones of Allahabad

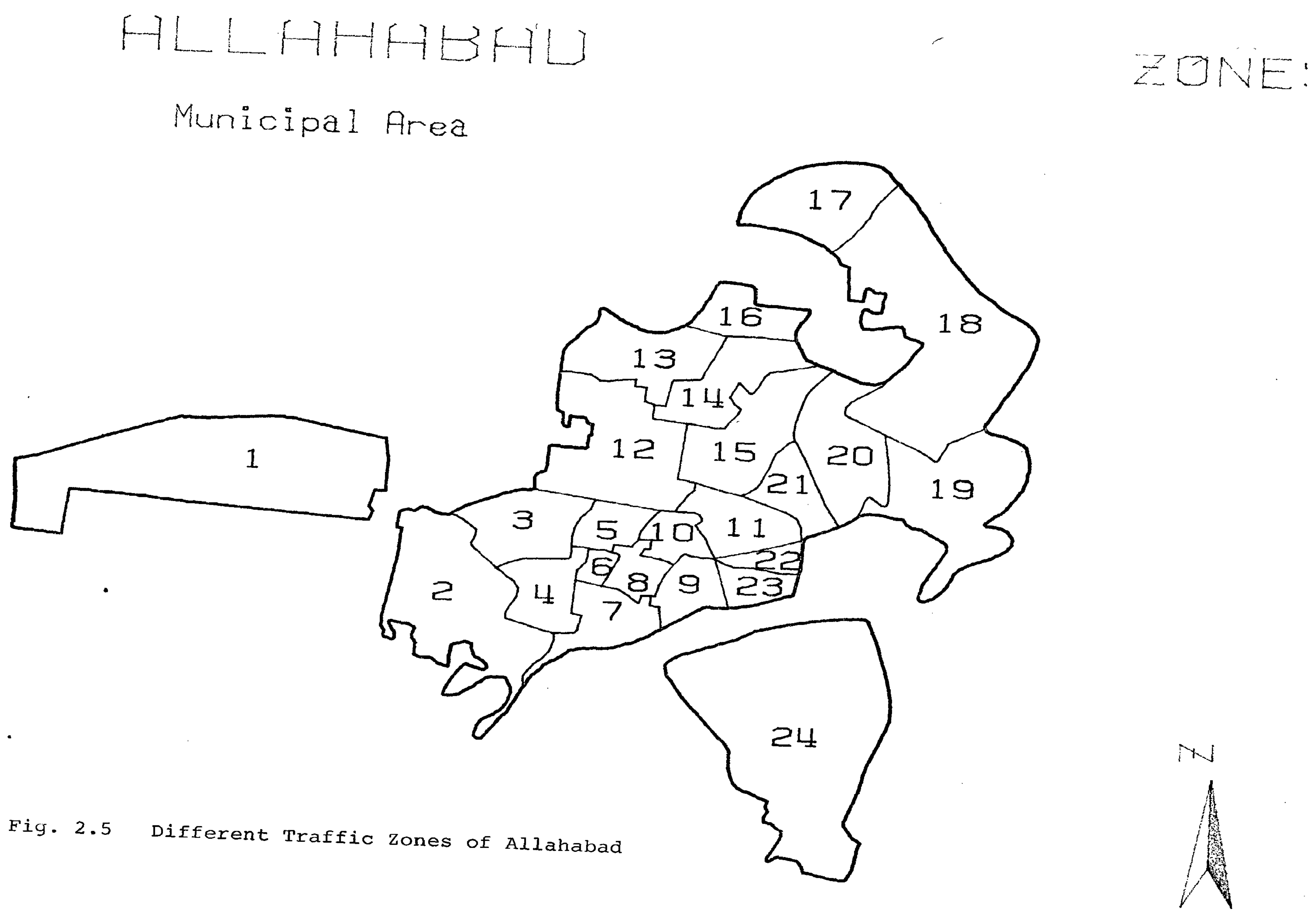

Fig. 2.5 Different Traffic Zones of Allahabad

3. REVIEW OF LAND-USE TRANSPORT MODELS

3.1 INTRODUCTION :

A model is a simplified abstraction of reality. It is used to gain conceptual clarity, to reduce the variety and complexity of the real world, to a level where the process can be understood and clearly specified. It is valuable in the sense that behaviour of a system can be simulated in the circumstance when it is not possible to construct or experiment with a real world situation.

Models are of two types, i.e. physical models and abstract models. Physical models are more easily understood and with which most people are familiar. These models are scaled objects, (usually scaled down) which are tested under different conditions that arise in reality.e.g. models of multistoried building, cooling towers, dams etc. are tested in laboratory which helps in predicting the behaviour of actual structure.

Abstract models, are the ones in which a real world situation is represented by mathematical relationship rather than by physical objects. In this type of models real processes or behaviours are simplified to manageable proportions.These are normally the relationships among different stimulus and response variables in a generalized form. In short it can be stated that all models generate systematic way of understanding to unfold intricate relationship in natural and man made systems.

This type of models are very useful in urban planning field, where urban behaviour and functional relationships are to be established. As cities can be thought of as interrelated collection of individuals and organizations. The individuals create demand for residence, forms, shopping and recreational facilities and these needs are supplied by a variety of private enterprises and public institutions.These two component of urban structure are bound together by flow of people, goods, money and information. This whole structure can be referred as an urban system and each component of it as subsystem. Such a system is very complex and dynamic, as system behaviour keeps on changing with time.

3.2 Role of Models In Planning Process:

According to Chadwick(*) :-

> "Planning is a conceptual general system. By creating a conceptual system independent of but corresponding to, the real world system, we can seek to understand the phenomenon of change. Then to anticipate them and finally evaluate them to concern over-selves with the optimization of the conceptual system".

There are many attempts made to identify a structure for the problem solving process in planning field. Patrick

* CHADWIK, G., A Systems View Of Planning, Pergamon Press

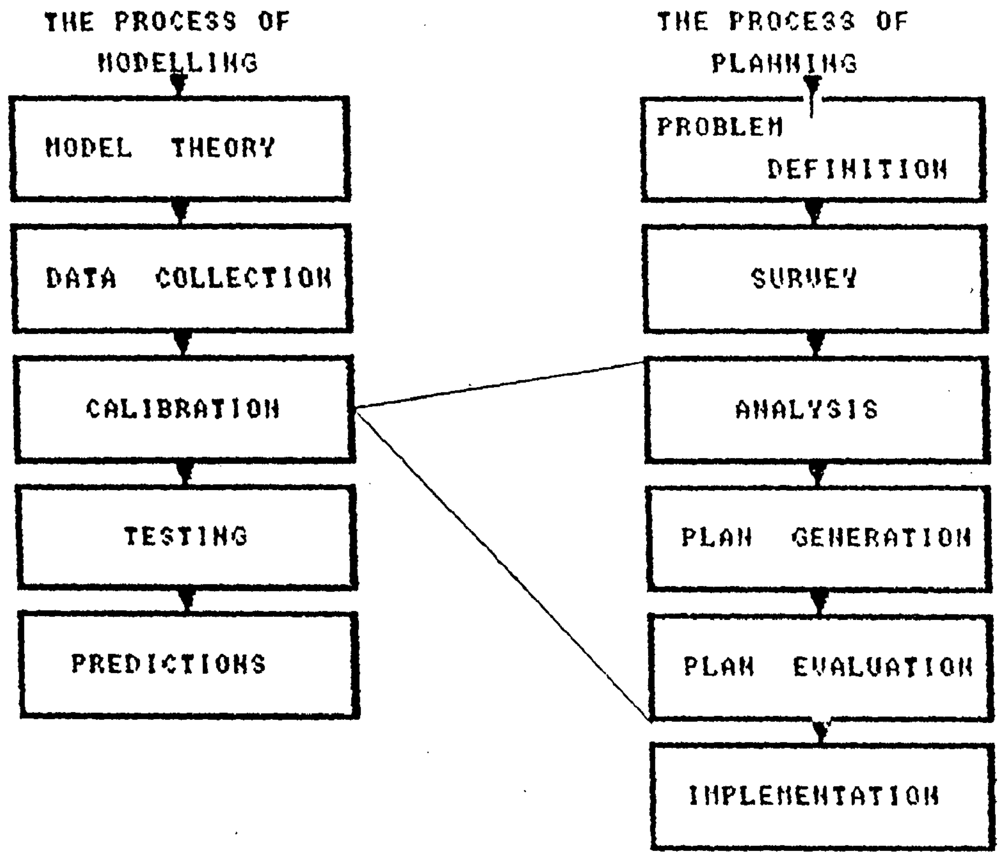

FIG.3.1 DIFFERENCE BETWEEN PLANNING PROCESS AND MODELLING

Good descriptive models are of scientific value because they reveal much about the structure of the urban environment, reducing the apparent complexity of the observed world to the coherent and rigorous language of mathematical relationships. For example the data for household income is difficult to collect and therefore a descriptive model can be used. It has been found that household income depends upon the other measurable variables. So a simple model can be made as

$$In = a + b\ Rn + C\ Zn$$

In - average household income in a zone 'n'

Rn - average rateable value of residential properties in zone 'n'

Zn - average household size in zone 'n'.

a,b,c are constants to be determined empirically.

This model cannot be used for forecasting as an average rateable value of residential properties in a zone is subject to planning policies and changes from time to time. Also, the average household size will change (may be due to extension of education, increase in working women etc.) with time. Thus, this relationship will distort with time, and hence, this model is a good descriptive one but not a predictive model.

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Predictive models are required to simulate future situations although they operate in the same way. Only those relationships which can be expected to remain reasonably stable over time should be used in forecasting models and it should be constructed so that cause and effect phenomenon are reliable. It might be found that there is a reciprocal relationship between car ownership and infant mortality, but it is not reliable relationship and can not be used in predictions, instead relationship between household income and car ownership is reliable relationship and can be used in forecasting. In forecasting, income plays the role of cause and the car ownership the effect. Where the cause and effect can not be clearly separated because of high interaction, between the variables, the results must be interpreted with a great deal of caution.

Planning models are extension to forecasting models. The difference is that they not simply tell us what is likely to happen as a result of certain assumption, but to tell the range of performance that is possible in relation to defined objectives. It means that planning models have a built in certain constraints and goals. The model might be designed to produce the plan which has the least capital cost, or which keeps the journeys to work at a minimum. It might have constraints built into it about the density of development to be allowed, about the location of certain kind of activities, the amount of traffic to be generated within a given area or about the maximum length of journey to work that can be permitted. The output of this kind of model is very much a reflection of what the planner thinks desirable rather than a simple projection of natural forces, and is the most useful type of models.

As a mathematical model represents the behaviour of a real world system by symbols and numbers, if we alter the inputs according to the some policy, we can see the affects of the policy. Computer aided models within the planning process are not just a black box approach to planning, in which the analyst feeds information and obtains a series of alternatives and details of cost and effectiveness of each alternative. The application of models to planning is not intended to replace expert judgment. It attempts to provide a systematic approach which help the decision maker to choose a course of action by investigating his problem, searching out alternatives, comparing them and choosing the best among them to fruitful and desired objective.

However, there are certain limitation in the use of models in planning. Generally, the limitations are due to inadequate understanding of the real world system and how to represent and manipulate it with the help of computer. The limitations are also imposed by the data requirement of a model. Generally, data requirement is so large and disaggregate that special surveys have to conducted.

3.3 Classification Of Models :

Classification is done according to the issues based upon, the substantive issues and issues reflecting the techniques and style of modelling. With regard to substantive issue distinction can be made between partial and general model, optimizing and non optimizing, micro and macro and static and dynamic models.

3.3.1 Partial And General Models

Partial models are those which simulate one subsystem of a system and general models are those which simulate more than one subsystem of a system.

3.3.2 Optimizing And Non-Optimizing Models

The model which locate activities in an non optimizing way is called non optimizing model. Most of the models fall under this category. But certain models which attempt to simulate optimizing certain activities, are optimizing models.

3.3.3 Micro And Macro Models

Models are micro or macro are connontated on the basis of aggregation of activities not on the basis of the spatial dimension under study. The micro urban models involve theories attempting to explain the behaviour of individuals where as macro models deal with groups, institutions or larger aggregations of activity. This is a useful indicator as to the amount of data required for calibration of an urban model.

3.3.4 STATIC AND DYNAMIC MODELS

When a model describe the structure of the system at one cross section of time it is static. Most of the models used in planning are of static type. But some models incorporate the time component in its structure. This type of models are dynamic models. These are more rational than static one as they use time series data of the phenomena modelled.

3.3.5 LINEAR AND NONLINEAR MODELS

Design issues of urban modelling mainly involve technical factors converting the mathematics formulation and solution procedures used. On this basis, generally, models are classified as linear or nonlinear models. Statically based regression models are linear in contrast to the intrinsic non-linearity of gravity type models.

Classification according to solution procedure can be made as analytic or simulation procedure. Analytic solution procedure do not require any form of iteration and the results are directly obtained by solving equations. But in simulation process solution is obtained gradually after a number of iterations. Mostly, models are solved by simulation process harnessing the efficiency of computers.

that "The law which governed matter in all its forms, whether that of coal, clay, iron , pebble, stone, tree, oxen, horses or men, is the same." He formulated the gravity model stating that " Gravitation is here in human society as everywhere else in the material world, in the direct ratio of the mass of cities and inverse ratio of the distance." Ravenstein (1885) formulated the first model of migration following the analogy of Carey. Then comes the retail location models by Reilly (1931). This model do not predict the location of shopping centers by the flows of people from certain origins to a given destination. Thus ,this includes only transport component in it. Hansen and Lakshmanan market potential model (1965), is based on the same concept. This treats explicitly the flows of money between one origin and destination. Model can be expressed as :

$$S_{ij} = P_i \, G_i \, \frac{A_j^{\alpha} \, d_{ij}^{-\beta}}{\sum_{n} A_j^{\alpha} \, d_{ij}^{-\beta}}$$

S_{ij} — flow of money between zone i and zone j

P_i population of zone i

G_i mean expenditure per person in zone i

A_j attraction of place j

d_{ij} distance between i and j

α β parameter to be determined at calibration

Hansen(1859), developed accessibility model based on gravity concept. Lowry (1964) used this concept in the development of model of a metropolis for Pittsburgh. This model is later dealt in detail.

3.4.2 PENN-JERSEY MODEL :

This model was originally designed to simulate the locational behaviour of different house types in the Penn-Jersey Transportation study. This was abandoned by that study in favour of other approaches but its development was resumed at the Institute of Environmental Studies, University of Pennsylvania. Originally it included all activities and their distribution to be simulated over a set of time period in such a way that their distribution was sensitive to changes in the transportation network. But of enormous data requirement and conceptual difficulties as well, all residential activities were dropped and treated exogenously, and the development of model concentrated on the simulation of residential location . This model falls in the category of partial, optimal and linear model. It simulates the residential location based on economic theory that individual household tends to maximize their local advantage and at the same time land is allocated to that group of households which can pay the highest price for it. The equilibrium location of household is based on maximization of satisfaction which is generated within the constraints imposed by their budgets.

Linear programming techniques were used to make the model operational.

TREATMENT OF TIME:

Regarding the time, it is quasi-dynamic model. The total relevant period is subdivided into a number of short iterative periods. To avoid complexity and at the same time to obtain proper interaction among land-user, a period of one year is taken. In this iterative period, the number of households are located and the land expected to be available for residential use is forecasted exogenously.

DATA REQUIREMENT

This model is probably one of the models that require large amounts of data. Households are classified by incomes, pattern of consumption preferences and patterns of daily movement, an inventory of all residential sites in the region grouped into districts such that sites within a given district are homogeneous with respect to size of lot, type and quality of structure and neighbourhood amenities. Also, for each district, accessibility to alternative destination sets must be calculated.

MODEL FROM

The model attempt to maximize total savings in locational rents subjected to constraints. First constraint is the availability of land. Second is that all the

~~projected~~ household groups should be located even though some household groups have negative or zero rent paying ability.

All the above things can be expressed in the mathematical form as :

$$\text{Maximize} \quad Z = \sum_{k} \sum_{i} \sum_{h} X_{ih}(b_{ih} - c^{k}_{ih})$$

Constraints are

$$\sum_{i} \sum_{h} s_{ih} X^{k}_{ih} \leq L^{k}$$

i.e availability of land constraint

$$\sum_{k} \sum_{h} X^{k}_{ih} = N_{i}$$

and for all $X^{k}_{ih} \geq 0$

X^{k}_{ih} — households of group i using residential accommodation type h in zone k .

b_{ih} — residential budget of household group i using residential accommodation type h

c^{k}_{ih} — cost to a household of group i using residential accommodation type h in zone k

s_{ih} — land for household group i using residental accommodation type h

L^{k} — total land in zone k

N_{i} — total number of households group i

COMMENTS

This model requires a large amount of data which is impossible to get without special survey. Also, it does not give transport element which is required for the work.

Calibration of this model is a tedious job. However, there is no doubt that the builder of this model had good insight of urban phenomena.

3.4.3 EMPIRIC MODEL

It is formulated by Donald M. Hill for the Boston Regional Planning Project in order to develop a comprehensive development plan for the greater Boston Region (USA, 1965). It falls under the category of general, linear and non optimal. It is designed to distribute or allocate externally supplied growth forecasts of activities such as population and employment among the zones. This process of allocation takes place as local changes occur in the quality of public services and transportation networks as well as changes over time in activity total.

TREATMENT OF TIME

Regarding the time factor it is also a quasi dynamic model. It is operated recursively in a series of short steps, where each step depends upon the results of previous steps.

DATA REQUIREMENTS

It requires data of population classified in two categories.

- White collar population

and data of employment in three categories

- Retail and wholesale employment
- Manufacturing employment
- All other employment

MODEL FORM

"The concept of this model is that development pattern of urban activities are interrelated in a systematic manner which provides a reasonable basis for their prediction" (Benjamin Reif 1973). The model theory can be expressed by the following equation :

$$R_i = \sum_j a_{ij} R_j + \sum_K b_{ik} (Z_k \text{ or } \Delta Z_k)$$

i,j = 1,2 ....N number of located variables (i.e. variables to be located by the model e.g.population and employment)

K = 1,2 ....M number of locator variables (i.e. variables whose presence or absence influence the amount of one or more located variables in each zone, such as accessibility, sewage facilities etc.)

R_i or ΔR_j is the change in ther level of i or j th located variable over the calibration or forecast trend

Z_k - level of locator variable at the beginning of calibration or forecast time interval.

ΔZ_k - change in the level of locator variable at the beginning of calibration or forecast time interval.

a_{ij}, b_{ij} - coefficients expressing the interaction ships among variables.

Comments

In this model future population and employment are exogenous variable. It also requires the environmental changes of the area during the forecast period. Data required for this model is at disaggreate level which can not be get through secondary sourses.

3.4.4 Lowry Model

Lowry model was made as a part of study of the Pittsburgh region and consisted of a series of equations. It falls under the category of general, nonlinear and non optimal models. Equations are used for allocating and generating land-use activities.

Treatment Of Time

Regarding the time factor, it is static. It simulates the pattern of total development and the associated service centers within the area under study, at a particular point in time.

Data Requirement

is an exogenous variable. It can be derived from a given land-use with it's intensity.e.g. If the land-use of a place is office, it's area is A and intensity is K persons per unit area. Then total employee will be K X A. In The same manner employment for other land-uses can be derived. The intensity of use is fixed on some policy. It may be fixed by Development Authorities or by Town and Country Planning Department. From this Basic employment population can be derived by multiplying by Total employment by the population employment ratio of the area under consideration (i.e. average household size or inverse activity rate). This population will need service. Service employment can be derived by multiplying by ratio of service employment to population (average labour participation rate). This service employees will again generate population by the factor, inverse activity rate and this increased population will again generate service employment. This process continues until the increment of service employment is within reasonable limit. Fig.(3.2) shows the functional structure of Lowry model.

The allocation of employees to residences and service employment to employment zones is done according to residential allocation function and service/retail allocation function (described in section 4.3.1 and 4.3.2). This interaction between the basic employment, population and service employment is given in the form of origin destination

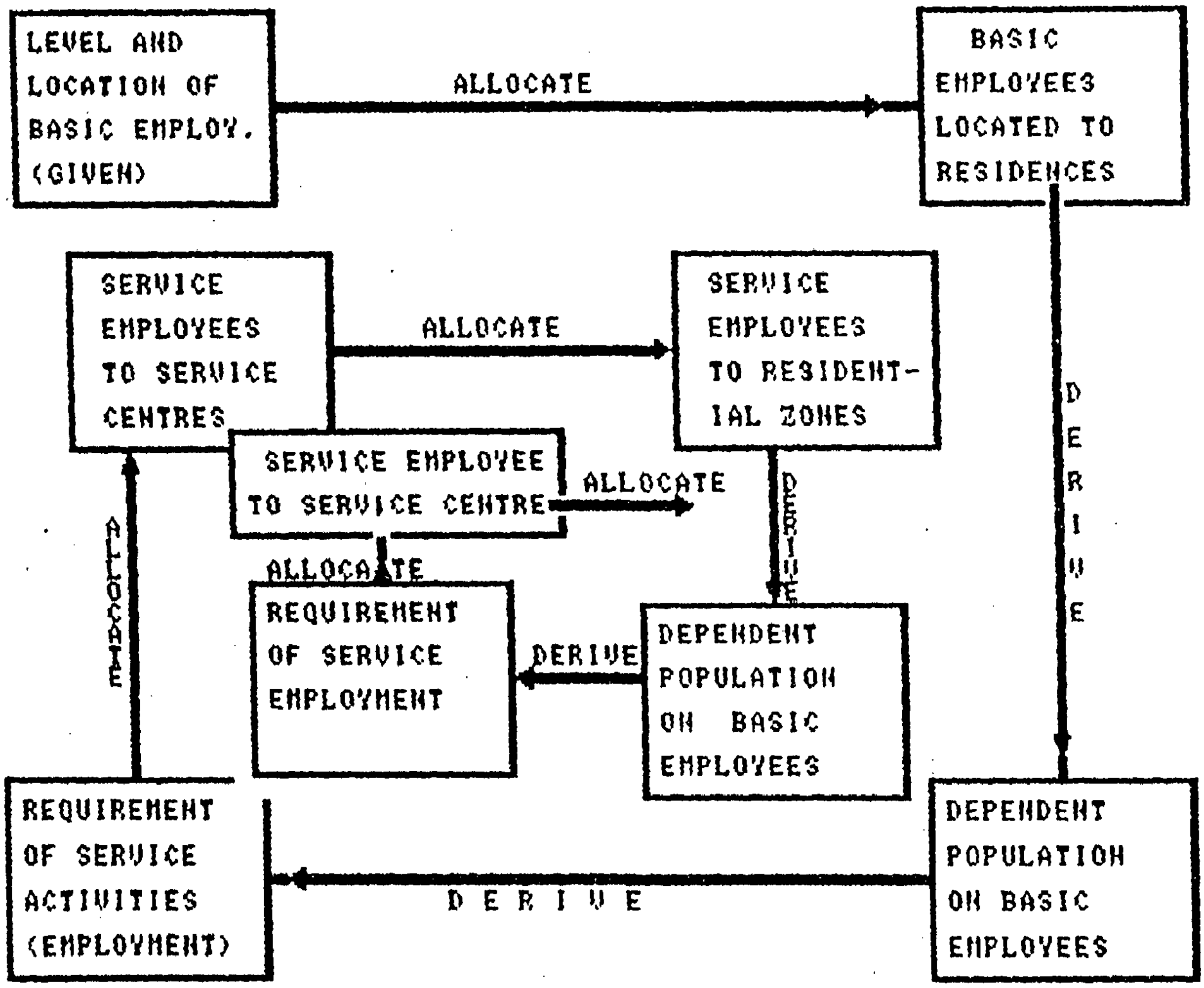

FIG.3.2 FUNCTIONAL STRUCTURE OF LOWRY MODEL

matrix. This matrix tells the desire pattern of the area. This is the Transport element of land-use which is given by the model. Desire pattern gives an idea about the loads on various links. However, trips can further be assigned to the network to and the adequacy of network can be checked.

COMMENTS

This model is perhaps the only operational model which requires the least data. This also gives the transport component related to the land-use showing the interaction among various zones. This type of model has been widely applied for practical cases in U.K and U.S.A.

4. SELECTION OF MODEL AND MODEL DEVELOPMENT

4.1 Selection of Model :

Lowry model has been selected from those reviewed in previous chapter. The most important consideration for its selection has been the nature of data available for the study. The data required for the model was available from secondary sources, thus, no special survey was needed for data collection. The other important reason for its selection was the fact that this model has the transport implication in the form of trip matrix or origin destination matrix relating to the land-uses of different zones, in the process of land use allocations. Thus, travel pattern and eventual traffic distribution in the network can be obtained to access the suitability of land use distribution. In a rigorous analysis, trips between different zones can be assigned to links and adequacy of links can be examined with respect to present and future demand for travel. Model for Allahabad was developed by calibrating the modelled values with observed data.

4.2 Data Required For The Model Calibration :

Data required for the model calibration are listed below

1. Population of different zones
2. Area of different zones and planning regulations on density and minimum levels of activities.
3. Basic employment of different zones

4. Service employment of different zones

5. Origin destination matrix

6. Inter zonal travel time matrix

All the above data must be collected at the same time i.e. the base year. In this study data was available for the base year 1987. All the data, listed above,were taken from the Allahabad Development Authority, Allahabad.

4.2.1 Population And Area of Zones

Population of different zones in 1987,was taken from Allahabad Development Authority. Area of different zones has also been taken from the same source. Zones have been delineated by the same authority for conducting transportation study. Zones were delineated to have uniform land use in a zone and zone boundaries confirming to natural/artificial barriers and administrative limits like wards boundaries. Population and density of different zones of base yearare shown in Fig. 4.1.

4.2.2 Basic And Service Employment

Basic and service sectors have been previously defined, in the discussion on Lowry model. These data have were collected through a special survey conducted by the Consulting Engineering Services, New Delhi, for Allahabad Transportation Study. These data are also of 1987. Population and employment of each zone of base year is shown in Fig. 4.2.

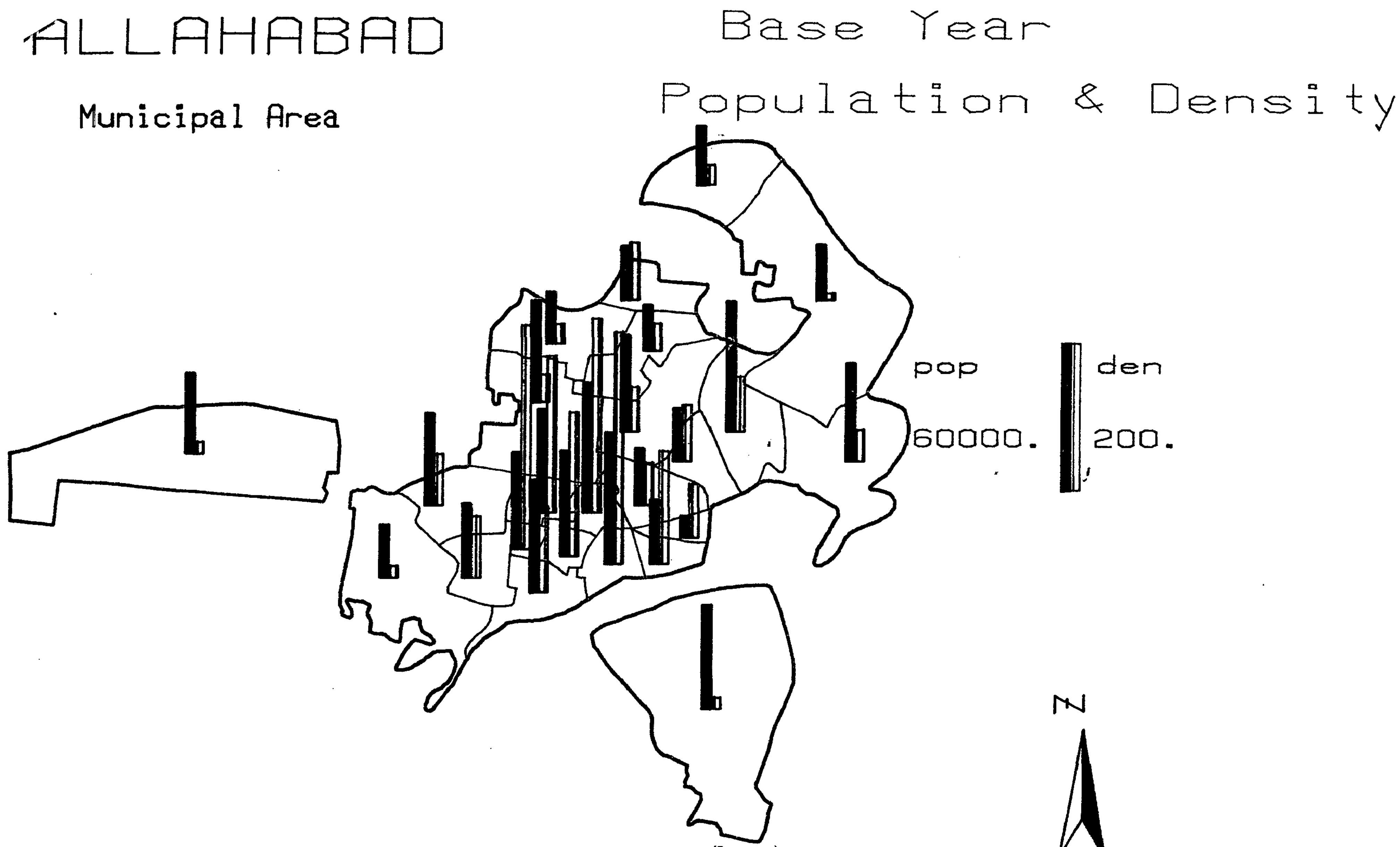

Fig. 4.2 Base Year Population & Density (Persons/Acre)

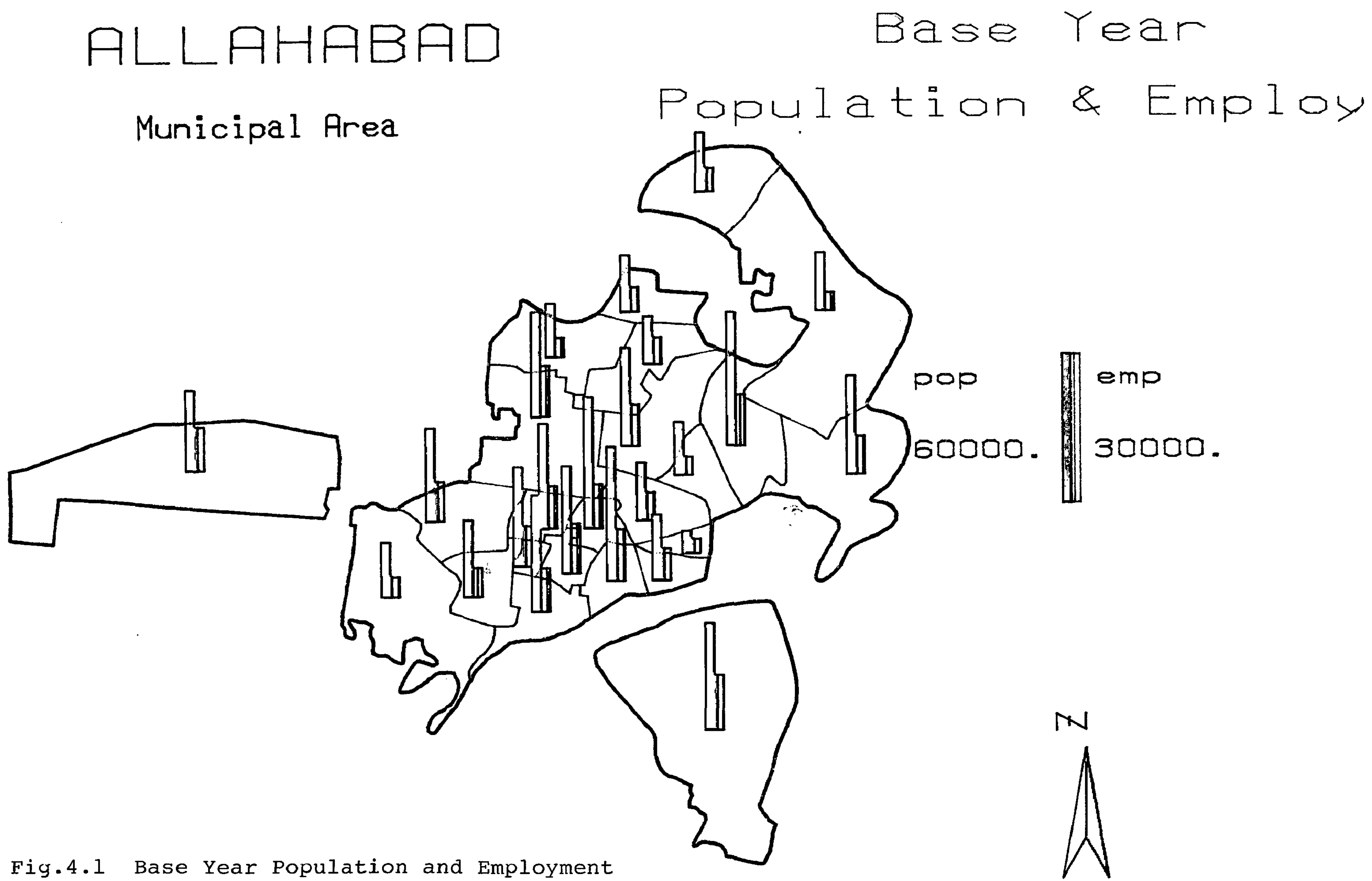

Fig.4.1 Base Year Population and Employment

4.2.3 Origin - Destination Matrix

The trip matrix shows the number of persons going from one zone to another for any purpose. Since the Allahabad city was divided into twenty four zones, a 24 x 24 matrix shows the persons trips from one zone to another. This origin destination matrix was for base year 1987 from the same source. This was the total trip matrix, which pertained to all purposes e.g.work trip, shopping trip, educational trip, recreational trip, etc. In medium size cities work and shopping/retail business trips may be in the range of 60 to 75 percent. Thus, 65 percent was assumed to be the share in this case.

4.2.4 Travel Time Matrix

The travel time matrix is normally the shortest path deterrence matrix to represent the resistance to travel. Using link data and shortest route algorithm the deterrence matrix can be computed. The travel time matrix derived by the Consulting Engineering Services, New Delhi which was available with the Allahabad Development Authority has been adopted for this study.

4.3 Model Calibration :

Lowry model is driven by basic employment alone. In the way of working it generates population and service employments. While allocating for residences and service travel component get generated in the form of trip matrix.

The two allocating functions are residential allocation and service allocation.

Residential Allocation Function

Person working in work zone i will choose his residence in residential zone j according to the function

$$T_{ij} = E_i \frac{P_j \, Exp(-\beta c_{ij})}{\sum_j P_j \, Exp(-\beta c_{ij})}$$

where

i-- work zone

j-- residential zone

T_{ij}-- Person working in zone i and living in zone j

E_i-- employment in work zone i

P_j-- population in residential zone j

c_{ij}-- travel time between zone i and j

β -- deterrence parameter to be determined at calibration.

Service Allocation Function

Summation of Tij over j will give the number of employed person living in a residential zone j. Multiplying this by the average household size will give the population of that zone. This population will need service. Multiplication of population of each zone with labour participation rate will give the number of people engaged in service sector and living in zone j. These people will go to work zones for employment. The number of persons living in zone j and working in zone i (for service) is allocated by the function

$$S_{ji} = Sep_j \frac{Se_i \, Exp\,(-\beta c_{ji})}{\sum_i Se_i Exp\,(-\beta c_{ji})}$$

where -

S_{ji} -- persons living in zone j and working in zone i

Sep_j -- service employment as predicted during residential location in work zone j.

Se_i -- service employment in zone i

It may be noted that same deterrence parameter has been adopted in both the allocation functions. This is primarily because both work and shopping/service trips were assumed to be equally sensitive to travel time due to nature of transport system existing in Allahabad. The calibration of the model would mean isolation of the best value of β so that model performance is satisfactory. The model performance in this case will be taken to be satisfactory if the trip matrix as well as population and employment vectors are closely reproduced by the model. Both the allocation functions are singly constrained entropy maximizing gravity models. The exponential deterrence function and the balancing mechanism makes the model intrinsically non-linear. Thus a direct estimation of parameter is not possible. The Lowry model works by generating population and service/retail employments in increments and this can be considered as model loops until the increments are too small to neglect. Each model iteration will have the whole set of loop in search for deterrence parameter. This mechanism is shown in Fig. (4.3) The cut off level of increment of employment was taken as 10. The allocation and generating loops of Lowry model were discussed in chapter 3.

The calibration of β (deterrence parameter) was done by Fibonacci Golden Section Search method. This is quite popular for the estimation of single parameter models. In this method search is made in the predetermined range. In this range at two values the values of function are calculated and compared. Now the range is reduced up to that value at which the function is smaller. This is done on the assumption of unimodality i.e. a function has only one peak. This process is shown in Fig. (4.4) . In the process of calibration the goodness of fit measure was the coefficient of determination. Best fit between three sets of data were sought through the calibration of trip .matrix, population and employment distribution.

4.4 Discussion On Calibration Results :

In fact Lowry model is not just a model, but a

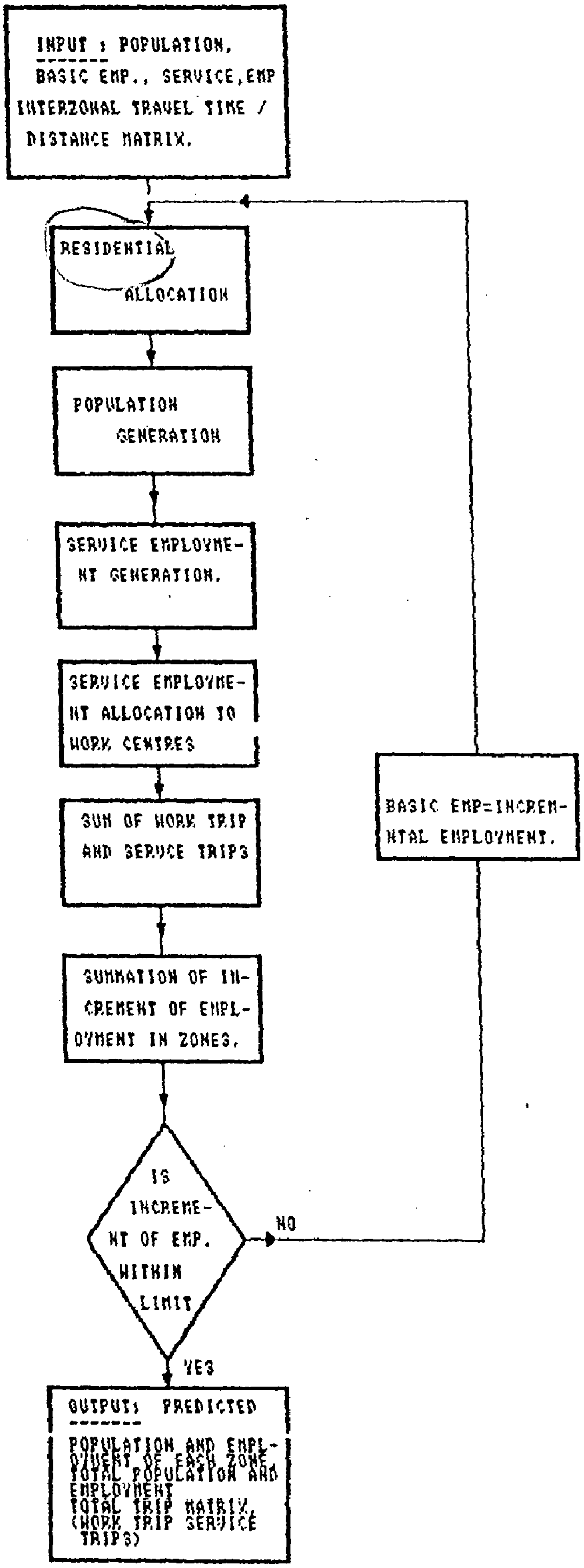

FIG.4.3 WORKING OF LOWRY MODEL

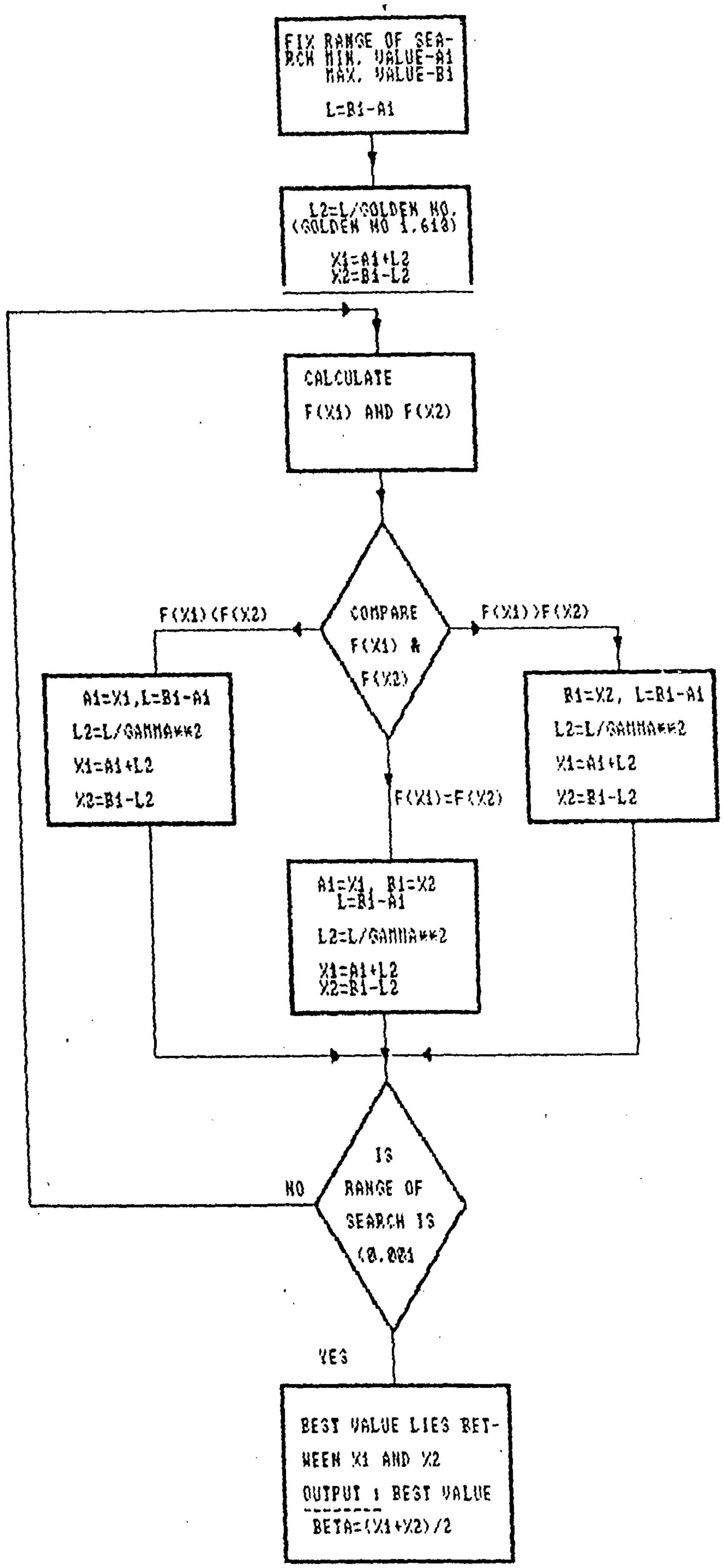

FIG.4.4 FLOW CHART OF GOLDEN SECTION SEARCH METHOD(CALIBRATION PROCESS)

system of models. The parameter β was calibrated as 0.032. This value of β i.e. travel parameter for Allahabad is very less which means that the people do not give much weight age to time of travel or distance among zones while choosing their residences. This reveals the fact that the city size is small (observed mean trip length 15.40 minutes). This is in contrary to the big cities where people choose to live near their work place. This gives an idea that there are some other factors which play role in deciding the residences and service centers. These factors may be the price of land, environmental quality of zones, floor area of retail shops, expenditure pattern of people, etc. The goodness of fit of the model was found in terms of following measures.

Coefficient of determination of

trip matrix	0.746
population	0.987
employment	0.886

The observed and modeled average trip length were 15.40 and 16.01minutes respectively. Coefficient of determination (R^2 value) with the observed trip matrix is low. The reason is the non-availability of the purpose wise trip matrix, i.e. work trip and service trip matrix and the model takes into account for the work trips and service trips only. Due to this reason the 35% of the total trips were sliced off and calibration made. 35% because in this type of city work trip and service trip account for about for 65% of the total trips. This sliced matrix do not give the actual pattern of trips but some representation of the actual trips is made. Due to this limitation of data a good correlation with the observed matrix could not be made. Fig. 4.5 to 4.10 shows the difference between observed and calibrated trips. For easy understanding trips of various range are compared. It is clear from the figures that small short trips are more closely reproduced than the longer trips by the model.

But the model calibrated for base year predict quite significantly the population and employment of each zones. High R^2 value with population and employment assures the good performance of model in predicting population and employment. Fig.4.11 and Fig. 4.12 shows the difference between base year population & modelled population and base year employment and modelled employment of each zone respectively. From the figures it is clear that population and employment of each zone are closely reproduced.

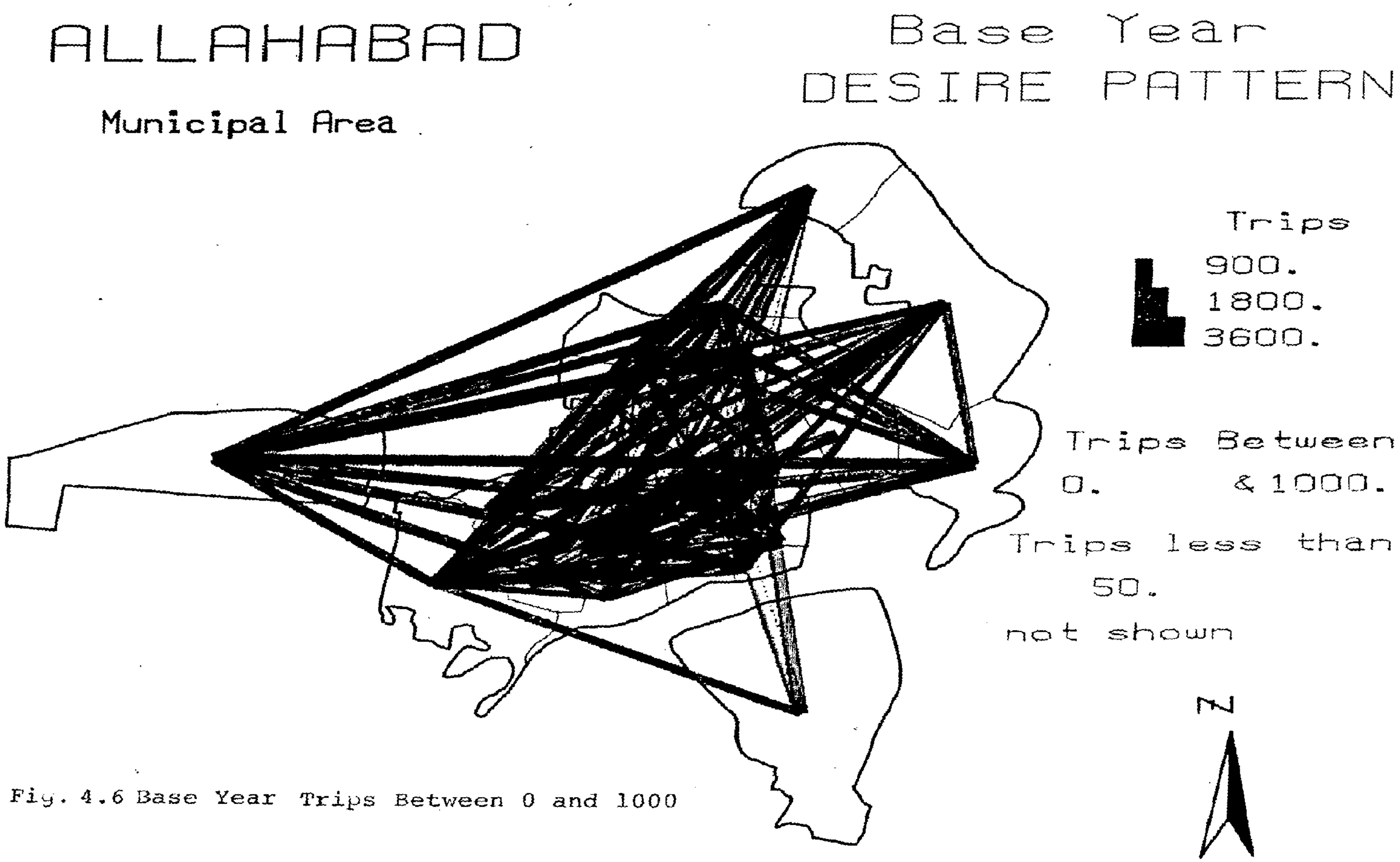

Fig. 4.6 Base Year Trips Between 0 and 1000

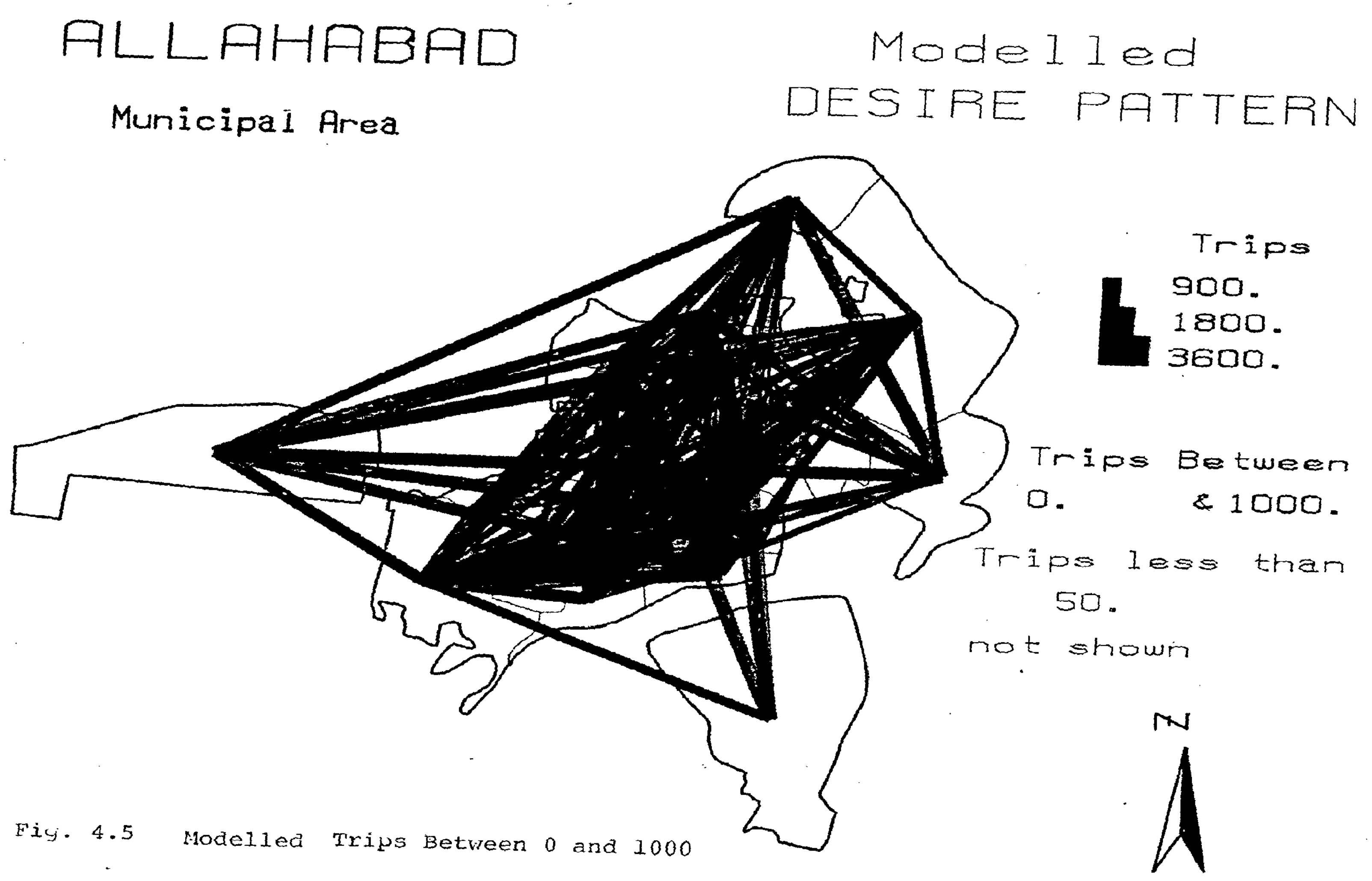

Fig. 4.5 Modelled Trips Between 0 and 1000

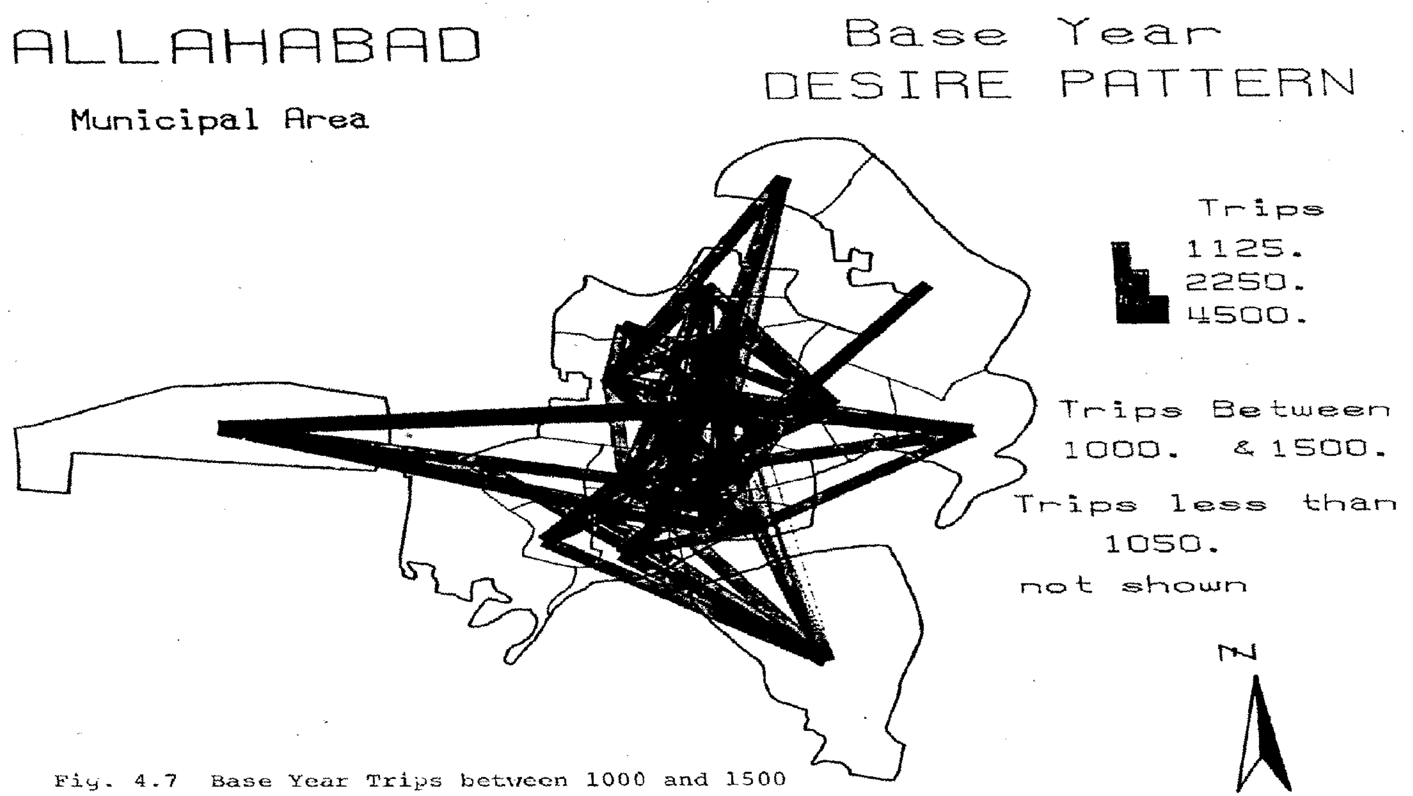

Fig. 4.7 Base Year Trips between 1000 and 1500

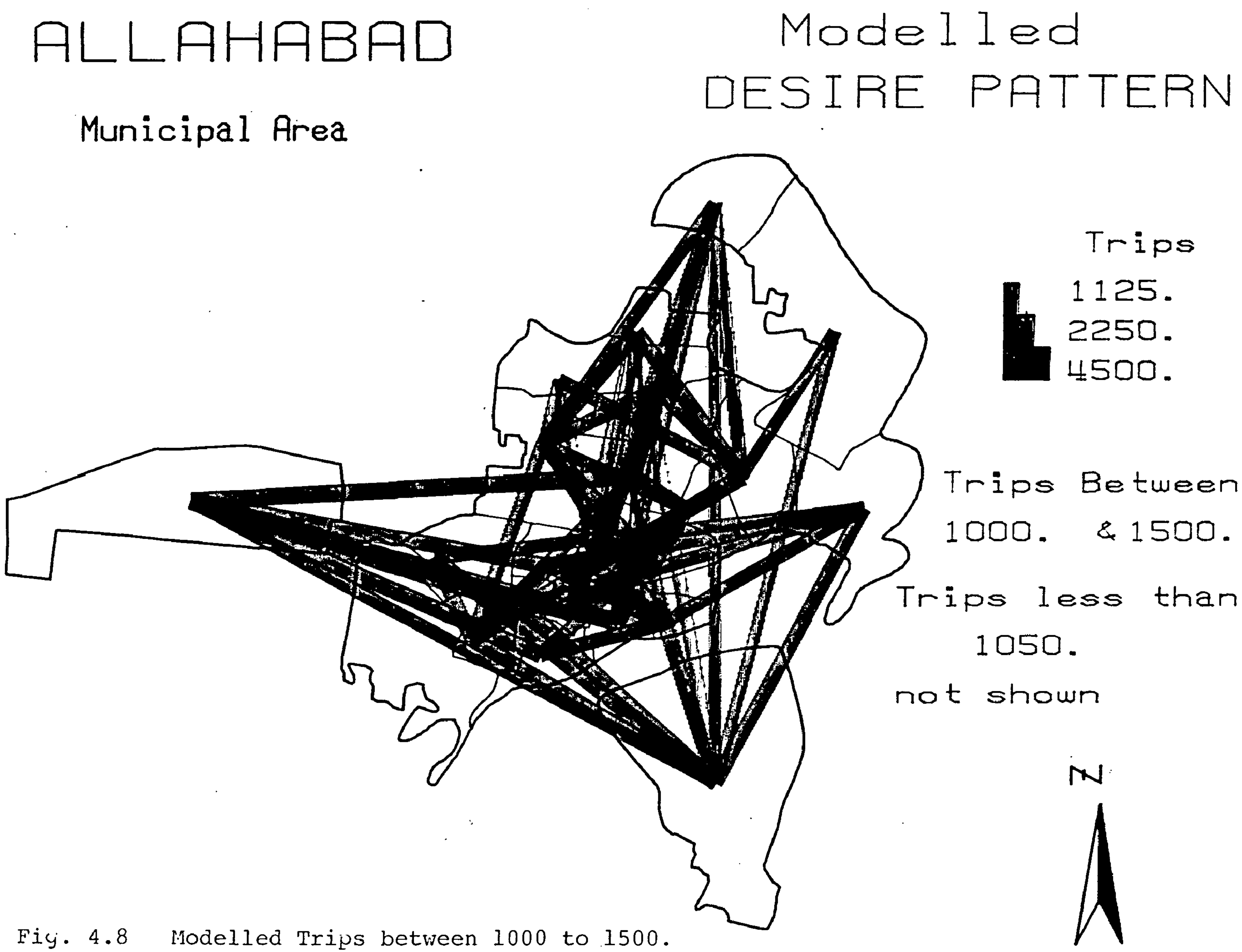

Fig. 4.8 Modelled Trips between 1000 to 1500.

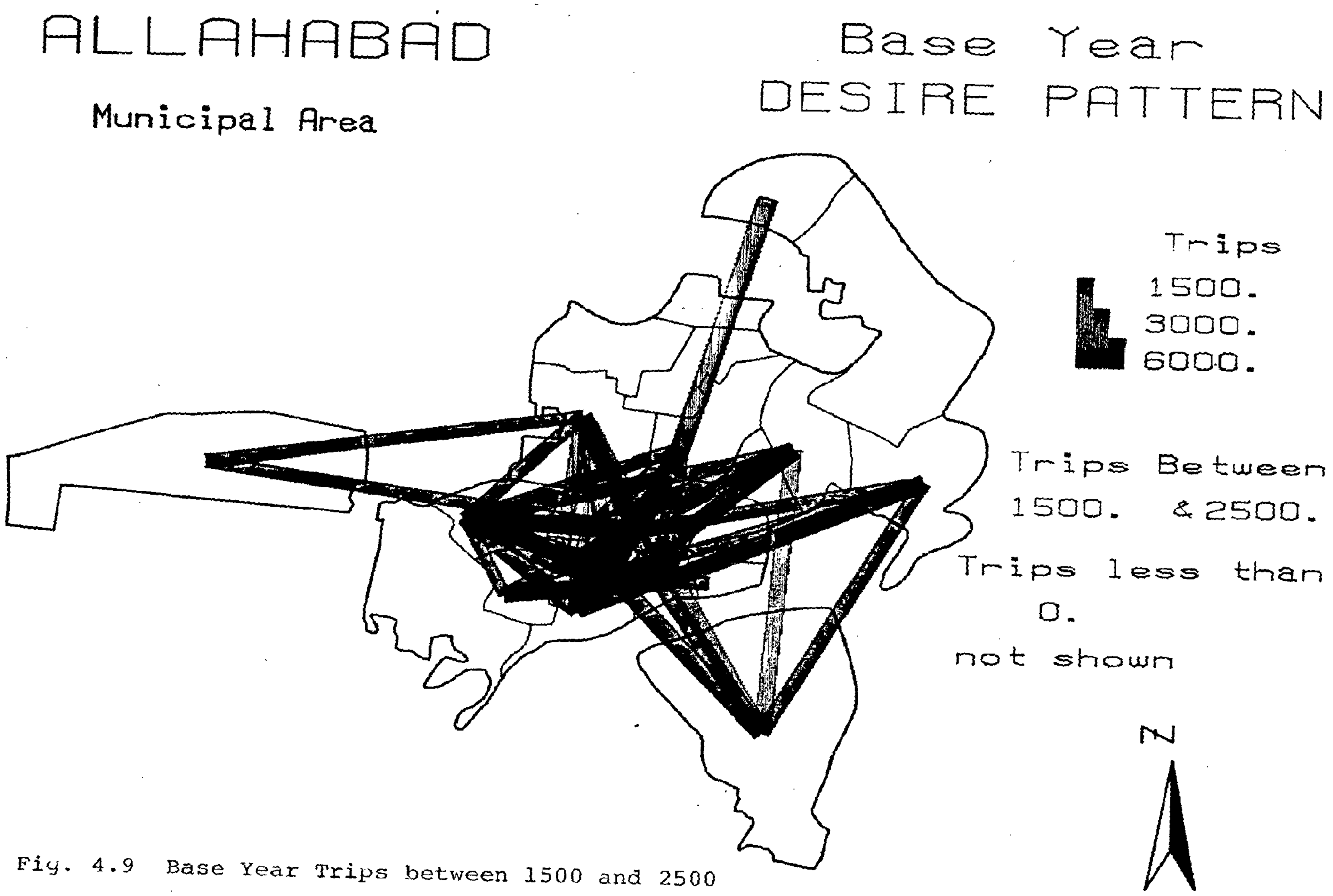

Fig. 4.9 Base Year Trips between 1500 and 2500

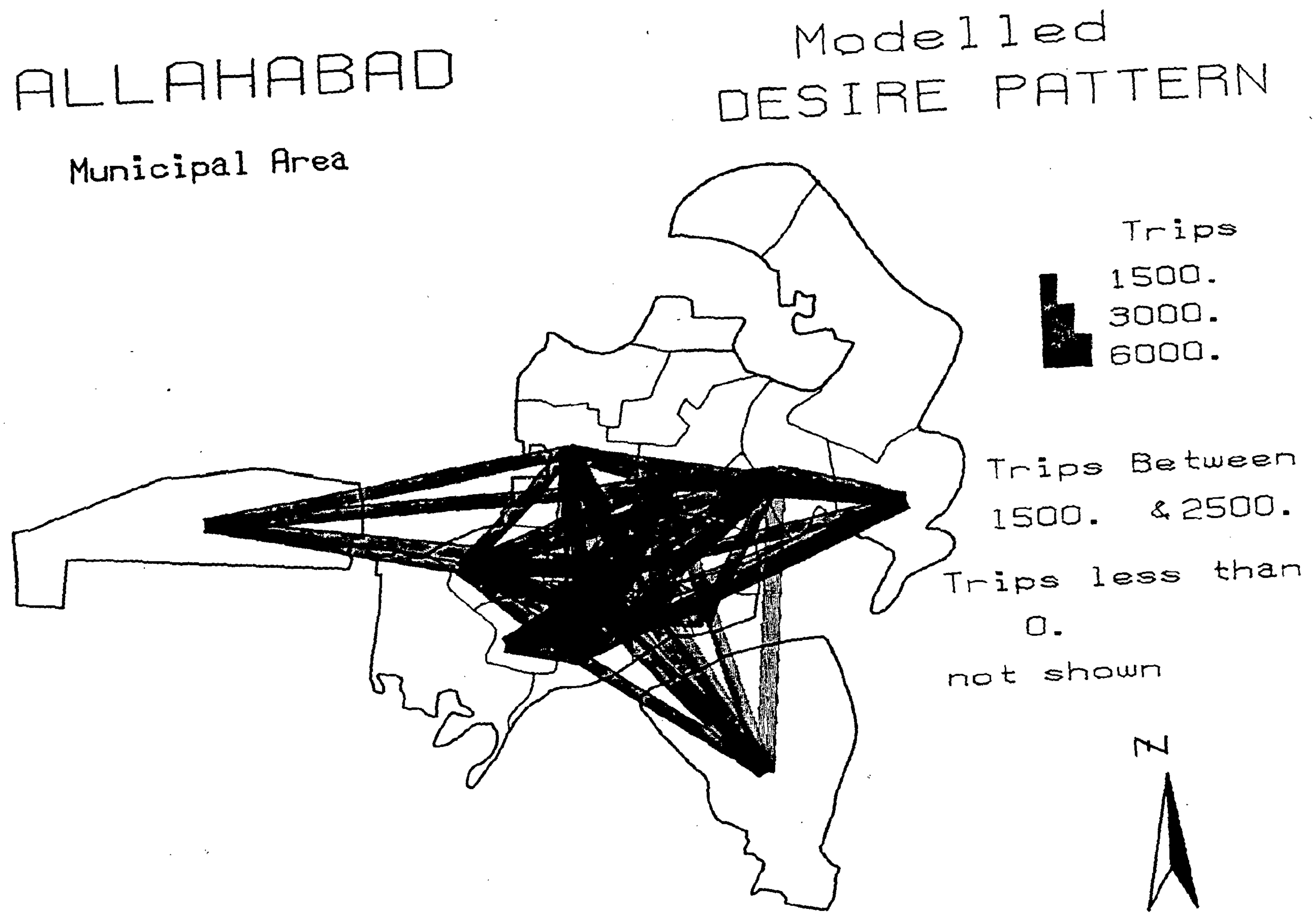

Fig.4.10 Modelled Trips between 1500 and 2500.

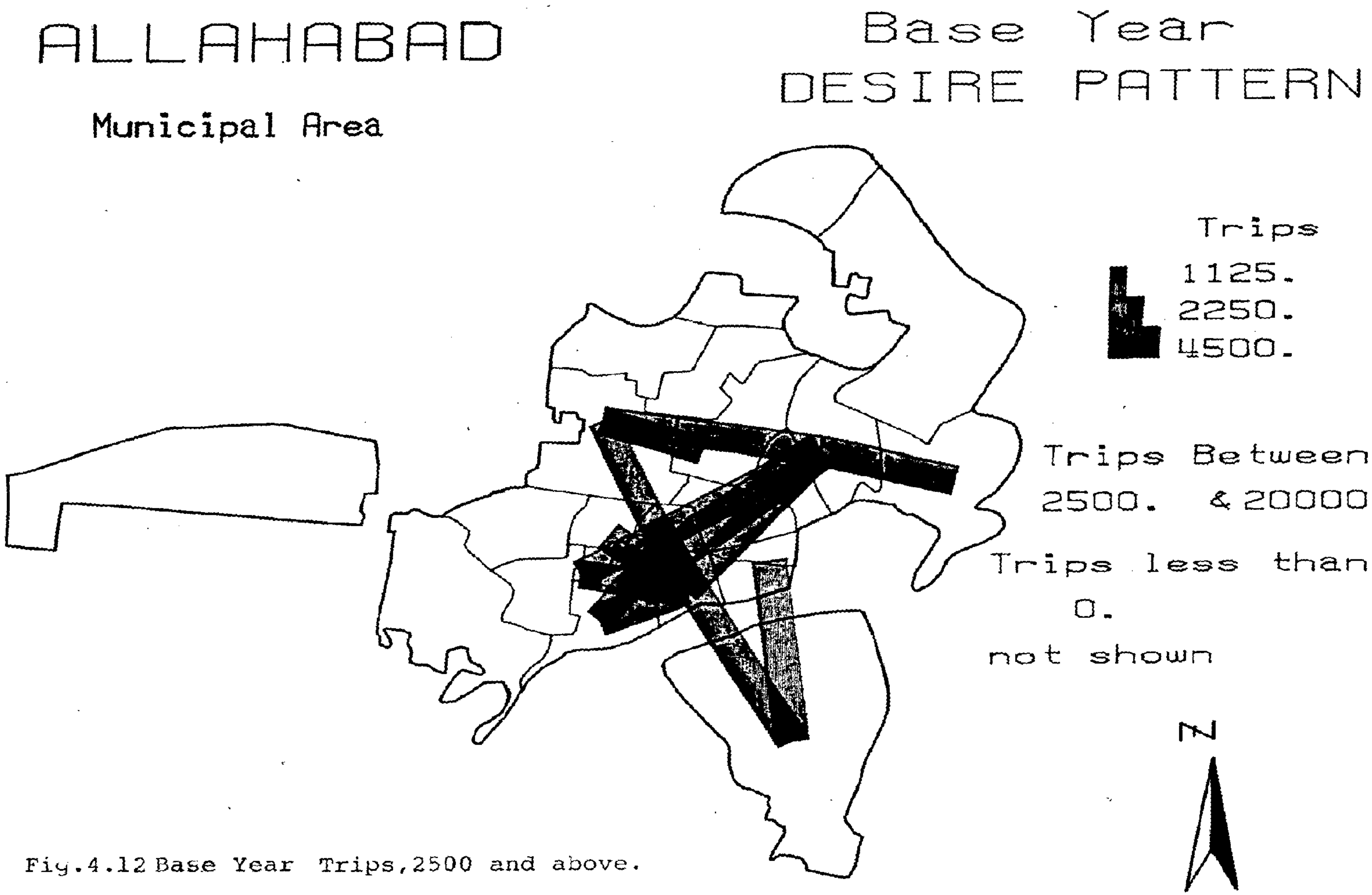

Fig.4.12 Base Year Trips,2500 and above.

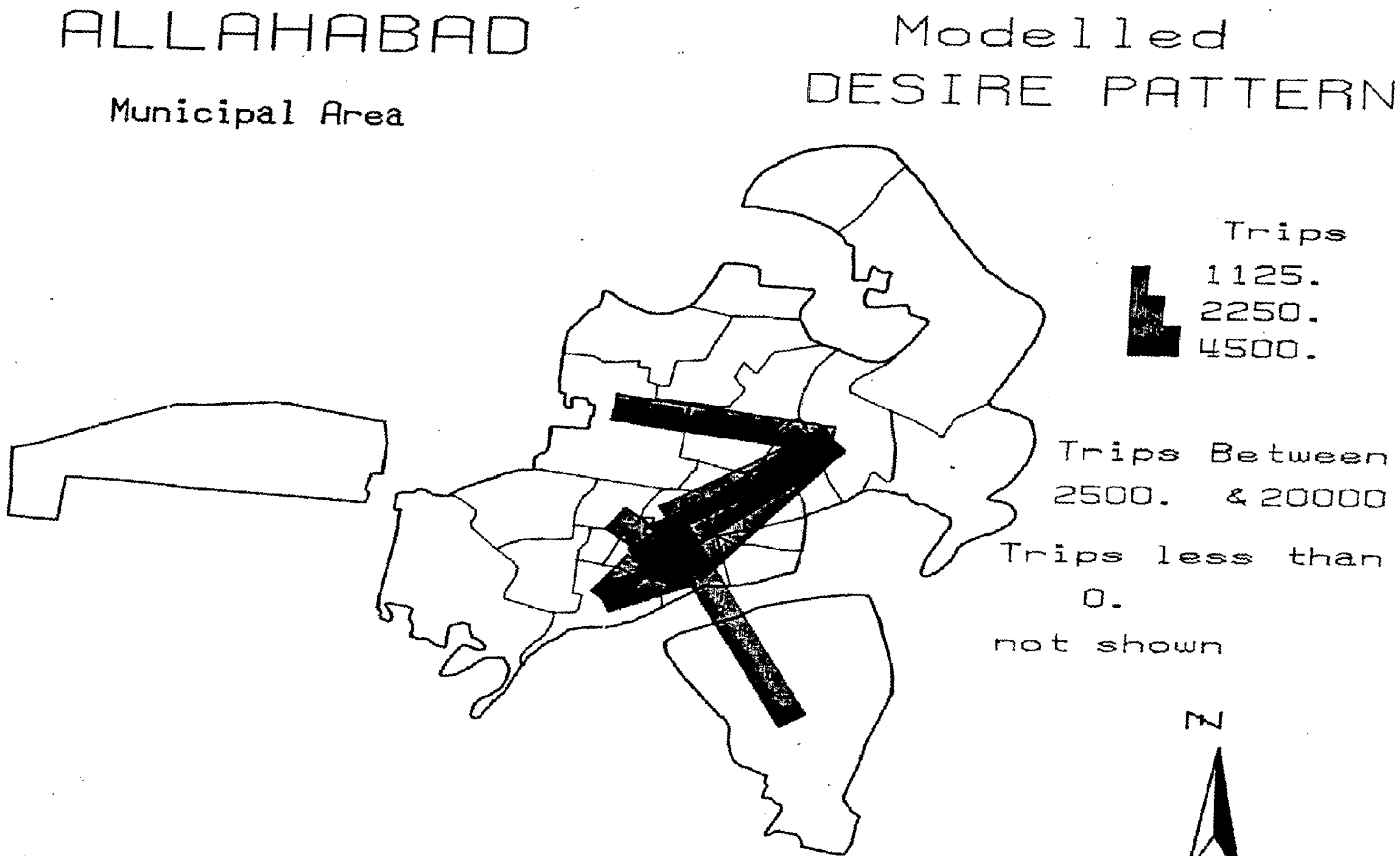

Fig.4.11 Modelled Trips, 2500 and above.

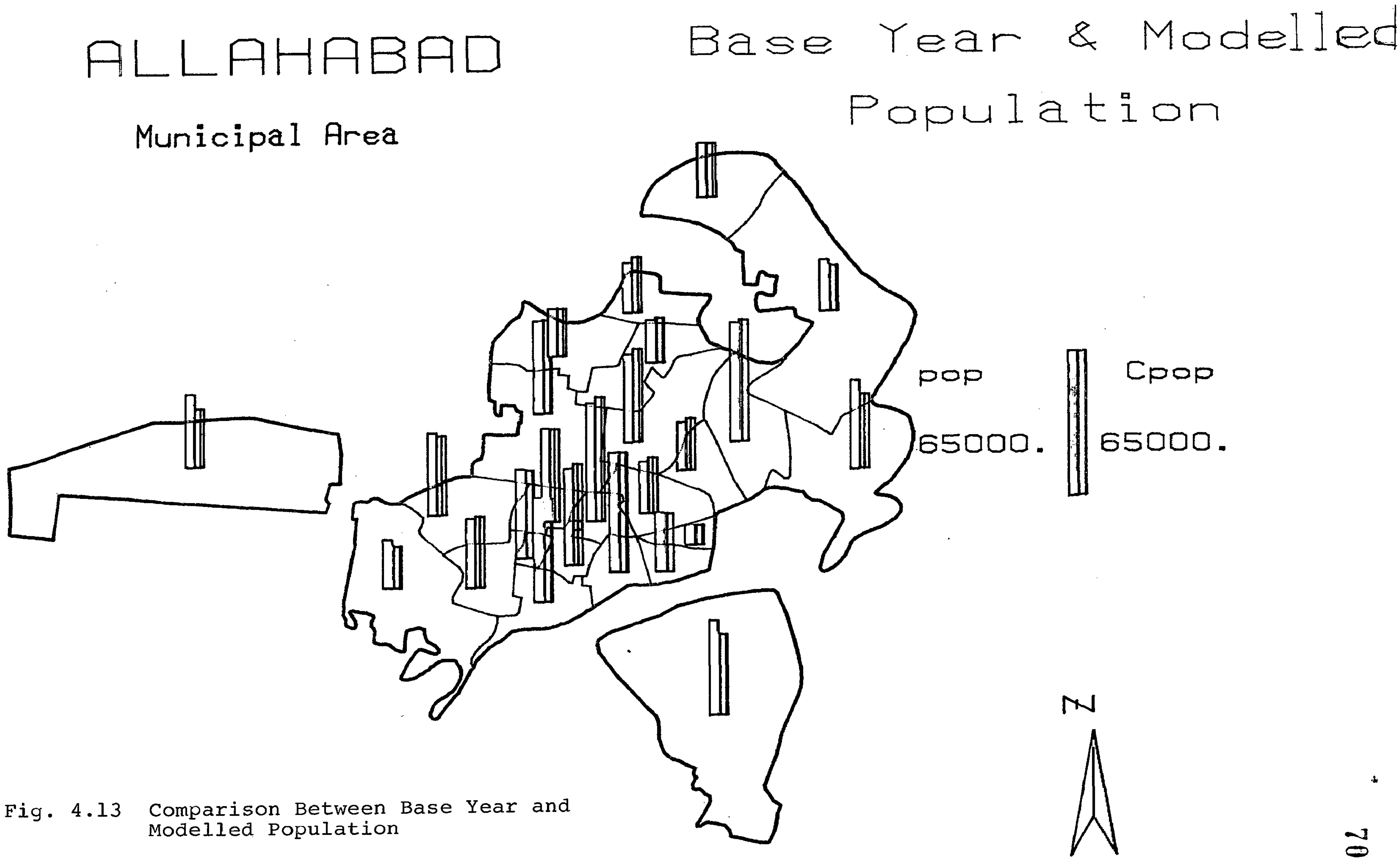

Fig. 4.13 Comparison Between Base Year and Modelled Population

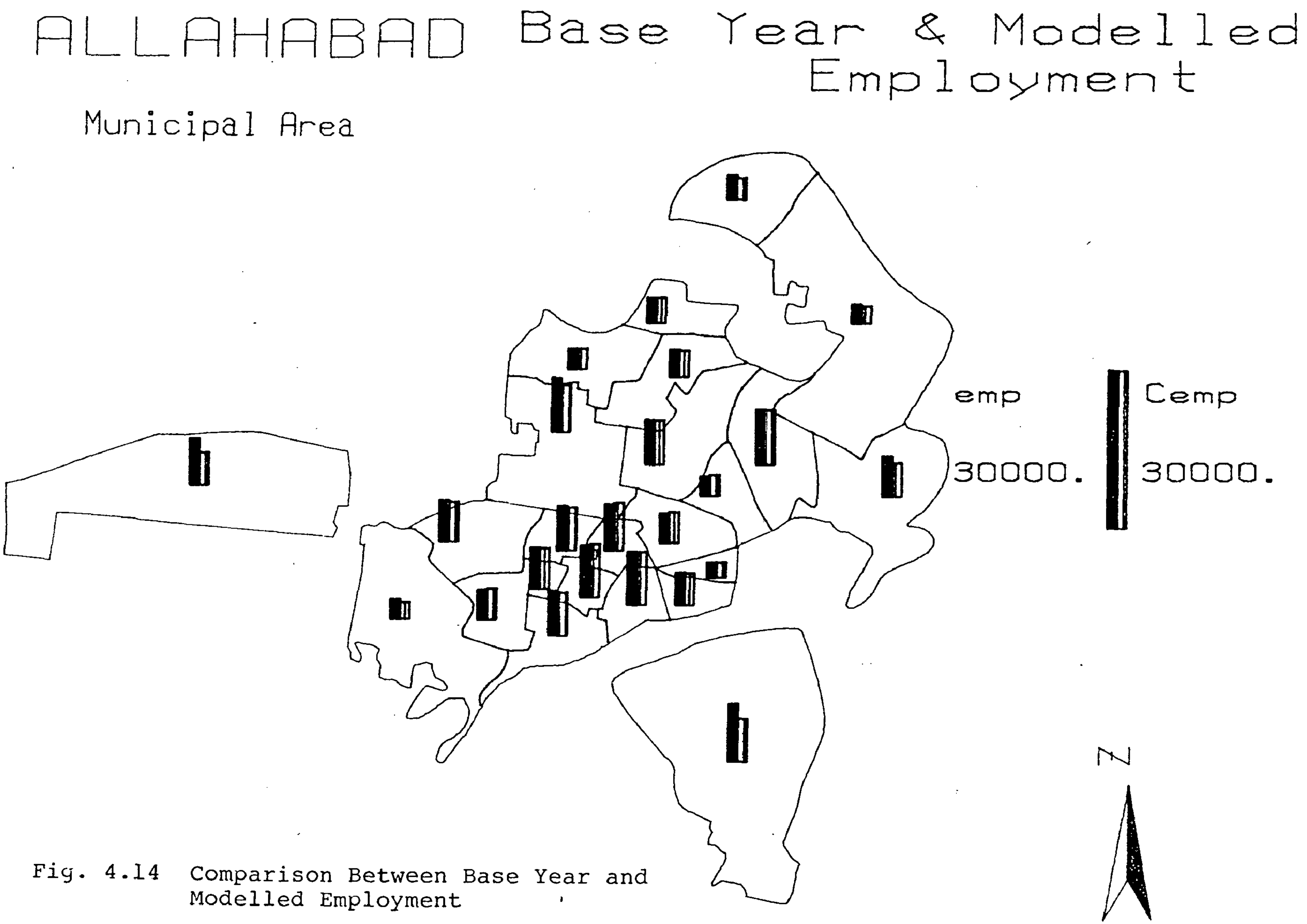

Fig. 4.14 Comparison Between Base Year and Modelled Employment

5. APPLICATION OF THE MODEL FOR ALLAHABAD

5.1 GENERAL :

The purpose of a model is normally for predicting for the future activities. The model as calibrated for the base year data can now be adopted for making forecasts to a horizon year. The assumption in such forecast is that the behaviour of the population in respect of choice for housing and service location will remain unchanged. However, in a land-use model the major emphasis being the intensity of use for the land, change in zoning laws and planning regulation / controls that can be foreseen in the future must be given due consideration. While the calibrated model used for generating loops for the allocation will remain unchanged with same or changed stopping rules.

5.2 DENSITY CONSTRAINTS:

For fixing the densities of different zones, first the existing density pattern was studied (Fig.5.1). It was seen that the central area was having very high density, around 250 persons per acre. The density decreases as the distance from the center increases, except at zone no. 12. This zone inspite of being very near to center has low density as 53 persons per acre. This is because of being very posh area of the city. Mostly there are bungalows for residences and all the major offices including High Court, Accountant General Office, Uttar Pradesh Educational Board, Police Head Quarters etc. Zone no. 1 & 24 inspite of having some big industries has very low population density. This is mainly because most of the area of these zones are under rural use i.e. agricultural, also there are much unusable land in these zones. Zone no. 13,17 and 18 also have the same characteristics but are located on the north eastern side of the city along the river Ganga. Fig.5.2 shows the major or dominant land-use of each zone. This has been shown as the percentage of total zone area which is helpful in visualizing the structure of the city.

For fixing the density of different zones the whole area is being conceived as composed of seven self contained districts with population ranging from one lakh to two lakhs. The concept is same as proposed in Delhi Master Plan. The area of a district has been conceived as a circle of 1.2 km radius. This radius has been taken so that the people of one district get their services within a walking distance of fifteen minutes. This will reduce the service trips of people. Further, each district is further has been conceived as a set of communities with their own nucleus. This nucleus will provide service to the people of a district. This community organisation is shown in Fig. 5.3. Districts of Central part is supposed to contain more people than the other districts, because the central districts will serve its own people as well as the rest of the city for providing city wide services. Thus the density will go on decreasing as one

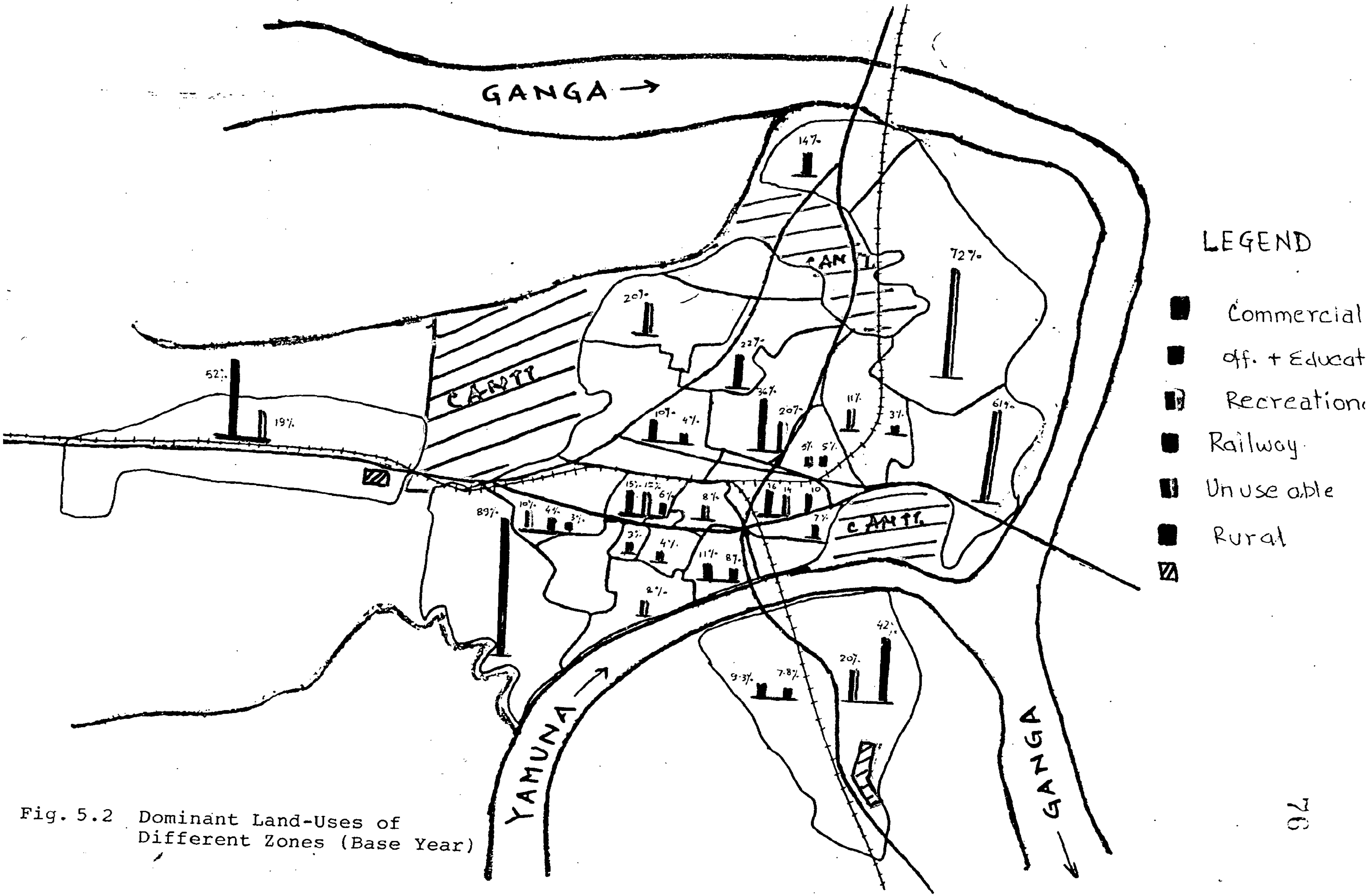

Fig. 5.2 Dominant Land-Uses of Different Zones (Base Year)

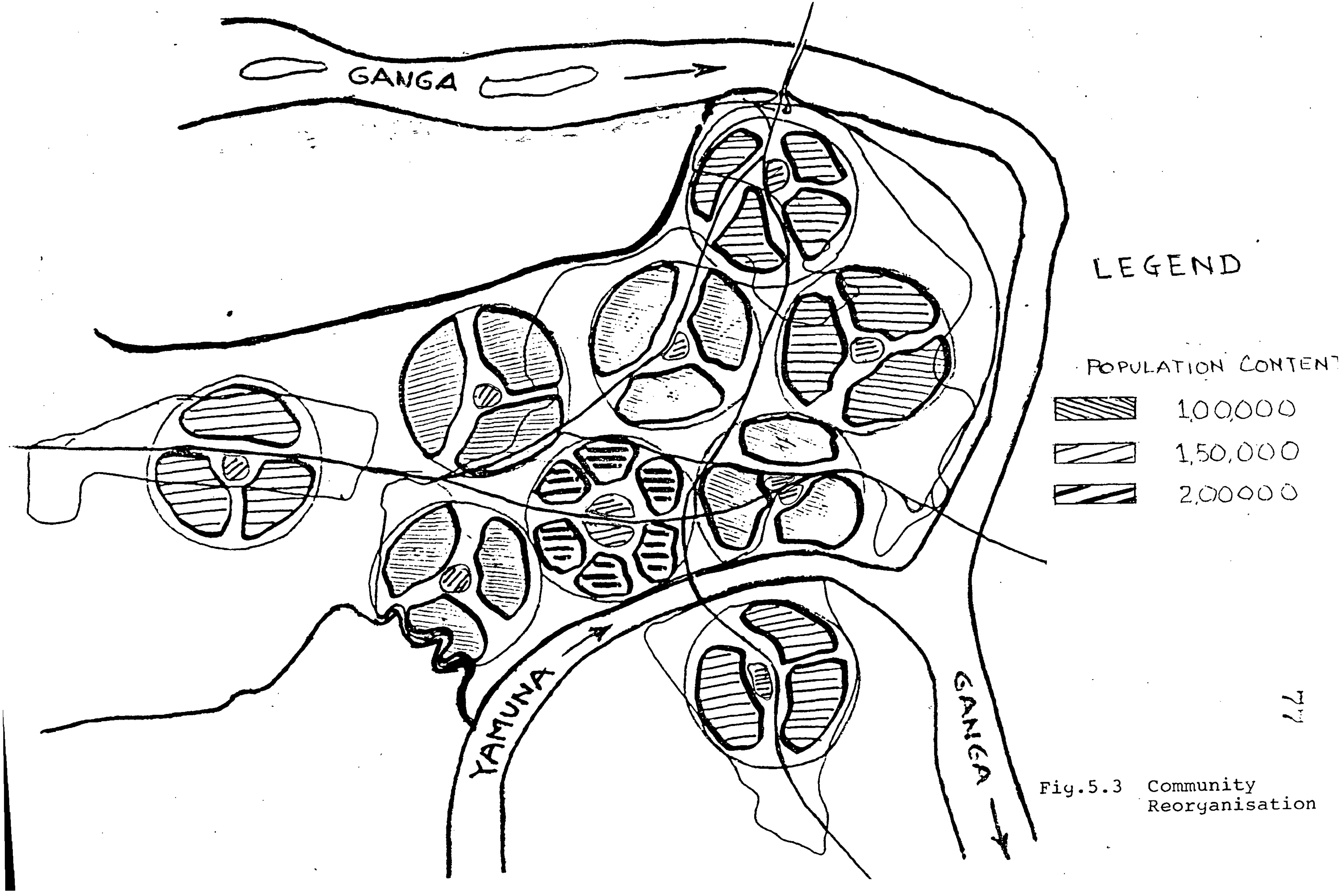

Fig.5.3 Community Reorganisation

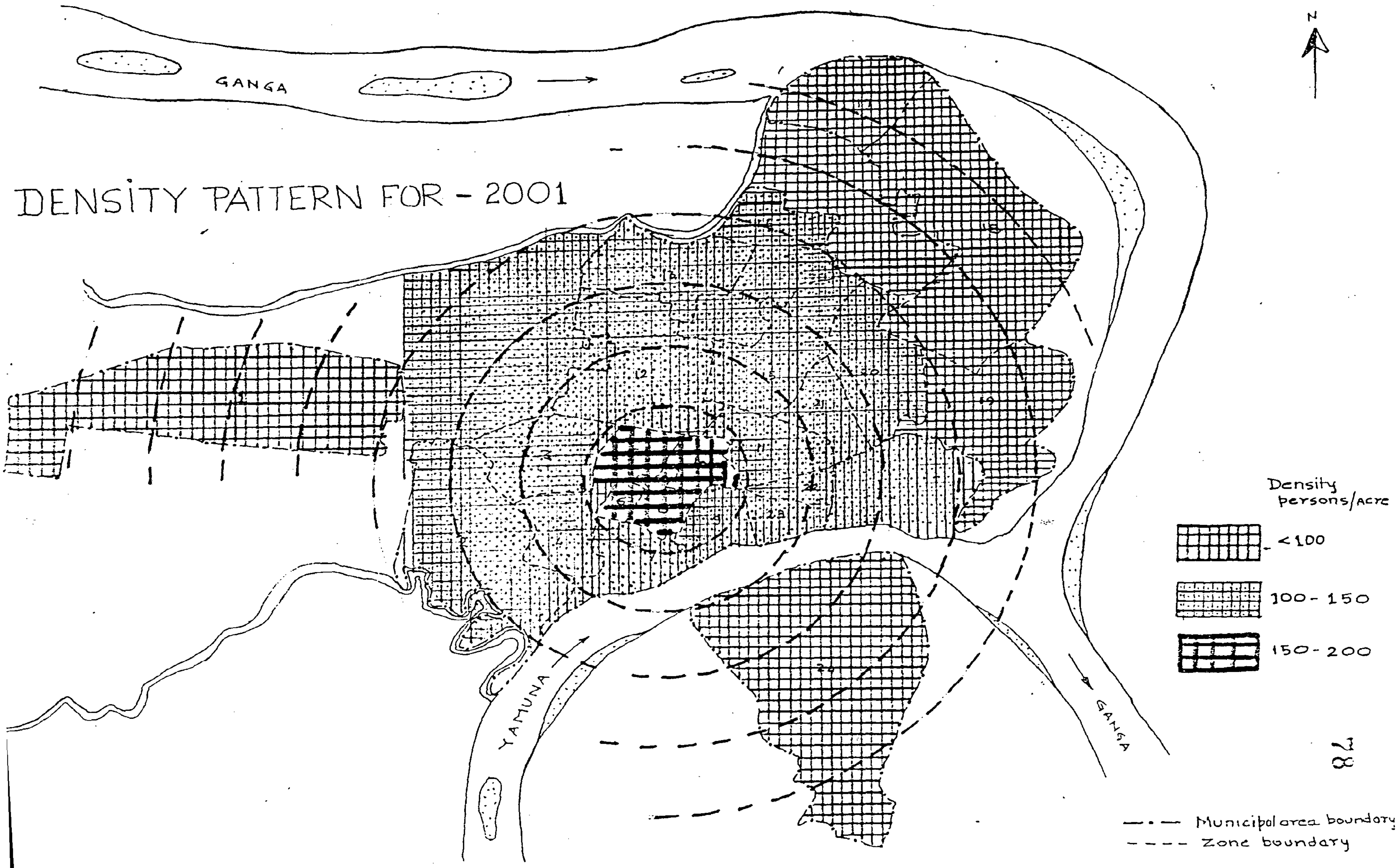

Fig. 5.4 Proposed Density Pattern for Harizon Year

Table No. 5.1

Intensity Of Basic Land Uses(employee/hectare)

Whole Sale	38
Godown	10
Mineral Sliding	40
Heavy Industries	3
Light Industries	10
Offices	100
Health(specialised)	10
Health(general)	50
Railway	10
Bus Terminal	12
Truck Terminal	15
Water Navigation	10

*

zone no. 1. from zone no.23. This zone (23) is presently very densely populated (154 persons per acre). Zone no. 1 is presently very thinly populated (16 persons per acre). NH1 passes through the zone no.1 which will provide good impetus to the development of wholesale business. Detailed, quantified land-uses under this policy is given in table 5.2. This distribution is same as envisaged by TCPD, Allahabad for 2001.

5.3.2 Policy - 2

In this policy all the basic sector landuses are proposed to be distributed throughout the city. The wholesale is distributed in zone 1 and zone 17. Zone 17 is on the extreme north of the city along river Ganga. A state highway to Faizabad and Lucknow passes through this zone. Presently it is very thinly populated with density 28 persons per acre. Also some light industries are proposed in this zone. Due to easy accessibility it can cater to this type of use . Also to facilitate wholesale sector in this zone truck terminal is proposed in this zone. Light industries are distributed through out the city so as to provide oppurtunity of work near the residences. A marginal bund on the north- eastern side of zone 17 and 18, along the river Ganga is proposed. This will, on one hand provide easy access to this zone, and on other a lot of land, which at present is prone to floods, would become available for future development.

5.3.3 Policy - 3

In this policy all the heavy industries are proposed to be located in zone 24 as was in policy 1 but the wholesale business is proposed to be housed in zone 17 and 18. These zones are presently not connected with mojor highways or railways except a state highway to Faizabad and Lucknow and railway to Lucknow, Faizabad and Varanasi. Thus, a marginal bund along the river Ganga is proposed as was in policy no.2. This will provide an easy access to these zones and a lot of extra space , which is presently floodable, for future development. Also, the railway extension , new truck terminal and a bus terminal are proposed in these zone. The quantified land-use distribution of this policy is given in table 5.4.

It is assumed that, in the period (1987- 2001) there uill not be any drastic changes in transport system infrastructure which will considerably change theinterzonal travel time. Hence, the value of deterrenceparameter, calibrated for the base year will be reliable. To explore the transport implications of different land-use distributions, future land-uses were distributed in three different ways. While testing each of these policies the allocation can be a constrained or unconstrained one.

Predictions were made for each policy by putting maximum density constraints. Maximum density were as described in 5.2. Eight percent discrepancy was put in

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Predictions were made for each policy by putting maximum density constraints. Maximum density were as described in 5.2. Eight percent discrepancy was put in

Table No. 5.2

Land Use Distribution for Policy - I

zone no. / Land Use(area in hectare)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Whole Sale	135(5130)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Godown	19(190)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mineral Sliding	-----	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6(240)
Heavy Industries	-----	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	636(1900)
Light Industries	31(310)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	75(750)	75(750)	--	--	--	--	--	75(750)
Offices	-----	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Health(specialised)	-----	--	--	--	--	--	--	--	--	--	--	--	--	--	--	17(170)	--	--	--	--	--	--	--	--
Health(general)	-----	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	11(550)	--	--	--	--
Railway	50(500)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	58(560)
Bus Terminal	6(72)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6(72)
Truck Terminal	25(375)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	25(375)
Water Navigation	-----	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	169(1090)
Total (basic employment)	6167	--	--	--	--	--	--	--	--	--	--	--	--	--	--	170	750	750	--	550	--	--	--	5834

* values in bracket shows employment

Table No. 5.3

Land Use Distribution For Policy - 2

Zone No. / Land Use(area in hectare)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Whole Sale	75(2850)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	60(2280)	--	--	--	--	--	--	--
Godown	9(90)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9(90)	--	--	--	--	--	--
Mineral Sliding	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6(240)
Heavy Industries	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	635(19
Light Industries	31(310)	50(500)	--	--	--	--	56(560)	--	--	--	--	--	--	--	--	--	--	75(750)	--	--	--	--	--	44(440
Offices	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Health(specialised)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	17(170)	--	--	--	--	--	--	--	--
Health(general)	--	--	--	--	--	--	--	--	--	--	--	--	10(500)	--	--	--	--	--	--	11(550)	--	--	--	--
Railway	50(500)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	50(500
Bus Terminal	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6(72)	--	--	--	--	--	--	6(72)
Truck Terminal	15(225)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	15(225)	--	--	--	--	--	--	20(300)
Water Navigation	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	100(10
Total (basic employment)	3935	500	--	--	--	--	560	--	--	--	--	--	500	--	--	170	2577	840	--	550	--	--	--	4630

* values in bracket shows employment

TablNo. 5.4

Land Use Dtribution For Policy - 3

zone no. / Land Use(area in hectare)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Whole Sale	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	60(2280)	75(2850)	--	--	--	--	--	--
Godown	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	19(190)	--	--	--	--	--	--	--
Mineral Sliding	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6(240)
Heavy Industries	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	200(600)	--	--	--	--	--	436(1390)
Light Industries	31(310)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	75(750)	75(750)	--	--	--	--	--	75(750)
Offices	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Health(specialised)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	17(170)	--	--	--	--	--	--	--	--
Health(general)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	11(550)	--	--	--	--
Railway	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	50(500)	--	--	--	--	--	58(580)
Bus Terminal	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6(72)	--	--	--	--	--	--	6(72)
Truck Terminal	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	25(375)	--	--	--	--	--	25(375)
Water Navigation	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	189(1890)
Total (basic employment)	310	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3282	5075	--	550	--	--	--	4415

* values in bracket show employment

maximum density to make the easy run of the model otherwise it will take a lot of time in prediction. Major findings for each policy was as follows :

Table 5.5 and Table 5.6 list the predicted population and employment of each zone under each policy recommendation. Table 5.7 lists the future density of each zone for each policy which is in accordance with the constraint imposed. The change in the population, employment and density between base year and horizon year for each policy are shown from Fig. 5.5 to Fig. 5.13.

Fig. 5.14 to 5.16 shows the predicted trip pattern for each policy. Only trips more than 7000 are shown to distinguish mojor flows for each policy. Table 5.8 and table 5.9 gives the trips produced from each zone under each policy. Mean trip length for each policy is as follows :

Policy - 1	16.68
Policy - 2	15.02
Policy - 2	16.40

Since predictions were made by putting maxim un density constraint, population and employment of each zone were more or less same. There were some difference in the predicted desire pattern for each policy. This is due to the different land-use pattern. Mean trip length ,also, has some difference. These two will be compared for each policy as these are the measures of transport implication.

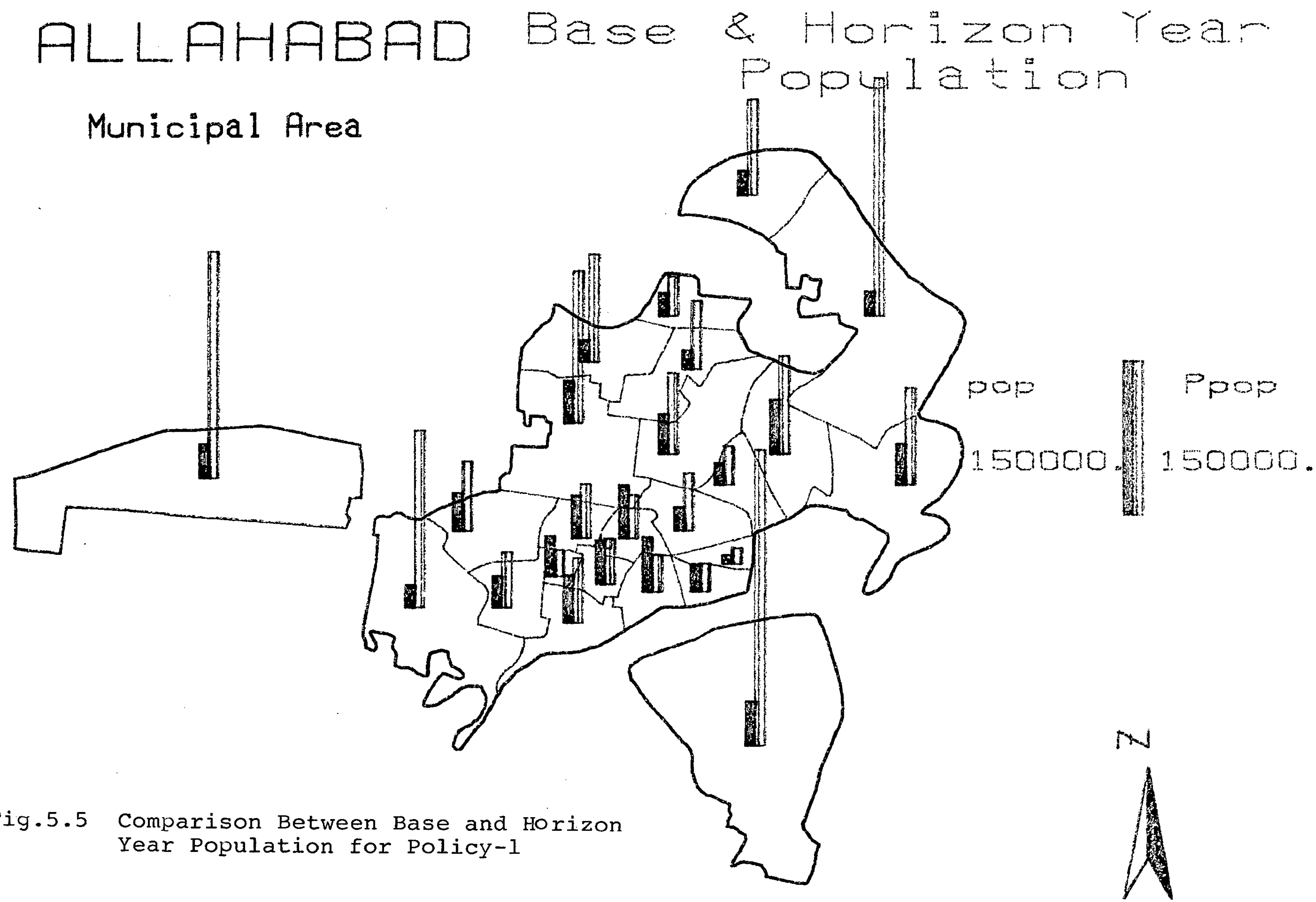

Fig.5.5 Comparison Between Base and Horizon Year Population for Policy-1

Since the existing density at

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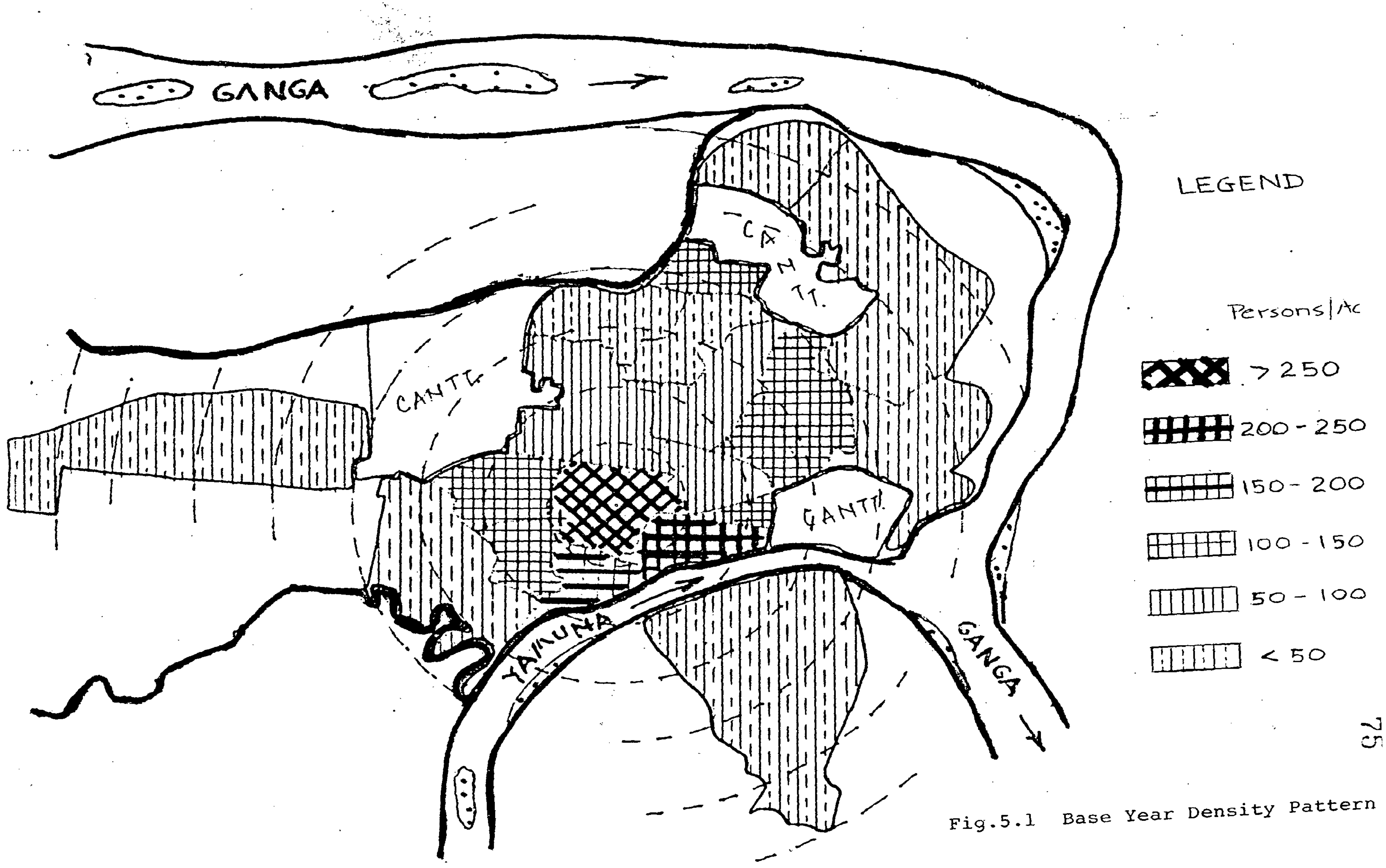


Fig.5.1 Base Year Density Pattern

moves away from the center. Since the existing density at the center is very high with respect to the periphery, this density is proposed to be curtailed. The density of other zones around the center are proposed to be increased. Fig.5.4 shows the proposed future density pattern of the city.

5.3 ALTERNATIVE LAND USE PLANS :

To foresee the future travel pattern and for predicting future activities (population and employment) of each zone the input required is the future employment in the basic sector. This is usually derived from the future land-use plans. For this purpose land use plans on macro level is sufficient. This is usually in the form of policies. In these land use plans land uses of only basic sector are required. Also, the exact location of these land uses are not necessary. The location should only tell the zone number in which the activities are to be located. The quantity of land-used for various purposes is multiplied by the intensity (employment area ratio) of its use which then gives the expected employment to be generated by various land uses. The intensity of uses is generally fixed by the planning department. For this study intensity of various basic sector land-uses were taken from the Town & Country Planning Department, Allahabad. Table 5.1 shows the intensities of different basic sector land-uses.

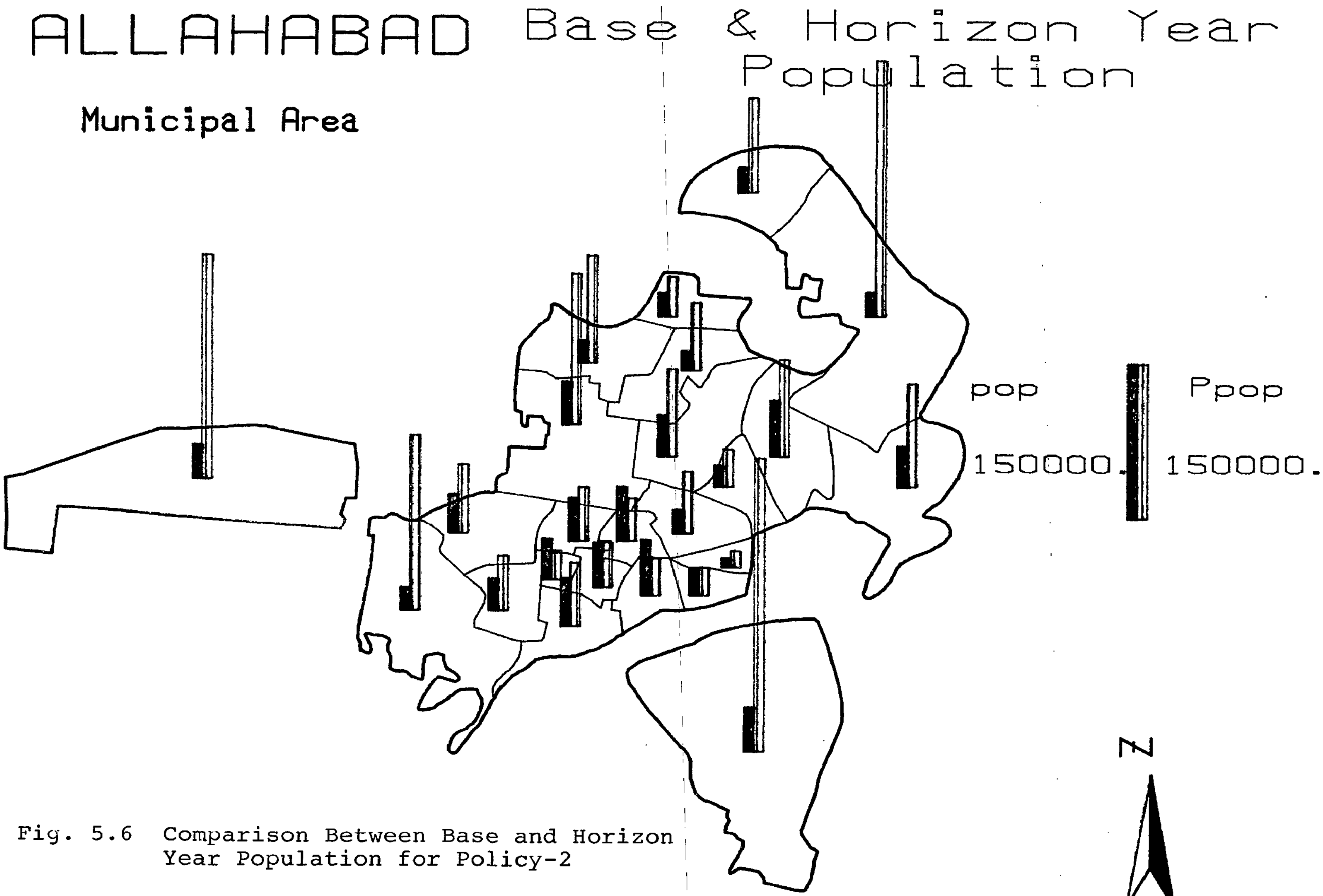


Fig. 5.6 Comparison Between Base and Horizon Year Population for Policy-2

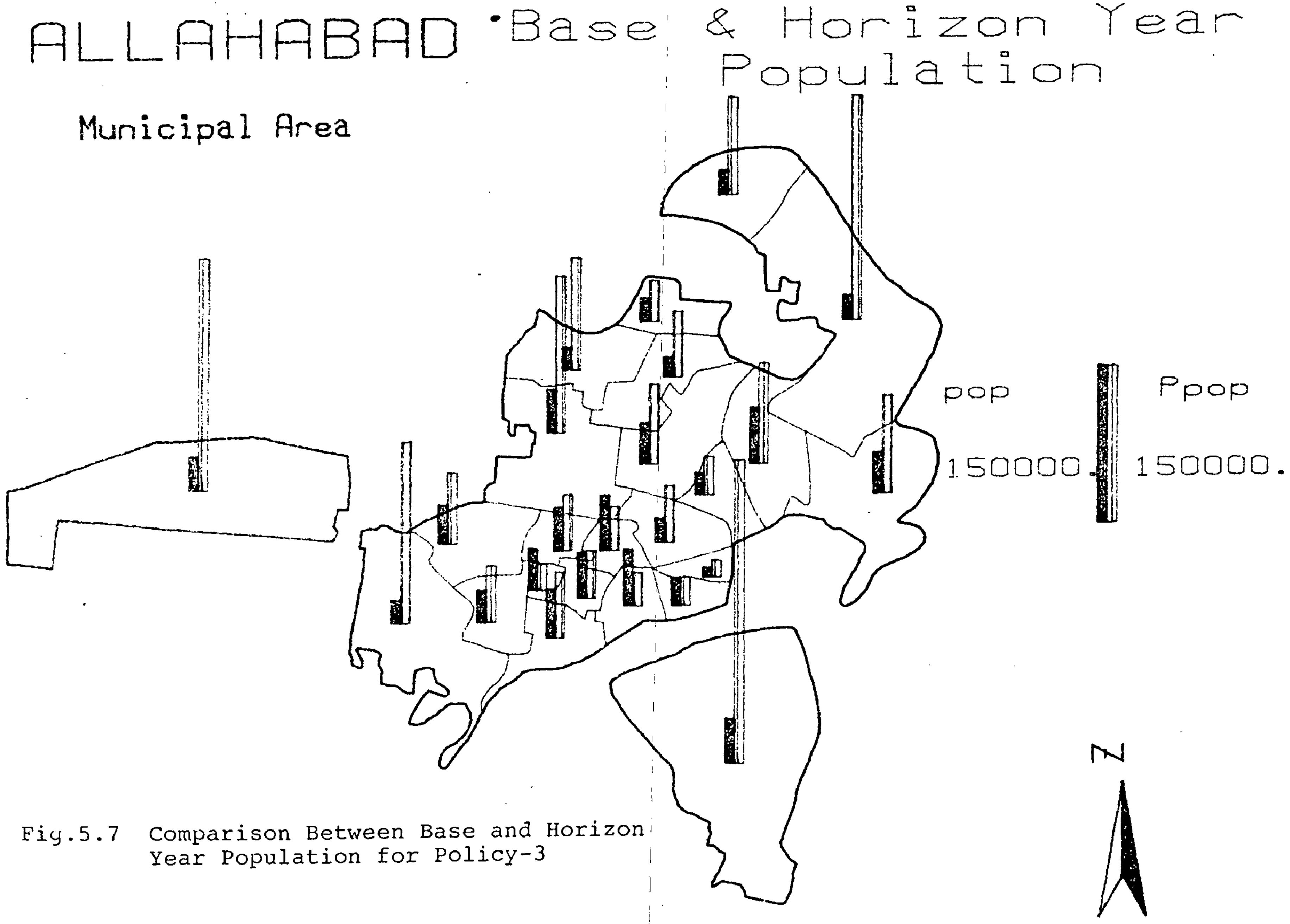


Fig.5.7 Comparison Between Base and Horizon Year Population for Policy-3

ALLAHABAD Base & Horizon Year Employment

Municipal Area

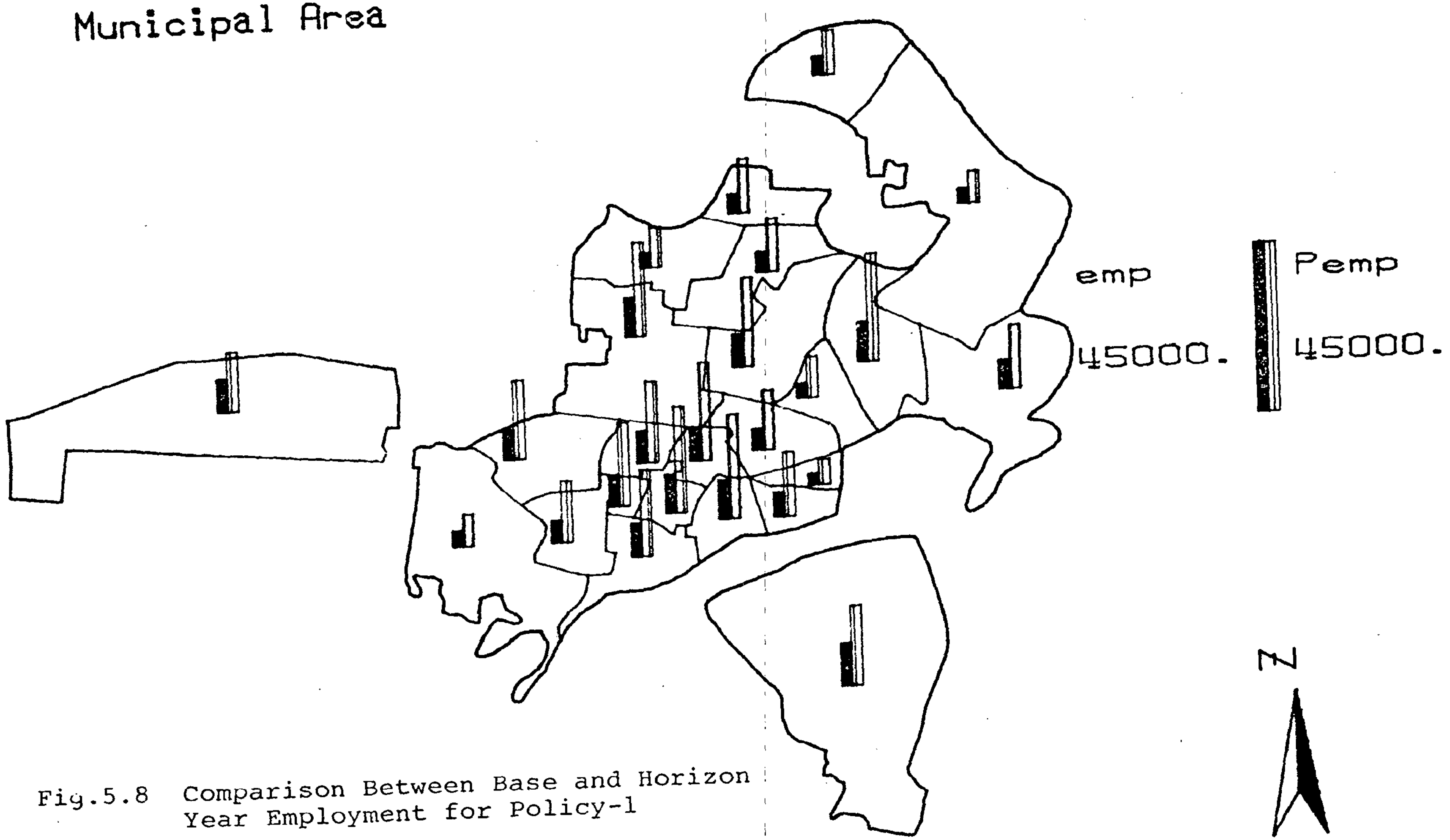


Fig.5.8 Comparison Between Base and Horizon Year Employment for Policy-1

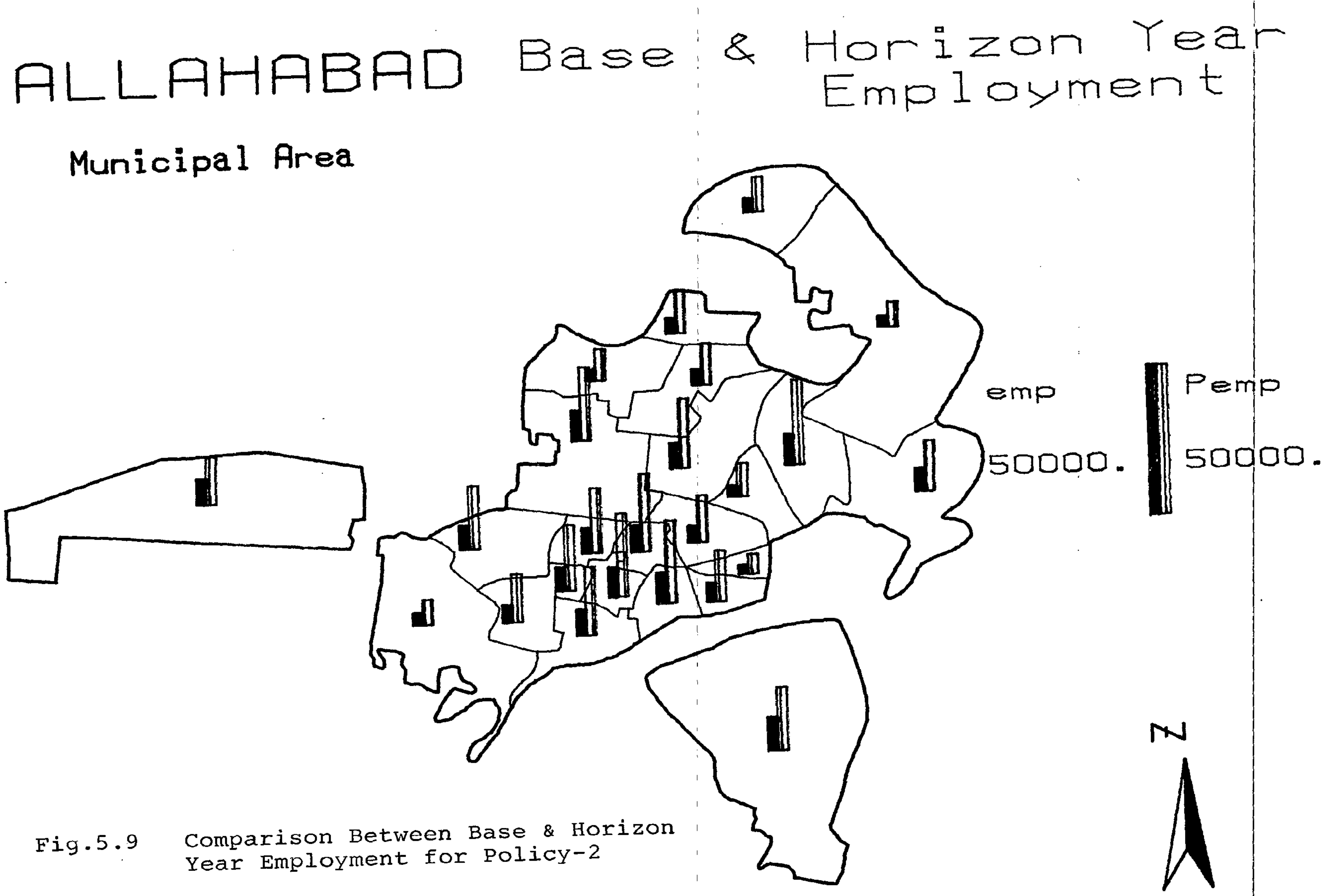


Fig.5.9 Comparison Between Base & Horizon Year Employment for Policy-2

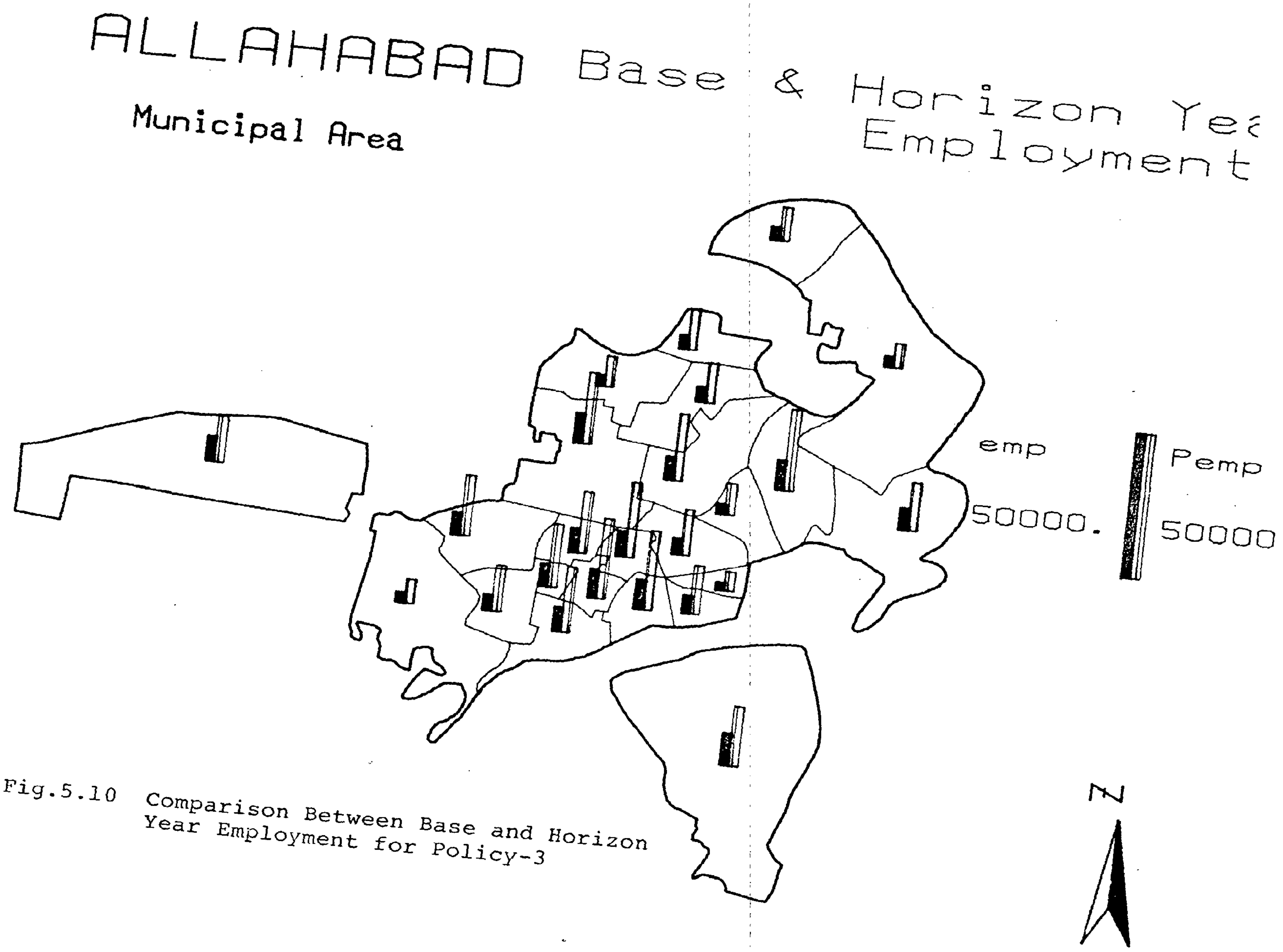


Fig.5.10 Comparison Between Base and Horizon Year Employment for Policy-3

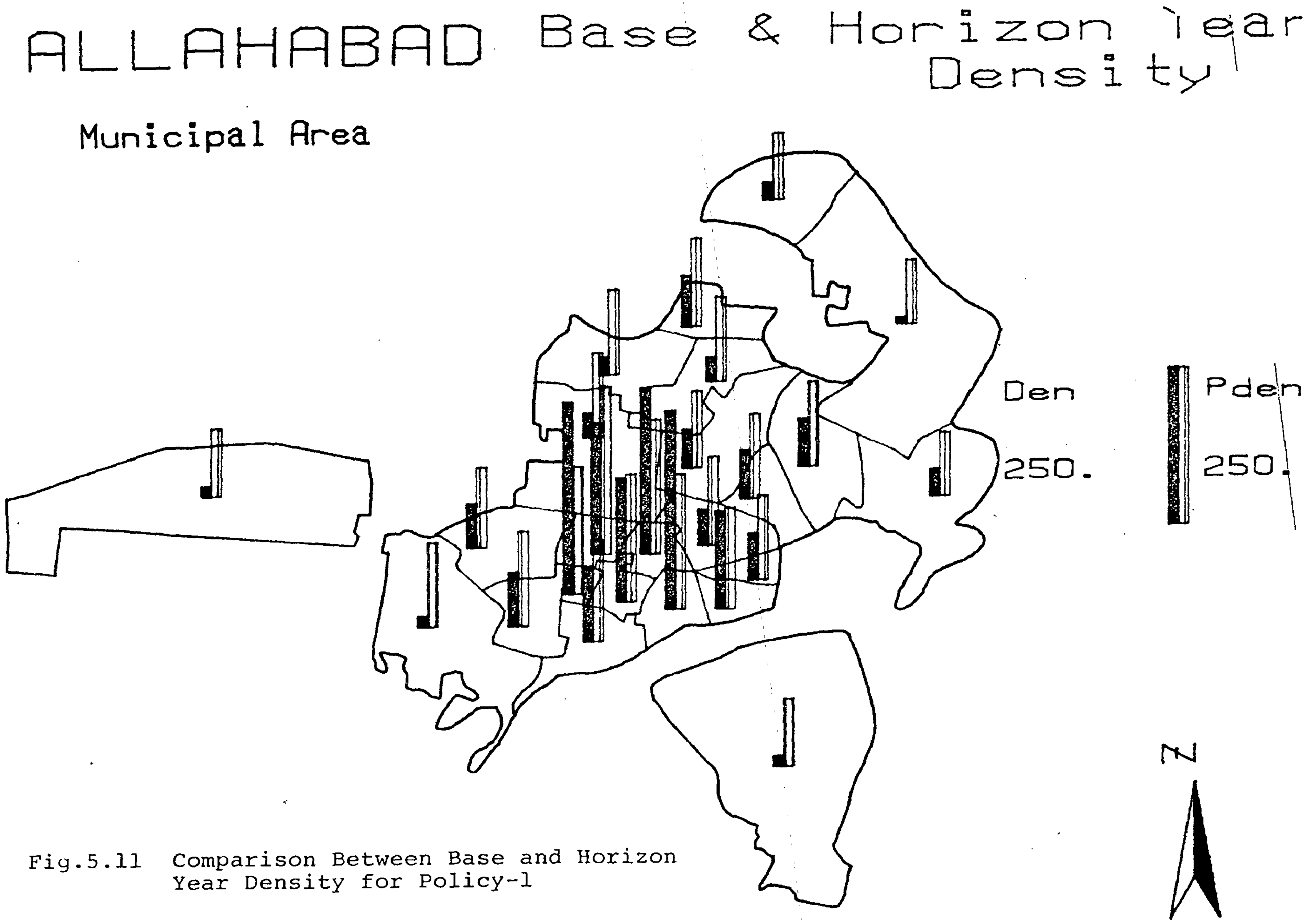
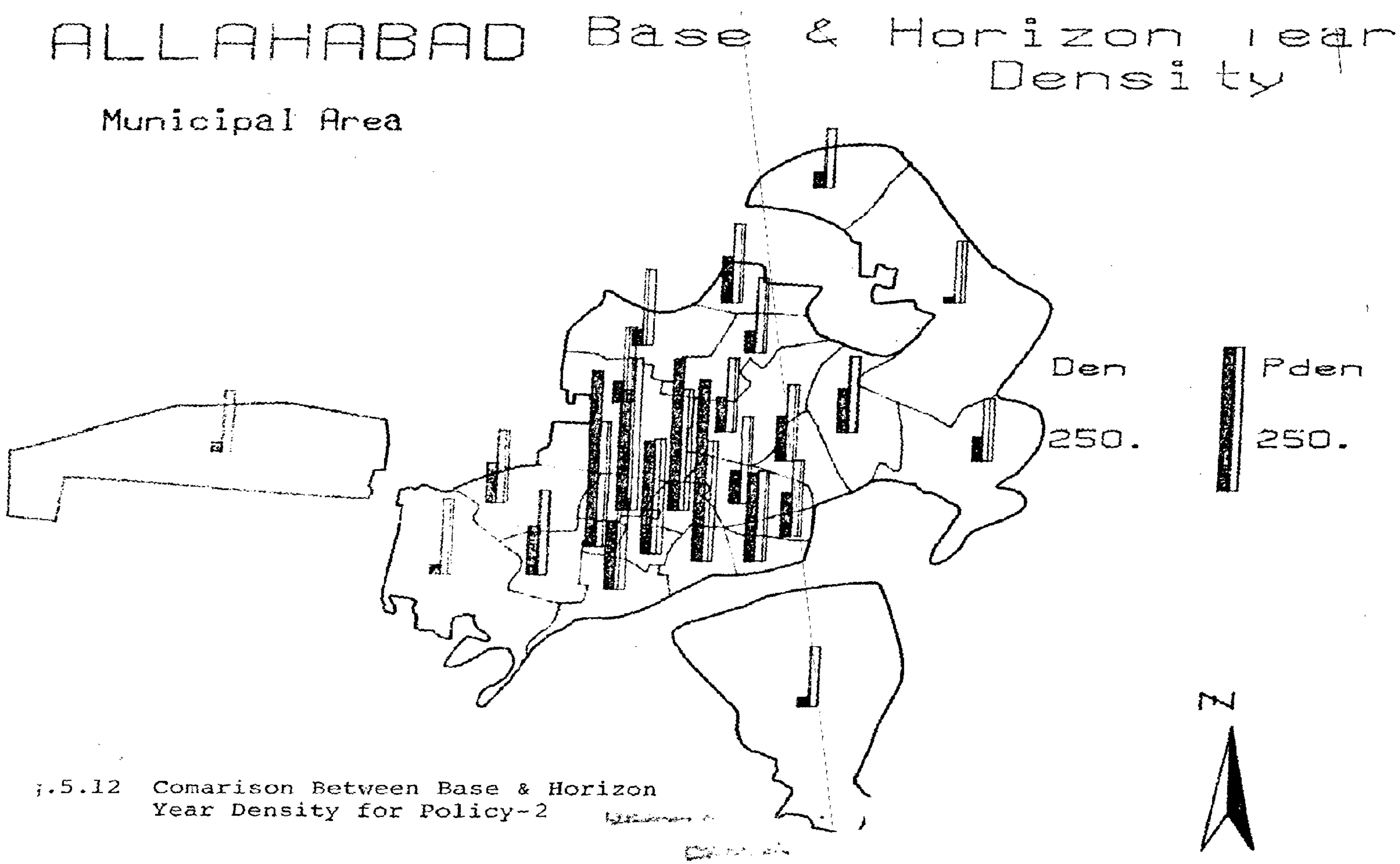


Fig.5.11 Comparison Between Base and Horizon Year Density for Policy-1



;.5.12 Comarison Between Base & Horizon Year Density for Policy-2

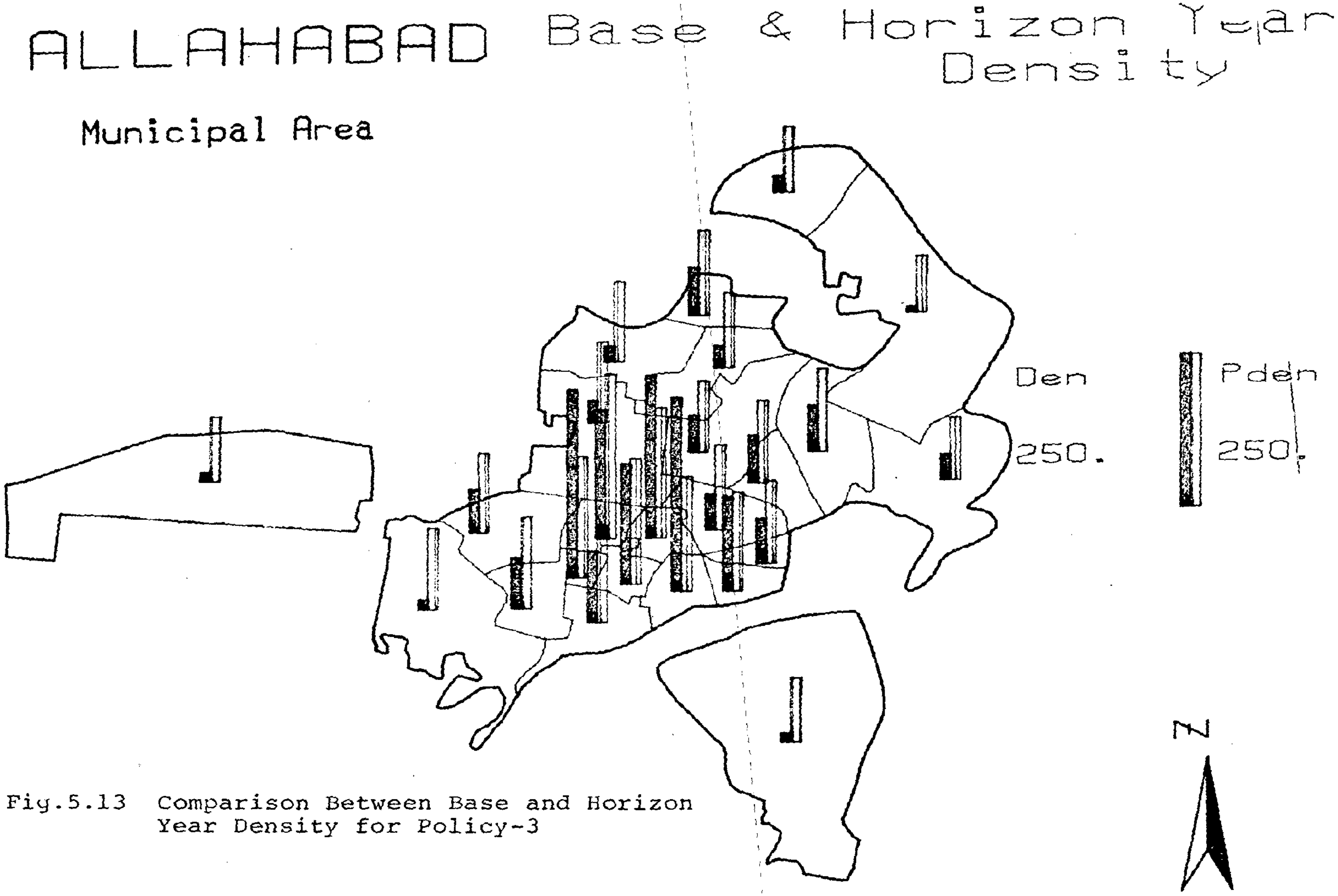


Fig.5.13 Comparison Between Base and Horizon Year Density for Policy-3

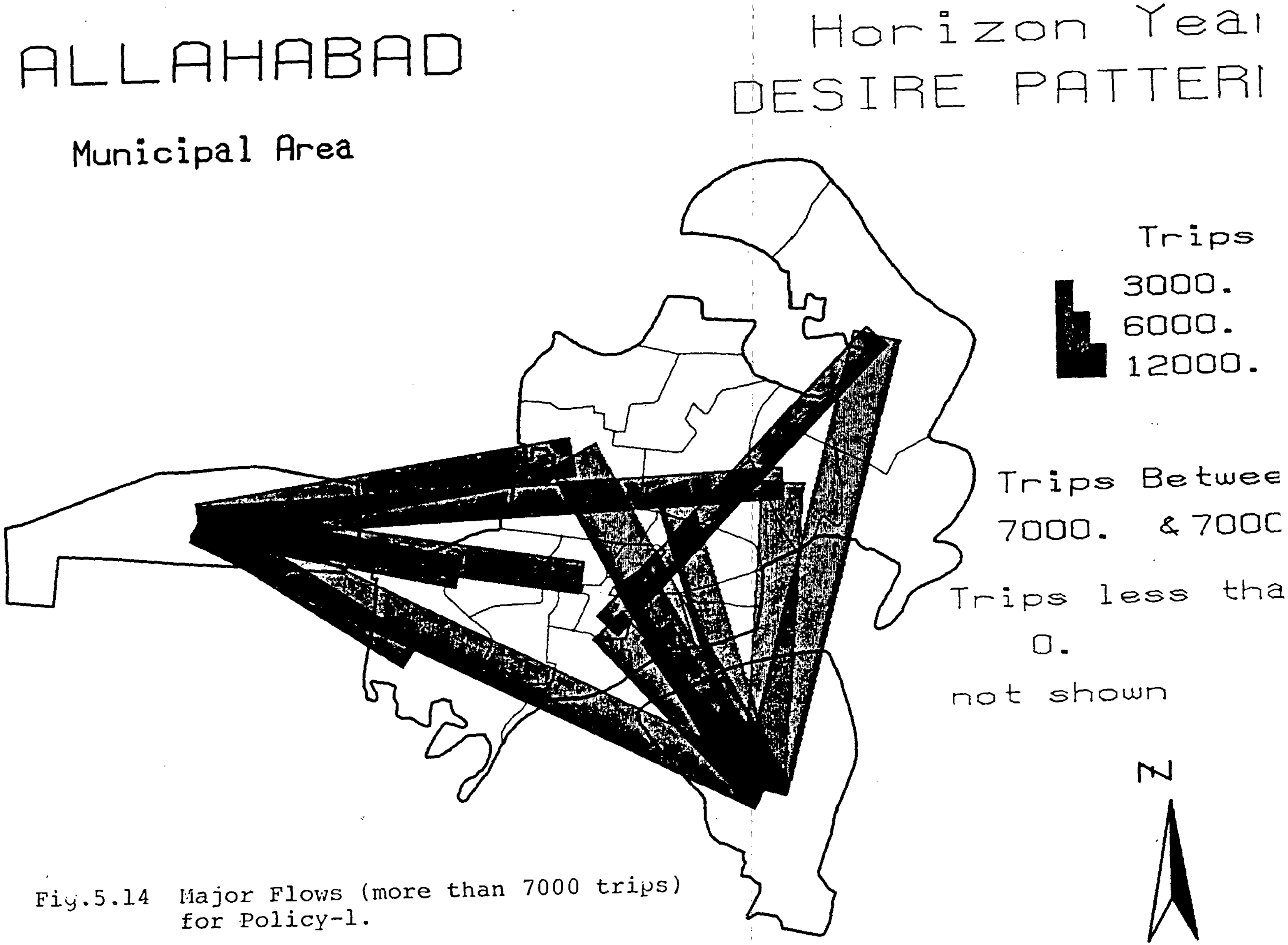


Fig.5.14 Major Flows (more than 7000 trips) for Policy-1.

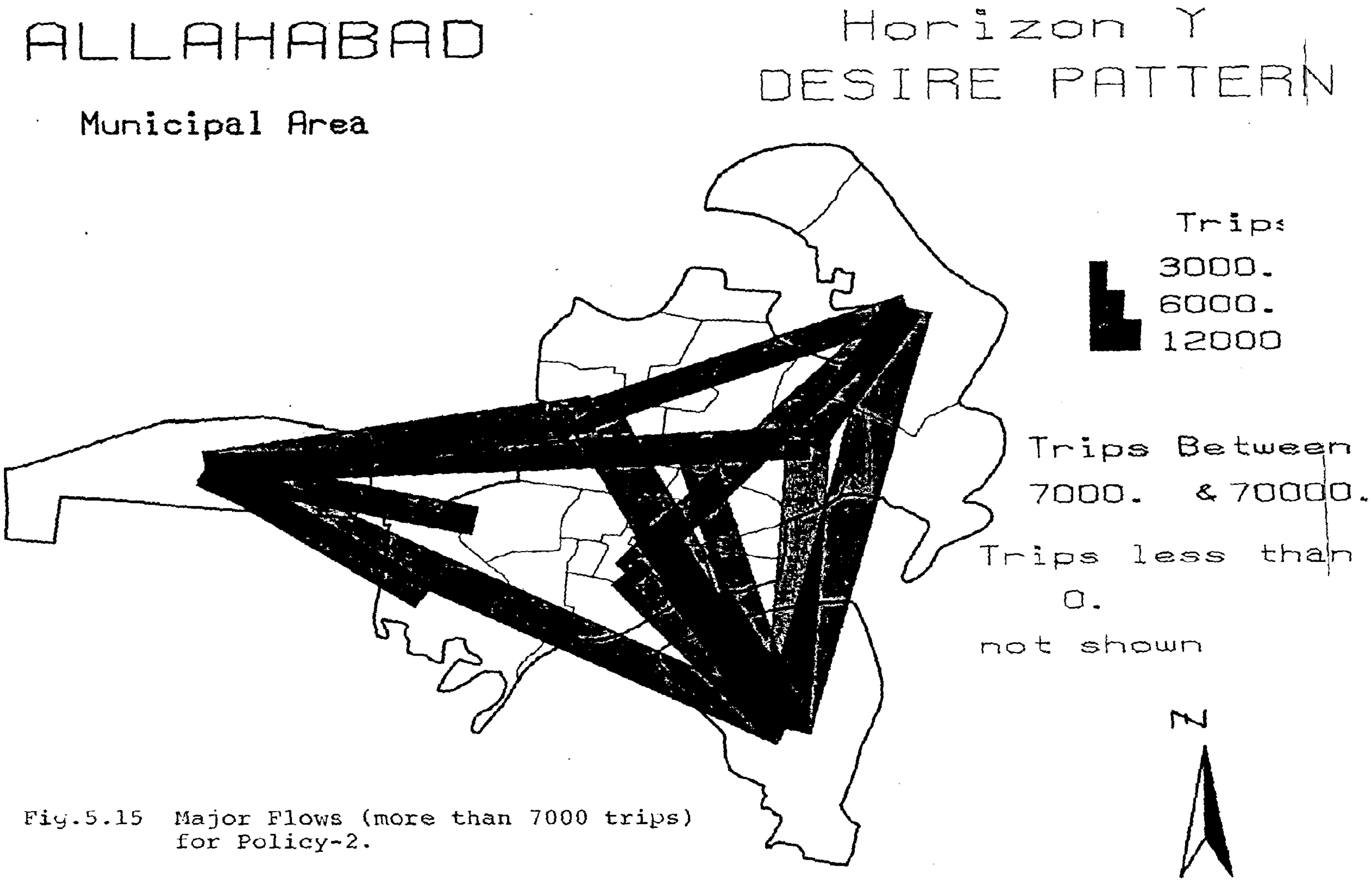


Fig.5.15 Major Flows (more than 7000 trips) for Policy-2.

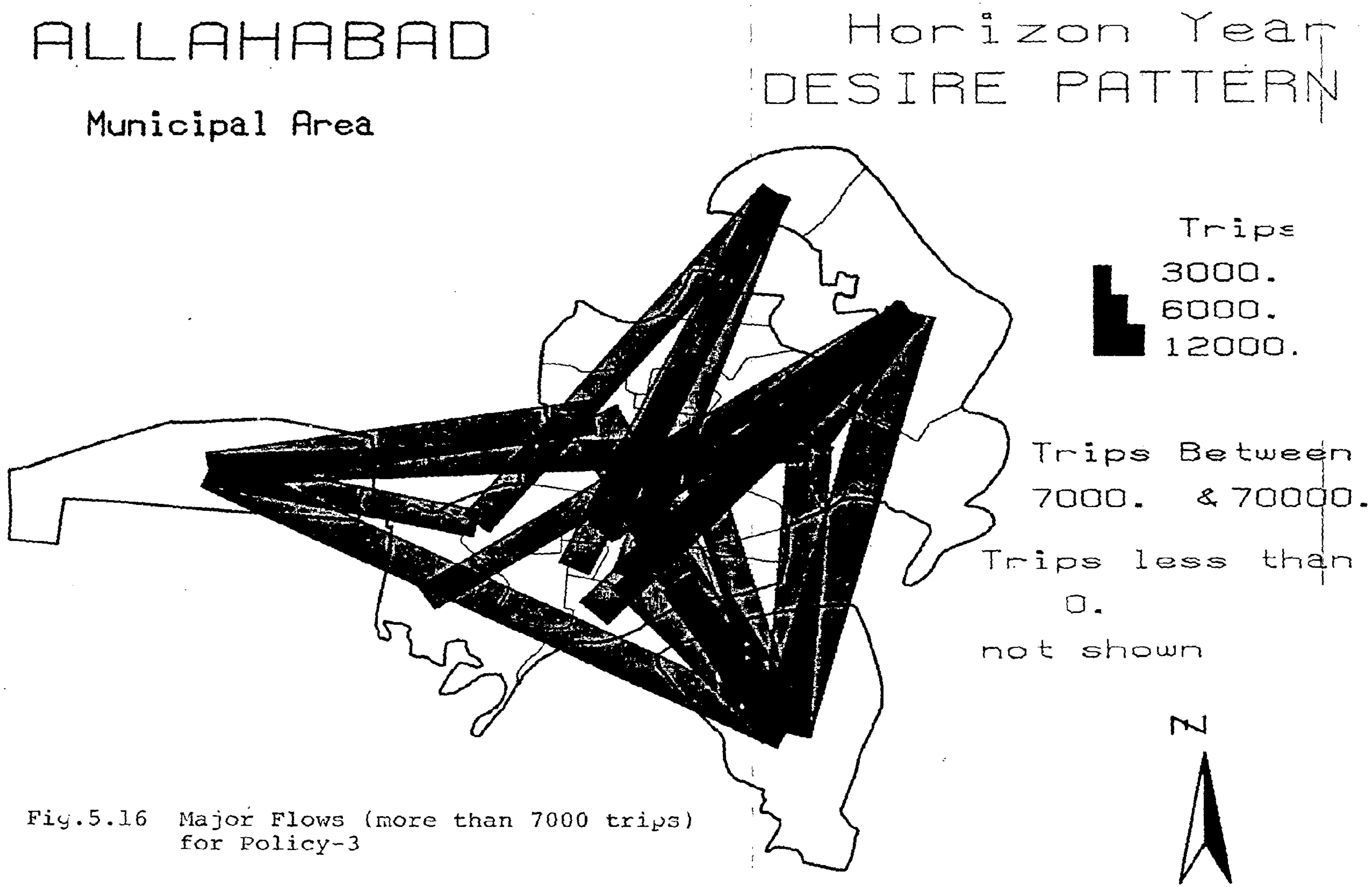


Fig.5.16 Major Flows (more than 7000 trips) for Policy-3

Table No. 5.5

Horizon Year Population of each Zone For each Policy

Zone No	Policy 1	Policy 2	Policy 3
1	219198	226347	219967
2	171572	177176	175338
3	69031	63726	67910
4	54700	50497	53815
5	53201	54938	53388
6	28549	26622	25991
7	62246	64278	62467
8	36176	36737	32420
9	44475	45929	44632
10	42558	43950	43283
11	61491	56980	55700
12	147624	152457	150868
13	107176	98947	105442
14	66500	68673	62767
15	85647	79366	77583
16	36693	33704	31408
17	93630	96691	93967
18	253651	235059	219510
19	102119	95226	95786
20	96338	88938	94766
21	37993	35072	37372
22	16283	15031	16015
23	27132	28019	27228
24	286273	295571	287290

Table No.5.6

Horizon Year Employment Of Each Zone For Each Policy

Zone No.	Policy-1	Policy-2	Policy-3
1	16230.	15958.	15748.
2	8583.	8454.	8326.
3	21550.	21377.	20998.
4	16499.	16349.	16045.
5	22127.	21817.	21477.
6	22569.	22291.	21920.
7	23368.	22978.	22620.
8	28225.	27803.	27421.
9	28592.	28139.	27696.
10	26547.	26217.	25803.
11	16166.	15947.	15709.
12	25190.	24798.	24386.
13	10759.	10654.	10432.
14	14222.	14010.	13823.
15	23681.	23399.	23041.
16	14624.	14451.	14212.
17	12082.	11870.	11671.
18	8521.	8485.	8385.
19	17127.	16921.	16628.
20	28859.	28498.	27929.
21	11291.	11119.	10929.
22	6870.	6820.	6748.
23	17466.	17186.	16905.
24	21354.	20862.	20510.

Table No. 5.7

Horizon Year Density Of Each Zone For Each Policy
Density in person per acre

Zone No.	Policy-1	Policy-2	Policy-3
1	106.	110.	107.
2	133.	137.	136.
3	130.	120.	128.
4	152.	140.	149.
5	266.	275.	267.
6	220.	205.	200.
7	160.	165.	160.
8	213.	216.	191.
9	202.	209.	203.
10	213.	220.	216.
11	154.	142.	139.
12	133.	137.	136.
13	136.	125.	133.
14	133.	137.	126.
15	132.	122.	119.
16	131.	120.	112.
17	106.	110.	107.
18	110.	102.	95.
19	110.	102.	103.
20	136.	125.	133.
21	136.	125.	133.
22	136.	125.	133.
23	160.	165.	160.
24	106.	110.	107.

Table No. 5.8

Trips Produced From Different Zones For Each Policy

Zone No.	Trips Produced		
	Policy -1	Policy-2	Policy - 3
1	39221.	36962.	33016.
2	17815.	17467.	16712.
3	43162.	42816.	42058.
4	32996.	32695.	32086.
5	44775.	43955.	43275.
6	45170.	44615.	43873.
7	46925.	46704.	45428.
8	56499.	55656.	54892.
9	57537.	56632.	55745.
10	53145.	52486.	51657.
11	32852.	32114.	31637.
12	51922.	51138.	50313.
13	22071.	21861.	20918.
14	29055.	28629.	28255.
15	47873.	47308.	46592.
16	29456.	29565.	29087.
17	24698.	26850.	27157.
18	17612.	17809.	21843.
19	34300.	33890.	33304.
20	58375.	57803.	56663.
21	22606.	22263.	21883.
22	13752.	13653.	13508.
23	35058.	34499.	33937.
24	50908.	47906.	46986.

6.1 INTRODUCTION:

Earlier chapters dealt extensively about the working of Lowry model, it's development and applications for Allahabad city. This involves a lot of computational work for which using modern computational techniques i.e. computer programming was inevitable. Also the computer programs makes the whole work very flexible i.e. using these programs same application can be done for other cities also, in least time and accuracy. Further, it may not be always possible to have a full understanding of the working of the model by the officials who want to plan the land-use and see its implications. In view of this and for actual computations required for the work presented in this work, computer programs were developed. The computer programs were developed in a systematical manner incorporating computer graphics to display the input and output of the work. Computer graphics provides an easy way to compare different variables, output in a digramatical form almost instantly.

6.2 PROGRAM STRUCTURE:

The various components of the program (package) which work interactively in a user friendly manner for easy understanding of input and model results are shown in flow chart as given in Fig. 6.1. The working of package facilities available are described below.

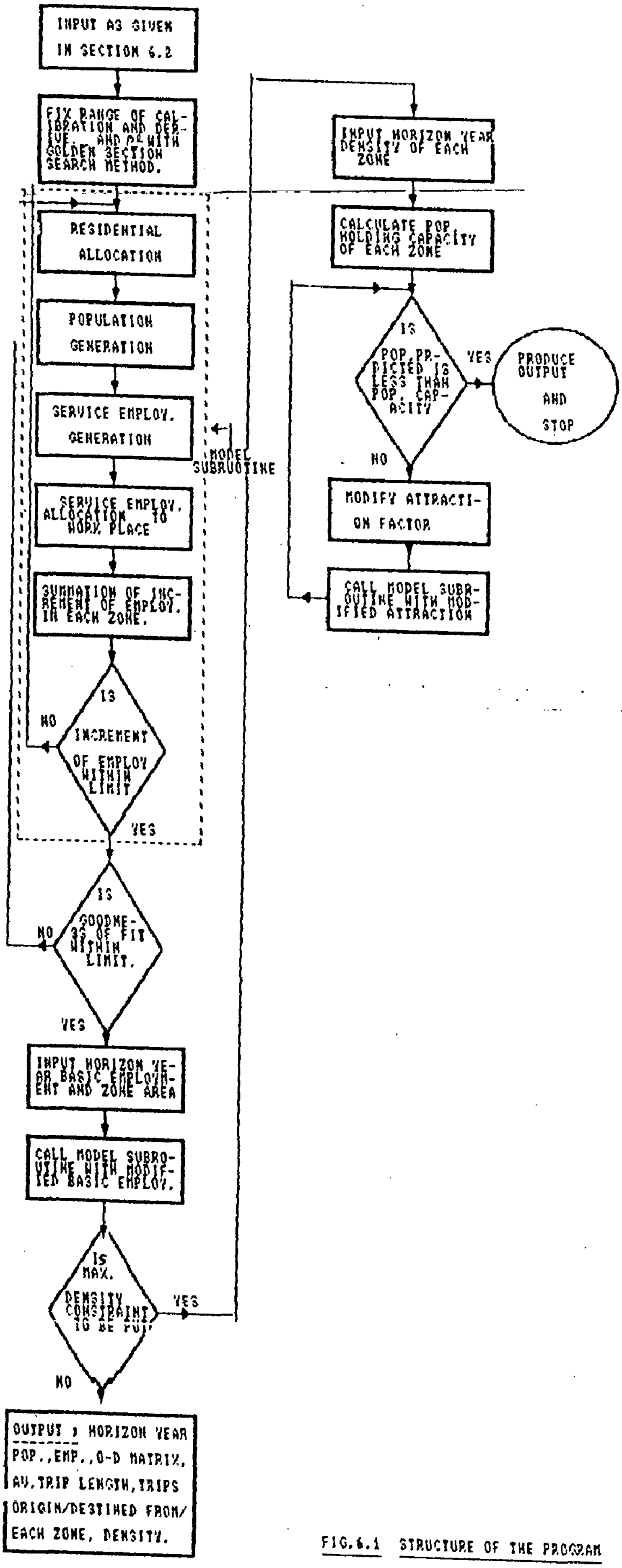


FIG.6.1 STRUCTURE OF THE PROGRAM

6.2.1 INPUT

All the input data must be stored in separate files. This provides easy manipulation of data. The following input are required for the development of the model.

Base Year

--Population of each zone in the form of a row vector.

--Basic employment of each zone in the form of row vector

--Service employment of each zone in the form of row vector

--Inter zonal travel time /distance matrix

-Observed trip matrix (work trips & service trip)

-digitized data of boundary of the study area and of each zone

-digitized data of zone centroids.

For predicting activities following data were required :

-- Future basic employment of each zone

-- Area of each zone, if prediction is to be made with density constraints or future density is to be estimated.

-- Maximum allowable density of each zone

All the required input data are asked by the program when required. However, program provides a check list of input data just after the start of program.

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6.2.2 OUTPUT

Output after calibration are

Modelled population of each zone

~~Modelled employment of each zone~~

Modelled trip matrix

Output after prediction are (of horizon year)

Predicted population of each zone

Predicted employment of each zone

Predicted density of each zone

Predicted trip matrix

Trips produced from and attracted to each zone

Average trip length

For each policy, all the above output are given by the program

6.3 USE OF THE PACKAGE :

The user friendly interactive menu driven package has been named as LUTIM(Land Use Transport Interaction Model). It has the facility for calibration, prediction and graphic presentation of input data as well as output results.

6.3.1 CALIBRATION

The program provide the facility for calibrating the model between the range defined by the user. Search for the best parameter ,by the program, is made with the help of Fibonacci Golden Section Search Method. Since the lesser is the range of search more accurate the search is.

Hence to obtain the best deterrence parameter search should be made in very narrow range. However goodness of fit is normally obtained in the range of 0 to 1. Hence, the default range for calibration in the package is 0 to 1. This gave considerable good goodness of fit for Allahabad. Calibration by the program terminates when the range for search is less than 0.001. This means that the calibrated value is accurate up to third place of decimal. All the output after calibration is stored in separate files whose name are to be given by the user.

6.3.2 PREDICTION:

After the calibration, prediction is to be made. However, if the user does not want to make prediction the program will terminate after calibration. Prediction can also be made without doing calibration but in this case user has to give the best fit value of deterrence parameter as derived after calibration. Prediction can be made with or without putting density constraint. Constrained prediction take more time in prediction in comparison with unconstrained one.

Future basic employment for each policy is needed as input for making prediction. For constrained prediction, Maximum allowable density and zone area are also required. After the prediction is made program asks the user to give file names to store different data. Different outputs given by the program are:- Horizon year population, employment, density, predicted trip matrix, trips originating from each zone , trips attracted to each zone and mean trip length.

Prediction program should be run for each policy. The program asks, after each prediction, if user has to make prediction for more policies. Each output data for every policy is stored in separate output files, whose name is to be given by the user.

6.3.3 GRAPHICS COMPONENT

The graphic part of package. is able to show the graphics in the following form.

1. Different Traffic Zones of Allahabad with their numbers.

BAR CHART OF :

2. Base year population and employment.
3. Base year population and density.
4. Base year population and Modelled population.
5. Base year employment and Modelled employment.
6. Base year and Horizon Year population.
7. Base year and Horizon year employment.
8. Horizon Year population and employment.
9. Horizon Year employment and employment.

DESIRE PATTERN :

10. Base Year trips.
11. Modelled trips.
12. Predicted trips.

The menu in the program shows all the above options. To operate any option only the respective number is to be entered. The program will ask for the data files required for the representation of option. After the data file names are entered it asks for the I/O PORT and MODEL number. These are the interfacing codes required to produce graphical output I/O PORT number is to tell the out put device the baud rate i.e. bits transferred per second form the computer and to the output device. MODEL number is the code for the type of output device. I/O PORT and MODEL nos. 99 and 99 must be given for the out put on the crt terminal ,0,0 for printer and 9650 and 30 for HP 7475 Plotter. After this, there is an option for if the user want to see some specified portion of the whole area. For this WINDOW size is to be given. The default window size is 8.25 x 6.00 inches.

For Bar charts, fill codes are required. Any integer number between 1 to 8 can be given. Each fill number has different types of fill patterns which is helpful in distinguishing the two variables. For the Desire Pattern there in an option to see the desire pattern for the whole city or trips produced from or attracted to a specified zone. There is an option to see a definite range of trips and the trips below which the user do not want to see, generally for clarity purpose. After each presentation the program asks if the user want to continue with the same option . This is helpful for seeing the different alternatives available in each option or for having the same output on different output devices. The figures in this thesis ,showing the results during development and application of model are the out put from the graphics program described above.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS :

A Lowry type model for land use allocations was calibrated in this study and travel, for obtaining the best fit with respect to the observed travel, was obtained. The model was calibrated to data for Allahabad city. In view of the fact that the medium size cities (population 0.3 to 1 million) are mostly neglected inrespect of planning input, this study was specially directed to this class of the city which is going to face the highest population growth and transportation problems.

The Lowry model calibrated, was for a common deterrence parameter in the allocation functions which was estimated to be 0.032. The low value of deterrence parameter shows the fact that in this city people do not give much weightage to the distance or time of travel for work and service/shopping. This may be due to the small size and regular shape of the city. The calibrated model produced acceptable goodness of fit as indicated by the coefficient of determination which are as follows :

Travel matrix ---- 0.746

Population distribution ---- 0.987

Employment distribution ---- 0.889

Fibonacci Golden Section Search technique was used to isolate the best parameter. A complete interactive package

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Travel matrix ---- 0.746

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Employment distribution ---- 0.889

Fibonacci Golden Section Search technique was used to isolate the best parameter. A complete interactive package for the calibration and forecast has been developed for general application and use. Extensive graphics of the package provide clear understanding of input and out put from the model.

Using the Allahabad Master Plan and forecast of population, employment etc. Three strategies were formulated for future development which were referred as policy 1, policy 2 and policy 3. The densities were fixed from analysis of the existing pattern and suggested density pattern was discussed in chapter 5.Three alternative development policies were tested for Allahabad to study their transport implications.

The minimum average trip length is for policy 2 .This is much due to the distributed basic employment. The implementation of this will require to provide some extra infrastructrural facilities in zone 17 and zone 18 for the development of the wholesale business. For this a marginal bund on north east side along the Ganges is proposed. In policy 2 it self. Policy 1 and 3 have average trip length more than that of policy 2. This is due to the concentration of the basic employment in zone 1 and 24 respectively. These are the out lying zones. For each policy desire pattern are shown in Fig 5.14 to 5.16 . Only more than 7000 trips have been shown for easy comparison of the major flows under each policy. It is clear that in policy 1 major trips are from zone 1 and 24 and in policy 2 from 24 and 17 & 18. In policy 2 major trips are produced from zone 24. This policy gives a relatively uniform desire pattern. The trips produced and attracted from/ to different zones are given in Tables 5.9 and 5.10. It is seen that in policy 1 trips produced from zone 1 and 24 and in policy 2 from zone 24 and 17 & 18 are high compared to policy 2. Trips attracted for each policy are more or less same for each policy due to same maximum density constraint imposed. Thus policy 1 will produce a heavy load on networks connecting zones 1 & 24 which are already heavily loaded due passage of inter city traffic. Policy 2 gives more uniform distribution of trips which the existing network can cater without much modification. And also in this policy care has been taken for the inter city traffic by proposing a highway on the marginal bund on the north east side along the river Ganga.

The interactive package LUTIM (Land Use Transport Interaction Model) developed in this study opens up a whole new area of urban planning by way of bringing the medium size cities in the main stream of planning process. The easy and handy way of exploring transport implication will go a long way in improving the conditions of the medium size cities. The intensive graphic presentation in the package provides most lucid and comprehensive understanding of the model input and output for the planners and policy makers alike.

7.2 RECOMMENDATIONS FOR FURTHER WORK :

The results obtained and described in various charts and tables were within the scope and limitations described earlier. However, this study can be extended to make the package free from all limitations. First of all, the data should be made available at some what disaggreate level, such as, trip matrix by purpose and land use classification at zone level. These will allow to calibrate separate allocation function factors for the land price, housing cost in terms of rent, retail service activity magnitude etc. will allow calibration of multi-parameter allocation functions using gradient search technique.

Further, in the present study the transport implications have been studied in terms of pattern of travel generated or average trip length suggested by a given policy of land use distribution. Also it could identify the shifts in corridor of travel due to change in land use allocations. However, inclusion of traffic assignment in the process will provide link volumes which will directly show the transport implication at a much detailed level. Though it is a much labourious stage of transport planning process, it could identify the best land-use distribution for creating least congestion in the network. Alternatively, it will be possible to identify the network improvements required for chosen land-use.

BIBLIOGRAPHY

1. BARAS, E.M., Guide to Using LOTUS Tm 1-2-3™, (Osborne, Mc Graw Hill Singapore), (1988).

2. BATTY, M., Urban Modelling Algorithoms, Calibrations, Predictions, (Cambridge University Press, Cambridge), (1976).

3. BLUNDEN, W.R., and J.A. BLACK, The Land Use/Transport System, (Pergamon Press, New York), (1984).

4. CHADWICK, G., A Systems View of Planning", (Pergamon Press, Oxford), (1971).

5. DIXON, L.C.W., Non Linear Optimisation, (The English University Press Ltd., London), (1972).

6. FOOT, D., Operational Urban Model : An Introduction, (Methven & Co., New York), (1981).

7. GOLANY, G., New Town Planning :Principles and Practice (Willey-Interscience Publication, Canada), (1976).

8. KREYSZIG, E., Advanced Engineering Mathematics, (Willey Eastern Limited, Canada), (1985).

9. LEE C., Models in Planning, (PergamonPress, New York) (1973)

10. LEIBBRAND, K., Transportation And Town Planning, (Leonard Hill, Hill), (1964).

11. MCLOVGHLIN, J.B., Urban and Regional Planning, (Faber and Faber Ltd. London), (1969).

12. McMILLAN, C. AND GONZALRZ, R.F., System Analysis :A Computer Approach to Decision Models, (Pergamon Press, New York),(1971).

13. MITCHELL, R.B. and RAPKIN, C. Urban Traffic :A Function of Land Use, New York, (1954).

14. RAJARAMAN, V., Programming In FORTRAN -77 , (Prentice Hall Of India , New Delhi),(1981)

15. RAO, S. S., Optimisation ,(Tata McGraw Hill, Bombay),(1980)

16. REIF, B., Models in Urban and Regional Planning, (Intertext Educational Publishers, New York),(1973).

17. SIKDAR, P.K. and P.D.Porey, "Graphics Using PLOT88" Paper in Q.I.P. Course On "Computer Aided Drafting" (University Of Roorkee, June 1989).

18. WILSON, A.G.,Urban and Regional Models in Geography and Planning ,(John Willey & Sons, Bristol, UK),(1974).

19. YA DAU, C.,S.,Models in Urban Geography,(Concept Publishing Company, New Delhi), (1986).