THE GROWTH PROBLEMS OF GUWAHATI CITY AND ITS REGIONAL IMPACT

by

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This is to certify that **Sri Siddheswar Sarma** has carried his research work for his thesis entitled **THE GROWTH PROBLEMS OF GUWAHATI CITY AND ITS REGIONAL IMPACT** under my guidance. He fulfilled all the requirements laid down in the Regulation of Ph.D. Programme. The thesis is the result of his own investigation and neither the thesis as whole nor any part of it was submitted to any other University/Educational Institute for any research degree or diploma.

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CHAPTER - I

INTRODUCTION

Guwahati is a historically famed ancient city of the North-East India. The city is situated predominantly on the south bank of the mighty river Brahmaputra (though traces of the ancient settlements are found in the north bank also). The old city was situated within a fortified hill range, in an amphitheatre structure. The river Bharalu originates in the landlocked area east of the city and flows in a serpentine form, in the process draining the water of the city.

During the rainy season, both the Brahmaputra and the Bharalu swell and flood most of the low lying are of the basin land. This creates unspeakable problems to the city life. Since long, attempts have been made in a piecemeal to overcome this situation but with very little success. On the contrary, with the rapid rise in the population, settlement and resultant expansion of the city area, the problem has assumed a gigantic form.

Urban Planners, Gauhati Municipal Corporation and other connected organisations were faced with problems of measuring the spatial dimensions of this issue and their attempts to resolve the problems have not been successful. Therefore, it is believed that a geographer might

relieve this burden by providing a viable alternative to this problem which the people have endured till the present day.

A geographical approach to the problem needs a thorough investigation of various aspects of the environment. Naturally, it is proposed to explore the problem from the points of view of its relief and structure, drainage, soil composition, underground water level, climate, vegetation, etc., in relation to the urban hydrology and socio-cultural phenomenon. To this, another vital feature is added towards explaining the relationship between ecosystem and human geography - so that a balance in the habitability may be understood.

It is logical on the part of the geographers to accept the challenge of solving the colossal drainage problem, as faced by the Guwahati City. Guwahati itself is a regional urban centre and a gateway of North-East India. It has been, in the recent years experiencing rapid population growth and consequent mushrooming of settlements. This has overtaxed the existing municipal facilities as well as made the provision of minimum civic amenities a very difficult task to provide.

Like other classical cities of India, Guwahati has also negative effects of urban growth such as defective

road structure, drainage and sewerage facilities, lack of open spaces, public spaces etc. The cumulative actions of these unplanned growth of different wings of the city life has jeopardised the habitability of the city. To have a clear idea of the dimension of the problem and the dilemma of the city, it can be stated that:

> "The torrential rains last night inundated all the low-lying areas in the city particularly in Silpukhuri, Gandhibasti, Ambari, Islampur, Rehabari, Lachitnagar, Santipur, stretches along the R.G. Baruah Road. The rain waters entered thousands of homes forcing the inmates to spend a sleepless night. All roads passing through low-lying areas went under knee-deep waters. Large stretches of major roads including the G.N. Bordoloi, the R.G. Baruah Road, Fakkaruddin Ali (A.T.) Road and others were also topped by the rainwater".1

Another news report of 16th August, 1987, revealed that:

> "About one square kilometer area of the city around Pragjyotish College, on the west bank of the Bharalu river has been inundated by the back-flow of the river caused by the rising of the Brahmaputra above its tributary.
>
> The Bharalu which spilled over on Saturday (15th August 1987) last has forced a large number of families to leave their houses and take shelter at the relief camp

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1. A news report under the caption "Six Killed in Landslides, One Electrocuted", Published in The Assam Tribune, August 15, 1982.

> opened at the Kaliram Barooah Girls' High School at Bharalumukh. The camp housed a total of 450 inmates....
>
> Water from the Brahmaputra has also seeped into the Uzanbazar riverside areas of the city through the clustered network of underground drains which are actually meant to discharge sewage into the river...."2

The piecemeal remedies to this problem might have eased the problem temporarily, but it created graver problem in other areas. Thus the habitability of Guwahati particularly in certain localities have gone to the lowest ebb of city life. The empirical observations and patch work of the various organisations for improvement did not bear any definite result in the past. The problem then is evidently explicit - i.e., drainage and its associated aspects as relevant to Guwahati city.

I.1. **Nature and Purpose of the Study**

In the introductory part, a brief outline of Guwahati and its environs has been drawn up. The itinerary of Guwahati City leads us to belief that Guwahati, including North Guwahati was a fortified administrative centre of lower Assam during the pre Ahom age. The Guwahati had the reputation as the centre of astronomical studies where

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2. A news report under the caption "City Areas Flooded", Published in The Sentinel, August 17, 1987.

the settlements were confined to selected areas only. With the establishment of Shillong as the capital of Assam in the early part of British rule, Guwahati served as the gateway to the capital as well as to the rest of North-East. In due course of time, it achieved eminence in two social activities viz. education and commerce.

After shifting of capital of Assam from Shillong to Dispur in the eastern suburban of Guwahati, three exigent features cropped up. They were: (i) necessity for rebuilding the city, (ii) resolving the chronic problem of the city in war footing, and (iii) reconstruction of its ecology. Natural increase of population together with migration of large numbers of official staff, business communities and other associated personnel, tremendous congestion and chaos was suddenly created in the city. This extraordinary increase of population led to unplanned expansion of the city. On the other hand, the chronic problems of the older city remained pending over the people since long, demanding a rational resolution. The influx of people and reckless alteration of the landscape brought hazards to ecosystem of the city environs. The cumulative results of all these activities, tarnished the fair name of the old city and turned it into one of the dirtiest cities of the country.

In this scene of chaos and confusion, a trained geographer has enough scope for providing adequate spatial background for the dignosis of the root causes of the various problems and thereby suggest effective alternative remedial measures. For this purpose, two types of approaches will be necessary viz. qualitative and quantitative. For qualitative studies, detailed survey would be undertaken on various aspects of the city. Assistance have been taken mainly from: (i) Municipal Corporation, (ii) Flood Control Department, (iii) Town and Country Planning Organisation, (iv) Meteorological Observatory of India, Guwahati, and (v) Board for Prevention and Control Water and Air Pollution.

Here, the topic that has been selected primarily on the basis of: (i) low-lying areas of Greater Guwahati are filled up resulting in obstruction in sewerage and drainage, (ii) abrupt rise in population, (iii) rapid spatial expansion of the city, (iv) great strains on civic amenities, and (v) water logging problem during the period of rainy season especially after every heavy shower.

Therefore, in order to throw light on the root cause of the alien problems - this study is found to be useful and indispensable. However, this problem could be effectively solved under joint interdisciplinary endeavour and in this context geographers' viewpoint would be of immense benefit.

I.2 Hypothesis

In order to achieve the above objectives, following hypotheses were tested in the study area.

1) The mighty river Brahmaputra and three rivulets become ineffective due to topographic constraints in Greater Guwahati during flood season every year.
2) Water level of Brahmaputra, equals or exceeds to the danger level almost every year. At times all three rivulets, Bondajan, Bharalu and Khanajan receive water from their catchment area and inundate lowlying areas of most part of the city.
3) Rainfall intensity is higher during monsoon period and causes water logging in some parts of the city.
4) Population pressure over limited space and encroachment upon the land haphazardly became serious problem for proper planning.
5) Environmental degradation by hill cutting, earth-filling, deforestation together with water pollution and air pollution etc., turned Guwahati into ecological imbalanced region.
6) There is a grading of influence from Guwahati city to the surroundings, i.e. Guwhati's influence decreases as the distance from the city increases.

and (II) $COV = \frac{\sigma}{\bar{x}} \times 100$

where COV = Coefficient of variation of mean hourly rainfall

σ = Standard deviation

$\bar{x}$ = Mean hourly rainfall

The data regarding various levels of water in Brahmaputra of seven years (1980-1986) has been collected from Brahmaputra flood control Department for the monsoon period of 150 days (May to September). The average water level percentage of 150 days and cumulative percentage of 150 days have been computed.

For demarcation of the influence zone boundary the 'Gravity Potential Model' (based on Newtonian law of physics, modified one) has been used for Guwahati city and its surrounding towns. The model is as follows:

$$(I) \quad P_p = \frac{P_i}{d_{ij}}$$

where P_p = Population potential at a centre

P_i = Population of the town

d_{ij} = Distance between the main city and j-th town

Another model regarding the attraction of surrounding towns and main city Guwahati, the 'Breaking Point Model' has also been applied:

$$(II) \quad BP = \frac{d}{1 + \sqrt{\frac{PZ}{PY}}}$$

where BP = Breaking Point

d = Distance between the two trade centres

PZ = Population of larger city

PY = Population of smaller city

This way most of the parameters have been analysed and presented with the help of suitable diagrams and other cartographic (choropleths, isopleths etc.) aids.

I.4. **Arrangement of the Study**

It is observed that the growth problems of Guwahati demands an interdisciplinary approach for evolving a workable solution to the problem. Keeping these ideas in mind a detail survey in various aspects of geography, geology, ecology, hydrology etc. is envisaged for formulation of a workable solution. The survey has been obviously followed by interpretation, analysis and representation of the various phenomena. In order to cover these aspects of the problem, the work has been divided into nine major chapters.

In the chapter I, a concrete and brief description on nature and purpose of study area has been discussed.

A statement of the problem is also discussed in this chapter. The review of works in the past that had been attempted are discussed in chapter II. This provides a theoretical background towards formulating ideas on the theme of the present study.

The chapter III deals with the prospects and retrospects of the city in evolution where city changes from ancient times through historical ages, then to the modern age has been traced.

In the chapter IV, the geographical setting of the city is discussed, which is directly related to its evolution vis-a-vis the creation of the problem. The basic need of study of physical setting has been to understand the relief, drainage, and its basin area and the co-related phenomenon like geology, soil, climate and vegetation. The distribution of urban population, land-use pattern and nature of roads which affect drainage are the cultural setting. These are discussed in the later part of this chapter.

Chapter V is devoted for projecting the problem of the city - with reference to its drainage system. The qualitative, quantitative analysis has been made to evaluate the problem.

The physical landscape has been undergoing continuous transformation with the prospective growth of the city. Obviously man made environment, helps in creating certain advantages to human settlements, on the other hand, it indirectly disturbs the eco-system. Chapter VI, deals with the ecology of the city environ and its consequent setting at the present moment. The chapter VII deals with the planned and unplanned urban growth of the city. The functional classification and its peripheral dimension of the city is discussed in this chapter. The geo-social, geo-economic characteristics and the interaction pattern between the city and its neighbouring areas are studied in chapter VIII.

In the last chapter (Chapter IX), the entire work, an analysis and interpretation has been summarised. Further, on the basis of the empirical and quantitative observation contain concrete suggestions and proposals are forwarded for effective solution of the problem of the city.

CHAPTER - II

REVIEW OF LITERATURE

It is true that we do not have the Centre for Urban Studies like London Centre for Urban Studies, Chicago Centre for Urban Studies and Birmingham Centre for Urban Studies. The world of these urban centres links the expertise of geographers, sociologists, economists, traffic engineer, hydrologic engineers, planners and a host of other experts ask variants of the same question: What is the city? How does it function? What are its sustaining mechanism? What are its implications for human behaviour and economic development? Although a long way from resolving such questions, different scholars have tried to provide answers within the frameworks of legastic, historical, economic, sociological and psychological concepts.[1]

Geographical literature on the subject 'growth problems', especially on this part of the country is extremely meagre. The topic is undoubtedly broad in character where physical, social, economical approach etc. are required. In the physical approach, the expertise hydrological engineer role become vital and essential. A review

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1. B.T. Robson, 1969. Urban Analysis: A Study of City Structure with Special Reference to Sunderland, Cambridge University Press, London, pp. 3-35.

of these studies are essential towards understanding the types of work done, the approaches, and the methods used in them, as well as the findings arrived at from those studies and the limitations of them in different situations. Nevertheless, a geographer has a wide scope to contribute towards the conceptual framework of the problem. Naturally, a review of the past attempts, however, meagre, might throw light towards the assessment and evaluation of the achieved results.

The topic on growth problem, and drainage congestion on a city in particular needs systematic multivariate analysis, on its geographical setting, the land slope that controls the runoff, nature of the streamflow and drainage of the area. There are many physiographic and physical variables that affect the hydrologic and hydraulic aspects of urban stormwater runoff.[2] Until recently, little attention was paid to urban drainage research. There exists a serious need for much more extensive investigation consistent with the huge public expenditure in these fields, in India in general, and North-East in particular.

In 1851, T.J. Mulvaney made some observations of the relations of rainfall and flood discharges in a given

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2. S.W. Jen and M.B. Mcpherson, "Quantitative, Determination of Urban Stormwater Runoff", ed., V.T. Chow, Handbook of Applied Hydrology.

catchment by using self registering rain and flood gauges.[3] To measure the drainage problem and impending flood, resulting from rainfall in the surrounding catchment area, and peak runoff, there are many empirical or semi-empirical models. However, a representative of these models can be suitably applied for evaluation and estimations. The model applied in this case has certain advantages e.g. (i) it is simple and popular, (ii) it is easier to compute, (iii) it has been recommended by Calcutta Metropolitan Planning Organisation for designing the drainage basins of the Gauhati Metropolitan area in their project report in 1971. Das,[4] applied this model in his paper "Storm Drainage and Sewerage designs in High Rainfall Intensity Urban Areas" and obtained fruitful results.

In the meanwhile, a number of formula - have been evolved to evaluate the drainage problem on the basis of slope of a terrain. There are several methods of average slope determination of which Wentworth's method is a "general and random" method and is easier to follow. Guy

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3. V.T. Chow, 1962. "Hydrologic Determination of Waterway Areas for the Design of Drainage Structures in Small Drainage Basin", University of Illinois Eng. Expt. Sta. Bull., p. 462.

4. B.K. Das, 1982. "Storm Drainage and Sewerage Designs in High Rainfall Intensity Urban Areas", Seminar Proceedings, The Institute of Engineers (India), Assam State Centre, Sept. 14-16.

Harold Smith applied the technique for practical demonstration. The best example of his work was the Relative Relief Map of Ohio (1935). But in geologically and physiographically complex regions, this technique does not hold good. Raisz and Henry had tried to apply other methods to eliminate the defects of Smith's methods. In 1948, A.H. Robinson devised another method by which quantitatively accurate relief map showing slope variation could be made. In the recent past K.P. Dhurandher[5] has made a more rational approach to this method of determining slope of land surfaces and attempted modifications by replacing one of the most powerful component (average number of contour crossing per mile).

Drainage system has a direct bearing on the urban landuse pattern. While evaluating the drainage structure, quantitatively, it is imperative to keep a close eye on the existing and potential landuse in the urban centres. Dey, perhaps was a pioneer in evolving a methodology for landuse planning and engineering alternatives for flood plain management. But his attempt was introduced for specific purpose viz. landuse planning and development activities for optimum allocation of land for residential,

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5. K.P. Dhurandher, 1981. "A More Rational Approach to the Determination of Slope of Land Surfaces", Abstract, NAGI, Second Annual Conference.

commercial and open spaces. A methodology on landuse zoning was presented by Cortes Rivera (1973). The applicability of this proposed methodology, appears to be restricted to upland watershed with predominant agricultural activity.

Similarly, Darryl W., Davis (1975) determined optimal sizes of components of urban flood control system from detailed simulation analysis. Flood control measures within urban areas are required to take into cognigence of the presence of complex systems of detention and storage, reservoirs, water and sewage distribution systems, channel modifications, levees, land-use controls, flood proofing and pumping facilities.

S.W. Jens and M.B. McPherson co-author of a paper on "quantitative determination of urban-storm runoff" discussed empirical models critically. According to them, the engineers of late 19th century developed empirical formula to determine design discharge for storm drains through a general model

$$Q = CAI(\frac{S}{A})^x$$

Where Q is the peak discharge in cfs, 'C' is a coefficient, depending on climatic and physiographic conditions of the watershed, 'A' is the drainage area in acres,

'I' is the average rainfall intensity in inch per hour, 'S' is the slope of drainage basin in ft. per 1,000 ft. and 'x' is an exponent.

The value of 'x' has been computed differently by different authors e.g. in the famous Burkli-Ziegler Model, x = 0.25 in McMath formula, x = 0.5. The 'C' value of both the models varies from 0.20 in pervious rural areas to 0.75 in highly impervious built-up areas. About 100 empirical models have been collected by Chow,[6] in order to find out a workable model for determining the run off.

On the other hand, the critical review on the rational method currently used by many design engineers,[7] is usually expressed in terms of the following equation:

$$Q = CIA$$

Where 'Q' is the peak discharge in cfs*, 'C' is the run-off coefficient, depending on the flow characteristics of the drainage area, 'I' is the uniform rate of

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6. V.T. Chow, 1962. "Hydrologic Determination of Waterway Areas for the Design of Drainage Structures in Small Drainage Basin", University of Illinois, Eng. Expt. Sta. Bull., p. 462.

7. "Design and Construction of Sanitary and Storm Sewers". American Society of Civil Engineers, Manuals of Engineering Practice, No. 37, or Water Pollution Control Federation Manual of Practice, No. 9, 1960.

*cfs = cubic feet per second.

rainfall intensity in inch per hour for a duration equal to the time of concentration, and 'A' is the drainage area in acres.

The refinements of the rational method have been suggested by Gregory and Arnold[8] in 1932 and developed a general rational formula. They took into account some factors like watershed, shape and slope, the pattern of the stream system, and the elements of channel flow. Bernard[9] further modified the runoff coefficient in the general rational formula for particular area of the humid central and eastern half of the United States. Though they modified for specific cause the original rational formula of Kuichling[10] has been in use till the present day.

Now-a-days, the society become urbanised (in exception of Britain), and city's impact on its surrounding areas is undoubtedly of great significance. The socio-

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8. R.L. Gregory and C.E. Arnold, 1932. "Runoff - Rational Runoff Formulas", Trans. Am. Soc. Civil Engrs, Vol.96, pp. 1038-1099.

9. Merril Bernard, 1938. "Modified Rational Method of Estimating Flood Flows", Appendix A, in Low Dams, National Resource Committee, Washington.

10. Emil Kuichling, 1889. "The Relation Between the Rainfall and Discharge of Sewers in Populous Districts", Trans. Am. Soc. Civil Engre., Vol. 20, pp.1-56.

economic relationships in terms of space (physiography, location etc.) between cities and their surrounding areas are vital aspects of the spatial organisation of urban and rural societies. An understanding of the patterns and processes of such relationship is essential for designing policies of socio-economic development and transformation.

Growth problems of the cities were dealt with by many geographers alongwith human settlement and geography; these were limited mainly to the study of urban settlements as isolated units with little concern for physiographic region. Richthofen and Hettner extended their works in the field of settlement geography.[11] Schluter developed the methods of studying the internal pattern and layout of cities in 1899.[12] Following the work of Hassert,[13] subsequent works did much to define the scope and methodology of urban geography in Germany. Subsequently many studies of European cities had been coming up. Contribution of Patrick Geddes whose formulations of principles of urban growth and structure were popularised in Britain

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11. R.E. Dickinson, 1969. The Makers of Modern Geography, Routledge and Kegan Paul Ltd., London, pp. 78-80, 116-118.

12. Harold M. Mayer, 1954. "Urban Geography", ed. Preston E. James and Clarence F. Jones, American Geography: Inventory and Prospects, Syracuse University Press, p.144.

13. Ibid.

and brought to the attention of the students of urbanism in the United States by Lewis Mumford.[14] They emphasised on the problems of cities, growing out of rapid urbanisation but given less emphasised on city's impact on its surroundings. Later Raoul Blanchard recognized the 'city-region' study as one of the basic themes of urban settlement through his works on Annecy, Quebec and Montreal.[15] Further Maximilian Sorre has given some attention to the study of urban functions, morphology, physical structure, population and also study the impact of the urban centre on its surroundings.[16]

R.E. Dickinson elaborates (his paper "The Scope and Status of Urban Geography: An Assessment") on the Geographic approach to the study of a specific urban settlement. He stated that the task of the geographer in an urban study is to determine the characteristics of the site and situation of the urban settlement, its historical development, and the limits which has currently attained. The article is also concerned with comparative functional and morphological studies and presents a valuable review of the significant papers that have contributed

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14. Idem.
15. R.E. Dickinson, Op.cit., pp. 234-36.
16. Ibid., p. 238.

to a better understanding of the location, spacing, and size of the cities, and their layout and build. Prior to this work, he published "City Region and Regionalism"[17] and "City and Region"[18] which can be summarised as follows: Every urban centre has close relations with the group of village and town which surround it. The entire area, therefore, represents a geographical association of human space relationships and by virtue of its centralised activity acquires a sort of homogeneous character. The natural area which has a certain amount of homogeneity in socio-economic activities, cultural intercourse, human developments and space relationships may be called a 'region'. An urban centre with the group of towns and rural settlements surrounding it constitutes a distinctly marked region called the 'city region'.

In course of time, geography experienced interdisciplinary approaches and introducing mathematical model into it became vanity. David Ricardo (1817) was developing J.H. Von Thunen formula[19] which he formulated in an agri-

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17. R.E. Dickinson, 1960. City-Region and Regionalism: A Geographical Contribution to Human Ecology, Routledge & Kegan Paul Ltd., London.

18. R.E. Dickinson, 1964. City and Region: A Geographical Interpretation, Routledge and Kegan Paul Ltd., London.

19. Reference from Richard S. Thoman and Peter B. Corbin, 1974, The Geography of Economic Activity, McGraw-Hill Book Company, London, pp. 183-84.

cultural context, of most significance to geographic analysis in general and to economic and urban analysis in particular. It revealed the usefulness and the ubiquity of the basic geographic variable - 'distance', in influencing not only agricultural structures but all spatial economic systems. 'Central place theory', developed by the German geographer W. Christaller[20] earlier this century, based on observations concerning settlement patterns and functions in Bavaria, provides an economic interpretation of the size, spacing, and functional activities found in cities. But this theory is not applicable to manufacturing or other specialized activity.[21] The Gravity and potential models based on Newtonian law of physics was borrowed by Ravenstein (1885, 1889),[22] Stewart (1942)[23] and zipf (1949)[24] etc. They worked out mathematical rules

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20. W. Christaller, 1966. Central Places in Southern Germany (Translated from die Zentralen Orte in Suddentschland), Englewood Cliffs, Prentice-Hall, Inc., New Jersey.

21. Truman A. Hartshorn and John W. Alexander, 1988. Economic Geography, Prentice-Hall of India Private Ltd., New Delhi, p. 278.

22. E.G. Ravenstein, 1885-1889, "The Laws of Migration", Journal of Royal Statistical Society, Vol. 48, pp. 167-235 and Vol. 52, pp. 493-96.

23. J.Q. Stewart, 1942. "A Measure of the Influence of Population at Distance", Sociometry, Vol. 5, pp. 63-71.

24. G.K. Zipf, 1949. Human Behavior and Principle of Least Effort, Addison-Wesley, Cambridge.

pertaining to the distribution and support of population with a slight modification, one after another. A fundamental criticism was that the gravity model and potential surface of interaction appeared to be empirical regularities that lacked the basis of a persuasive theoretical rationale.[25] Though the model had been used primarily for descriptive purposes it could be used also for prescriptive purposes[26] as this sometimes appeared as a disturbing factor to the geographers.[27]

A series of studies was carried by the Indian Geographers on different towns and cities. They were R.L. Singh (on Banaras), S.M. Alam (on Hyderabad-Secunderabad), V.A. Janaki and Z.A. Sayed (on Padra town), N.R. Kar (on Calcutta), A.N. Agarwala (on Kanpur), K.R. Dikshit (on Poona), S. Nangia (on Delhi), C.D. Deshpande, B. Arunachalam and L.S. Bhat (on South Kolaba, Maharashtra).

The problem of delimitation of the rural-urban fringe, and characteistics of such area has been studied

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25. R.L. Merrill and R. Earickson, 1969. "Problems of Modelling Interaction", in K. Cox and R. Gollege (eds.), Behavioral Problems in Geography, Northwestern University Press, Evanston.

26. R.L. Merrill and M.b. Kelley, 1970. "The Simulation of Hospital Use and the Estimation of Location Efficiency", Geogr. Anal, Vol. 2, pp. 283-300.

27. M. Yeates, 1974. An Introduction to Quantitative Analysis in Human Geography, McGraw-Hill Book Company, New York, p. 131.

in the Indian context (Banaras).[28] Alam[29] seems to correctly differentiate two sets of indices for delineating the hinterland: i) which reflect the impact, and ii) which represent the central functions. In defining the boundary Janaki and Sayed[30] have taken into account the flow of exact amount of different kinds of goods to and from Padra, and the number of people visiting Padra for different kinds of services from the surrounding area. Kar[31] also dealt with the economic relationship of Calcutta with its neighbouring areas based on business activities such as collection of raw materials and supply of finished products. Apart from the identification of the interflows of goods (consumer goods, capital goods etc.) Agarwala[32] gave little idea about the spatial pattern of interflow

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28. R.L. Singh, 1955. Banaras: A Study in Urban Geography, Nand Kishore and Bros, Banaras.

29. S.M. Alam, 1965. Hyderabad-Secunderabad (Twin Cities): A Study in Urban Geography, Asia Publications Pvt. Ltd., Bombay..

30. V.A. Janaki and Z.A. Sayed, 1962. The Geography of Padra Town, Baroda University Press, Baroda.

31. N.R. Kar, 1963. "Economic Character of Metropolitan Sphere of Influence of Calcutta", Geographical Review of India, June, pp. 108-137.

32. A.N. Agarwala, 1969. "Interaction Between the Metropolis and the Hinterland in the Kanpur Region", in P.B. Desa, ed. Regional Perspective of Industrial and Urban Growth: The Case of Kanpur, Bombay, pp. 191-202.

between Kanpur and its hinterland. Dikshit and Sawant[33] studied city-hinterland relationship of Poona. The unit of observations used by them were so small, that they seemed to give some erroneous results. S. Nangia[34] studied a single city region Delhi. In her study, distance was the main factor for growth, and included density of population, percentage of worker engaged in tertiary activities which shows inverse relationship with distance. C.D. Deshpande, and others[35] studied the "Impact of a Metropolitan City on the Surrounding Region" which enlightened and encouraged the Indian geographers to study the virgin cities of India with the same methodology. The findings of the study served to sieve out the strategy for development appreciate to the local conditions. Further, the methodology adopted for this study could be used to geographers, social scientists, planners and administrators.

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33. K.R. Dikshit and S.B. Sawant, 1968. "Hinterland as a Region, its Type, Hierarchy, Demarcation and Characteristics: The Characteristics: The Case of Poona", The National Geographical Review of India, Vol. 14, pp. 1-22.

34. S. Nangia, 1976. Delhi Metropolitan Region: A Study in Settlement Geography, K.B. Publications, New Delhi.

35. C.D. Deshpande et al., 1980. Impact of a Metropolitan City on the Surrounding Region: A Study of South Kolaba, Maharashtra, Concept Publishing Company, New Delhi.

It is high time, we realised that the (so called) western path of industrialisation-urbanisation-modernisation is not the best path for Indian situation. At the same time we must clearly recognise the essential role of urbanisation in the process of economic growth and social change. Ashis Bose[36] warned that eversince the partition of India and tremendous influx of refugees to all the border states of India, squatting on Government lands has been increasing. In this way many colonies have been built without any municipal sanction and total disregard of municipal regulations. The fear part of it is the influence of these foreign elements over urban centres neutralise or pollute the urban environment. The spatial extent of impact should be studied not only according to size of the urban centre, but from variable to variable as studied by H.N. Sharma[37] in his doctoral thesis "Elements of Urban Impact on Rural Society in India". He attempted to explore the extent of the spread of city's influence and the pattern of urban induced effects in India as reflected in the economic, demographic and social characteristics over the areas. Planning for Guwahati (as it is premier

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36. A. Bose, 1978. India's Urbanisation (1901-2001), Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

37. H.N. Sharma, 1975. "Elements of Urban Impact on Rural Society in India: A Spatial Analysis". Unpublished Ph.D. Dissertation, Syracuse University.

city of North Eastern Region) requires a thorough study of the socio-economic characteristics in relation to physiographical aspects (nature of climate, river etc). Though a study carried out by J. Borah[38] on 'Spatial Structure of Urban Influence' in terms of socio-economic activities, a detail physiographic study in relation to those elements could have given better idea for future planning. Further S. Sarma[39] emphasised in this study 'Drainage and Urban Development' taking relief, rainfall and nature of river inside the city as the major parameters. He suggested some remedial measures to improve the situation in the city.

The Gauhati Municipal Corporation had long been trying to tackle and solve the problems of Greater Guwahati. Town and Country Planning Organisation of the Government of Assam has been working in coordination with Municipality rendering technical advice and in execution of such projects. The Department of Flood Control and Irrigation has also stepped into the scene, and extended help in

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38. J. Borah, 1985. Spatial Structure of Urban Influence in the Neighbouring Areas of Gauhati City, Inter-India Publications, New Delhi.

39. S. Sarma, 1985. "Drainage and Urban Development: Case Study of the Greater Guwahati Region", Hill Geographer, Vol. IV, No. 2, pp. 37-44.

resectioning, degrading, constructing sluice gates wherever necessary and diverting the stream flow to relieve the urban area from flood. The Calcutta Metropolitan Planning Organisation (C.M.P.O.), Government of West Bengal conducted a detailed study on the problems of Guwahati, and prepared a Master Plan for Greater Guwahati.[40] This plan was entrusted to the Guwahati Development Authority for implementation. Unfortunately, due to lack of sufficient financial allocation and other difficulties, the Guwahati Development Authority and (subsequently since 1973) the Guwahati Municipal Corporation could do very little to check the haphazard growth of the city. Further the adopted plan was valid only upto 1986. In view of the above, the Town and Country Planning Organisation found it imperative to revise the Master Plan prepared earlier so as to enable them to guide the growth and development pattern of Guwahati in a planned manner.[41]

A few years back (1982),[42] the Institution of Engineers held a well attended seminar. Engineers, architects,

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40. A Report on "Master Plan for Water Supply, Sewerage and Drainage for Gauhati Metropolitan District, 1971-2001". Prepared by Calcutta Metropolitan Planning Organisation, 1971.

41. The Assam Gazette, Extraordinary Issue No. 129, Dispur, 24th December, 1986, Government of Assam, pp. 925-926.

42. Seminar on Developmental Problems of the City of Guwahati, organized by the Institution of Engineers (India), Assam State Centre, Sept.14-16, 1982.

economists, senior citizens and other people connected with the development process attended the seminar and presented thought provoking papers. The recommendations of the seminar were finalised by a Committee of senior persons. Like other seminars, the organisers pulled down the curtain at that point. The Government of Assam also thought of organising a seminar on the same topic on 'Development of Guwahati' but ultimately it could not be held(?). It was followed by another seminar[43] on 'Greater Guwahati-Better Guwahati' where a good number of papers were presented which suggested controlled measures for the betterment of the city in the right perspective. Significantly, a study on average slope and rainfall analysis on Greater Guwahati is lacking behind in the above series of seminars. A recent seminar organised by non-governmental city based social organisation (Ashinam)[44] has once again served to focus the attention of the people to the urgent tasks of saving the city from chaos and anarchy. Repeated seminars on same colossal problem is a welcome and praiseworthy decision taken by different organisations and equally it indicated serious matter that Guwahati lost its ancient glory.

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43. Seminar on Greater Guwahati-Better Guwahati organized by the Assam Engineering Service Association, 6th-8th January 1987.

44. Seminar on Save Guwahati organised by the ASHINAM, 13th June, 1987.

Environmental pollution is not only associated with industrial growth but also with the pressure of poputation on scarce natural resources. Urbanisation without town planning is a cause of land pollution. Lack of basic civic amenities such as sanitation, water supply, housing in urban areas led to the problems of waste disposal. The continuous influx of population from rural areas to urban areas has added to this problem. Such study has been carried out recently by T.K. Misra.[45]

P.K. Bora[46] warns through his paper "Greater Guwahati - Better Guwhati":

> "that each litre of fuel consumed by diesel engine produce about twice as much hydrocarbon pollution as do petrol engines and nearly the same amount of oxides of Nitrogen, emissions from petrol engines contain 58 times as much carbon monoxide as do emissions from diesel engine. Considering both varieties of automobile Guwahatians may be in for some shocking revelations if and when some systematic atmospheric pollution study is undertaken".

With this background work, it is attempted to give a full appraisal of the growth problem of the premier

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45. T.K. Misra, 1982. "Studies on Some Water Pollutants", Unpublished Ph.D. Thesis, Visva Bharati, Santiniketan.

46. P.K. Bora, 1987. Greater Guwahati - Better Guwahati, Seminar Paper, the Assam Engineering Service Association, 6th-8th January, 1987.

city of Assam. Literature, facts and information regarding the actual dimension of the problem cannot be gauged from the scattered information that lie haphazardly in various departments. The available information are in piecemeal. Through these, it is difficult to build the framework of the real problem and to suggest workable solutions. This is where, the necessity of a geographer's intrusion is felt to be indispensable and useful.

CHAPTER - III

PROSPECTS AND RETROSPECTS OF THE CITY IN EVOLUTION

III. 1. Guwahati During Classical Age

Guwahati is an ancient and famous town of Assam. The historical antiquities of the city is gleaned from various sources. The sources are: i) ancient scriptures, ii) earlier inscriptions; iii) earlier literature, and iv) account of early foreign travellers and historians.

Ancient scripture like Kiskindhya Ramayana described as Pragjyotisa was a city built on an extensive sea-side mountain known as 'Varaha' with golden peaks. The whole city was built with gold and was ruled over by a Danava known by the name of Naraka.[1] Kalikapurana explains Pragjyotispura as the abode of 'Brahma', god of creation, who created stars and planets here in Pragjyotispura. This signifies that this was the city where study of astrology on a scientific basis was initiated. The word Pragjyotispura derived as prag - pre, jyotis - astrology and pur* - town, meaning the town or place of 'old astrological centre'. The present Navagraha stands as the evidence

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1. D. Sarma, 1981. Kamarupasasanavali, edited, Publication Board, Assam, Gauhati, pp. 8-9 (from Kiskindhya VIII in original Devanagar's script).

* 'Pura' is a sanskritised dravidian word meaning town or city.

of the ancient seat of astronomical studies in the city. The temple of nine planets with 'tole'* epitomises the ancient heritage of the city.

The inscription on the copper plate of Dharmapala Raja depicts certain sanskrit verses, where it has referred the name of Kamrup Nagar. Different sources ascertain it and refers to both Kamrupa and Pragjyotisa as a kingdom and as a capital city underwent changes at different periods. And it is specifically known that the name Pragjyotispura, is much older than the name 'Kamarupa'.

In classical literature, reference regarding the ancient city are abundantly found. The great classical poet, Kalidasa, in his epical literature, Raghuvmsa, had mentioned about the foundation of the Pragjyotispura. He mentioned Kamrupa along with the river Lauhitya.[2] The verse reads as follows:

Chakampe Tirualauhitya Tasmin Pragjyotisesvarah
Tamisah Kamarupanamtyakhandalabikramam.

Raghu IV. 81-83.

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* 'tole' is a place of learning in old age, i.e. school or institution.

2. D. Sarma, 1981. Kamrupasasanavali, edited, Publication Board, Assam, Gauhati, p. 10.

Huen Tsang, a Chinese explorer, visited Assam in 640 A.D. He recorded his observation in his travel diary about Kamarupa. At that time Kumar Bhaskar Varma was in the throne of Kamrupa. Baruah wrote in his "Early History of Kamrupa", that:

> "The kingdom came to be known as Kamrupa during the puranic time based on the legend that Kamadeva, the God of love - the Indian Cupid - who was destroyed by the fiery glance of Shiva returned to life in this country".3

After analysing the literatures, the 'Inscription of Ancient Assam' (M.M. Sharma) and 'the Role of Tambula in Assam's Social Life' (M. Neog), the capital city of Pragjyotisa, it was ascertained that modern name Gauhati was derived at a later stage. This is confirmed from the following verse:

> tambulavalliparinaddhapuga
> krisnaguruskandhanivesitailam.[4]

This meant that there were aracanut (tambula) trees, which used to be covered by encricling betel leaf creepers, and the trunks of the black sandal trees which used to

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3. K.L. Baruah, 1933. Early History of Kamarupa, K.L. Baruah, Shillong, p.11.

4. M.M. Sharma, 1978. "Inscriptions of Ancient Assam", Gauhati University, p. 129 (from "The Uttarbarbil Copper Plates of Balavarman III).

be encircled by the cardamom trees. From this rows of the arecanut the name of Guwahati seems to be originated. The "Guwa" is an Assamese pronouncing word of "Guvaka" (tambula) of Sanskrit and "Hati" is a row of trees i.e. "Guwahati" means rows of arecanut trees. This name Guwahati embraces both sides of the bank of Brahmaputra. It is obvious that the name of Gauhati is a corrupted offshoot of the word Guwahati - which was coined by the British. This English name of Gauhati was again recoined as Guwahati to revive the tradition.[5]

The main evidences, of classical age to know a particular place, the abandoned ancient citadel, curved stones, stone pillar, beautiful finished slab, remains of once famous temples, bricks, mortar and earthware etc. are utilised by the archaeologists and antiquarians. This, however, helped to find the missing links between the past and the present city in evolution. Fortification of this capital city, was done by joining almost all hillocks on the north and the south bank of the city, for protection from external aggression. This amply exhibits

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5. The Government of Assam has issued instruction to all Departments to use the spelling of Guwahati in place of Gauhati in all official correspondences, notification etc. with effect from August 15, 1985.

the remarkable engineering skill of the old planning engineers. The temples of Kamakhya, Umananda, Navagraha, Manikarneswar and Asvakranta which were built on the hillocks also prove the glory of the ancient architecture. Likewise, Sukresvar, Banesvar, Ugratara and Chatrakar where built on plan. All these temples of both north and south bank of Guwahati indicated immense monumental value and serve the religious thirst of the people. The scattered relics of the old monuments clearly indicated that Guwahati was definitely famous for religious and cultural activities of the region.

II.2. **Guwahati During Ahom Period (1625 A.D. to 1826 A.D.)**

Prior to the invasion of the Ahoms in 1625 A.D. Guwahati remained as a prominent centre of the western plain of the Assam Valley. For a short period, Guwahati was the capital of the Koch Kingdom. Ahom occupied both the banks of Brahmaputra, and in place of Pragjyotishpur, the Ahom rulers used the name Guwahata or Guwahati. Perhaps during the early part of the Ahom reign, the functional centre was shifted to the south bank, where the present Guwahati is located. From the historical records, it may be mentioned that almost all the battles against the Mughals were fought from this headquarters. For strategic reasons, the capital was shifted from north bank to south

bank thereafter. Guwahati - during Ahom period comprised the area between the foot of the Kamakhya hill and Navagraha hill including Kharghuli. In the north-south direction, Guwahati extended from the river Brahmaputra to Chalabil (Map 1).[6]

There were as many as ten chowky (Garrison gateway) constructed around Guwahati, including North Guwahati for its security and protection. Karoipani chowky, Patduar, Sendurighopa, Chilar chowky and Kanaibarashiboa chowky, are on the north bank, while Pandu, Duargaria, Dharamduar, Jaiduar and Latasil pani chowky are in the south bank.[7] Both the Kanaibarashiboa chowky of north bank and Jaiduar chowky of south bank were the eastern most gateway to Guwahati. The Chilar chowky on Momaikata garh of the north bank and Pandu chowky on the south bank of the Brahmaputra were the western gateway to Guwahati.

The "garh"* of Pre Ahom period were renovated and made strong as wall against Muhammedans. Mamaikata garh

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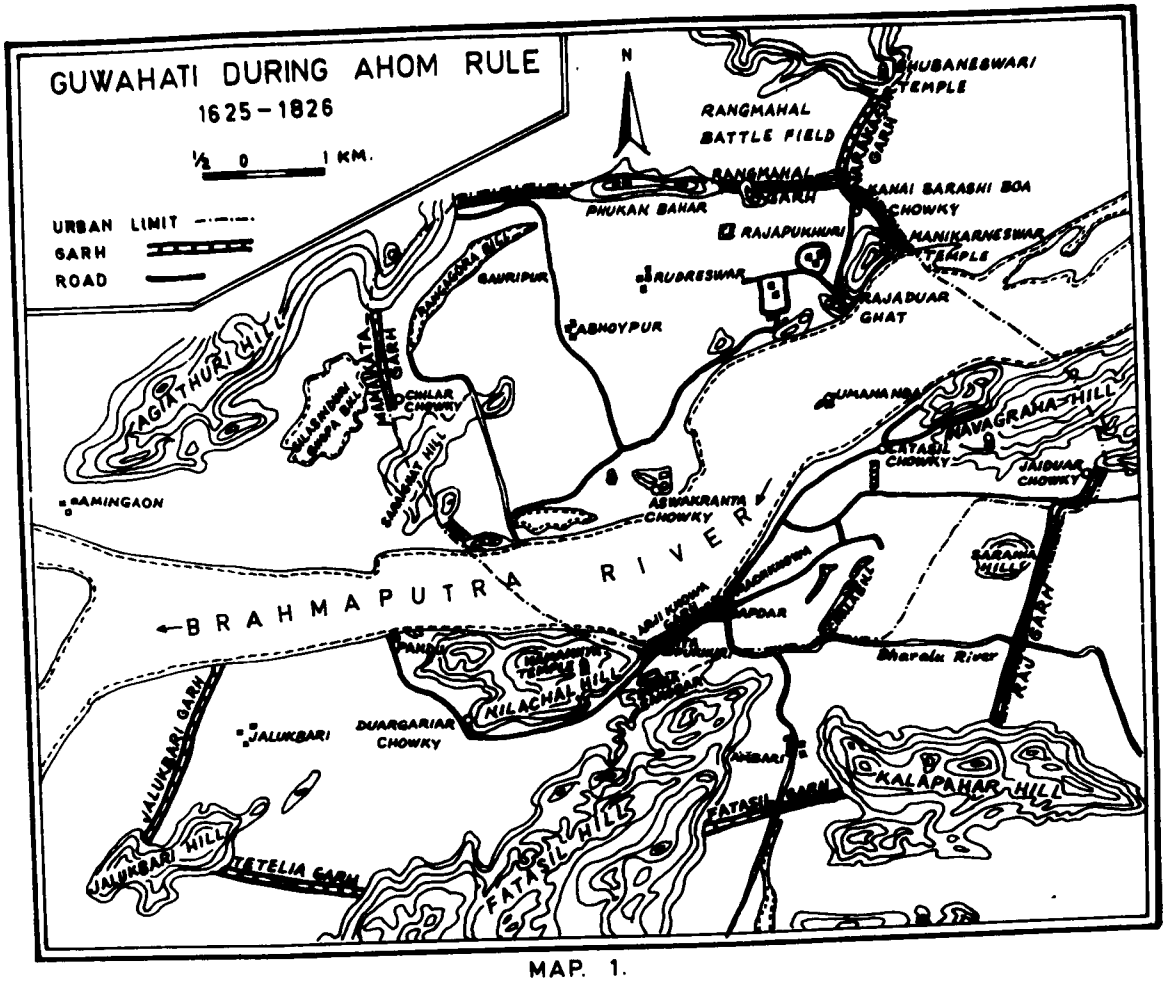
6. N.N. Bhattacharyya, 1977. "Gauhati: A Study in Urban Morphology", Ph.D. Thesis, Gauhati University, p. 52.
7. Murari Charan Das, "Yuge Yuge Guwahatir Ruprekha", Paura Bichitra, (G.M.C. Journal), 1st Issue, 1978, (Assamese Section), p. 15.

* "garh" is a local term meaning fortification of wall like embankment encircles capital town.


GUWAHATI DURING AHOM RULE
1625 – 1826
½ 0 1 KM.
URBAN LIMIT
GARH
ROAD
N
BHUBANESWARI TEMPLE
RANGMAHAL BATTLE FIELD
RANGMAHAL GARH
KANAI BARASHI BOA CHOWKY
PHUKAN BAHAR
RAJAPUKHURI
MANIKARNESWAR TEMPLE
GANRIPUR
RUDRESWAR
RAJADUAR GHAT
ABHOYPUR
KAGIATHURI HILL
CHILAKHANDI GARH
CHILAR CHOWKY
SARAIGHAT HILL
UMANANDA
NAVAGRAHA HILL
KATASIL CHOWKY
JAIDUAR CHOWKY
SAMINGAON
ASWAKRANTA CHOWKY
BRAHMAPUTRA RIVER
SARANIA HILL
PANDU
NILACHAL HILL
DUARGARIAR CHOWKY
Maraia River
JALUKBARI
JALUKBARI GARH
JALUKBARI HILL
TETELIA GARH
FATASIL HILL
KALAPAHAR HILL

MAP. 1.

is known for its great historic events along with the Rangmahal and Narakasur garh on the north bank; Jalukbari, Tetelia, Fatasil, Rajgarh on the south bank are still found in dilapidated form (Map 1).

There were regular boat service between the ghats at Rajduar, Asvakranta and Pandu, Boats were the only means of communication between north and south bank. As Guwahati was the regional headquarters of the Ahom rulers, the office of Barphukan (Chief Commander) was located on the west of the confluence of the Bharalu and the Brahmaputra river. Near Uzanbazar, there was a place of royal armory, known as Kharghuli. This was a strategically important garrison of the chief Commander of Guwahati.

III.3. Guwahati During British Period (1826 A.D. to 1947 A.D.)

After the treaty of Yandabo, Assam came under the control of East India Company in 1826. However, till 1836, the British could not establish any effective administrative control over Guwahati. In the absence of civic amenities and poor hygienic condition, the British soldiers suffered from various diseases. The British Officers, however, constituted a town improvement committee to look after the affairs of the town,[8] and perhaps for this reason

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8. V.V. Rao, 1978. "Early History of the Gauhati Municipal Board", Paura Bichitra (Journal of G.M.C., Gauhati), 1st Issue, (English Section), p.9.

the capital was shifted from Guwahati to Shillong. Though the capital was shifted to Shillong, Guwahati remained as the administrative headquarters of Assam. In the year 1878, Gauhati Municipality Board was formed and the first task of the municipality was to construct a water supply plant. At that time the municipal area was constituted of eight wards, covering 6.5 Sq.Km. and Shillong was linked with Guwahati by a narrow cart road.

By the year 1897 railways were extended from North Bengal to Guwahati and Upper Assam, Cachar was also linked by rail line in stages. Several other roads were also constructed by the public works department to and from Guwahati joining various important places.[9] The major road links noteworthy of their importance were constructed. These were: (1) Guwahati to Shillong (G.S. Road), (2) Guwahati to Agia (A.T. Road), (3) Guwahati to Kalong River (A.T. Road), (4) Guwahati to Digaru River (Old Nowgong or Sonapur Road), and (5) Guwahati to Mawphlang via Nongkhlaw.

Educational and cultural function of the town was geared up during the British period. Cotton College in

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9. W.W. Hunter, 1879. A Statistical Account of Assam, Trubner and Co., London, p. 55.

1901, the Curzon Hall (Nabin Bardoloi Hall) in 1903, the Assam State Musuem in 1940 were established in stages at Guwahati. Gradual growth of urban population was responsible for improvement of the amenities in the town. Subsequently, the municipality was expanded in 1940, and the area was extended to 7.5 Sq.Km.[10]

Guwahati witnessed the horrors of the Second World War. During this period, Guwahati was used as a strong holds of the British army. Civil Lines and Cantonments were constructed in the heart of the town, besides there was a face lift of the town with addition of new lines of transport and communication (Map 2).

III.4 Guwahati During Post Independence Period (1947 A.D. to 1986 A.D.)

There is difference between pre independent and post independent India. In the pre independent period the British administrators were busy in consolidation of their power and little interests were shown for improvement of the towns. The multifaced growth and development were envisaged only in the post independent period. During the post independent period, especially in planning periods, the following additions were made: (i) High Court of Assam,

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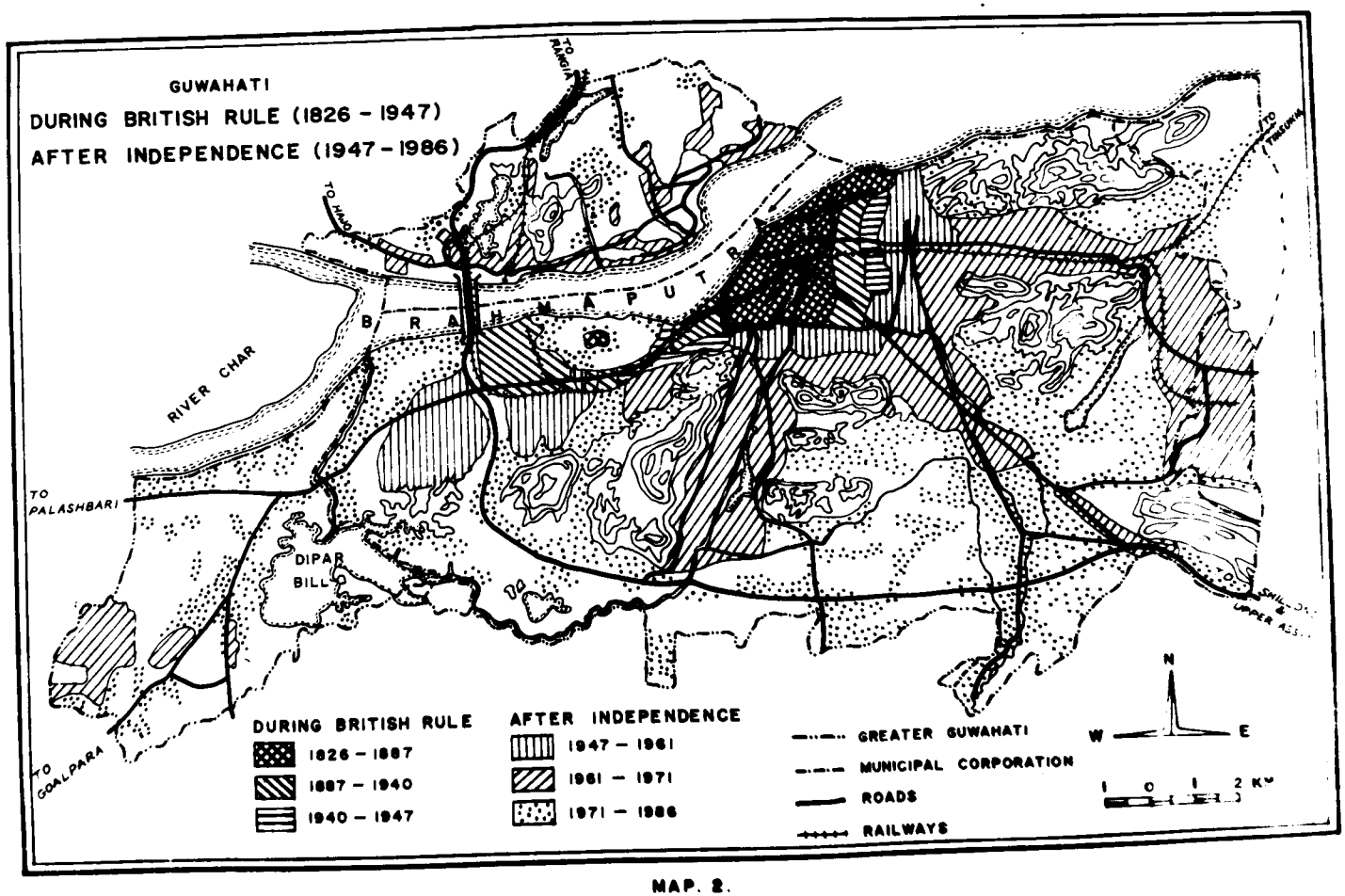
10. N.N. Bhattacharyya, 1977. "Gauhati: A Study in Urban Morphology", Ph.D. Thesis, Gauhati University, p.65.


GUWAHATI
DURING BRITISH RULE (1826 - 1947)
AFTER INDEPENDENCE (1947 - 1986)
TO RANGIA
TO HAJO
TO TEZPUR
B R A H M A P U T R A
RIVER CHAR
TO PALASHBARI
DIPAR BILL
TO GOALPARA
TO SHILLONG & UPPER ASSAM
DURING BRITISH RULE
1826 - 1887
1887 - 1940
1940 - 1947
AFTER INDEPENDENCE
1947 - 1961
1961 - 1971
1971 - 1986
GREATER GUWAHATI
MUNICIPAL CORPORATION
ROADS
RAILWAYS
N
W
E
1 0 1 2 K.M

MAP. 2.

(ii) All India Radio, and (iii) Gauhati University, and (iv) Railway Headquarters. Besides these, the State Central Library, the Assam Engineering College, the Gauhati Medical College etc. have been established in stages. All these new additions in the urban functions, have naturally enhanced the administrative as well as commercial functions in the city.

Consequently, the population of the town increased from 48,615 in 1951 to 100,707 in 1961.[11] The municipal jurisdiction was also increased from 7.68 Sq. Km in 1951 to 14.24 Sq. Km. in 1961 by including three more wards. In the mean time, multiple nuclei was developing from the core of the town towards the periphery. The Railway Station at New Guwahati, the Industrial Estate at Bamunimaidan, the Oil Refinery along with subsidiary industry at Noonmati, Military Cantonment at Satgaon, Military Hospital at Bashistha, the State Police Battalion at Kalapahar, the Airport with airforce Headquarters at Azara, all these had cumulatively expanded the spatial dimension of the Guwahati City (Map 2). The landmarks in the history of Guwahati, was the construction of the Saraighat Bridge

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11. Census of India, 1971, Assam, Series -3, Part V-B, Special Survey Reports on Selected Town -Gauhati, 1978, p. 4.

across the Brahmaputra in the year 1962. The significance and functional importance of Guwahati radically changed and magnified, when the North-Eastern States were politically reorganised into seven States. The North-Eastern States were linked with the mainland by a narrow corridor of about 14 Km. Guwahati is the major centre of this link, and served as the main gateway to the areas east of Guwahati. Growth of Guwahati accelerated with the shifting of capital from Shillong to Dispur in the year 1973 (in the eastern outskirt of the city).[12]

After independence, a large number of migrants (particularly refugees) from neighbouring countries like Bangladesh, Nepal, and Burma and job seekers from other States of India came to Guwahati, besides having spread themselves in the whole N.E. Region and the region which added to the growing complexity of the problem.[13] Ultimately, Gauhati Municipal Corporation, had to extend its area of jurisdiction to 216.19 Sq.Km (in the year 1974).

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12. The Assam Gazette, Extraordinary Issue, No. 129, Dispur, 24th Dec., 1986, p. 925.

13. R. Gopalakrishnan, 1984. "Some Theoretical Considerations in the Analysis of Immigration into the Brahmaputra Valley", The North-Eastern Hill University Journal of Social Sciences and Humanities, Vol. II, No.4, Oct. - Dec., p. 39.

At present, Greater Guwahati is composed of one Municipal Corporation, two town committees, fifteen special areas like Railway, Refinery, Gauhati University and Defence areas with 82 villages covering a total area of 243.2 Sq. Km. (95 Sq. miles).[14] Radical changes in its functional behaviour has not only made the city life uncomfortable, but also created innumerable problems. The abrupt growth of population, encroachment upon the open land and disturbances caused to ecosystem have led to serious consequences that are familiar to unplanned city development.

The trend and tendencies of its past history profusely indicated expansion of Gauhati Municipal Corporation into a metropolies in the near future; and of the problem faced by it, particularly those that are connected with the drainage, are not resolved immediately, it will compound its growth.

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14. A Report on "Master Plan for Water Supply, Sewerage, and Drainage for Gauhati Metropolitan District, 1971-2001", Submitted to the Government of Assamy by Calcutta Metropolitan Planning Organisation, 1971, pp.2-3, 2-4.

CHAPTER - IV

GEOGRAPHICAL SETTING OF GUWAHATI

IV.1. Physical Setting

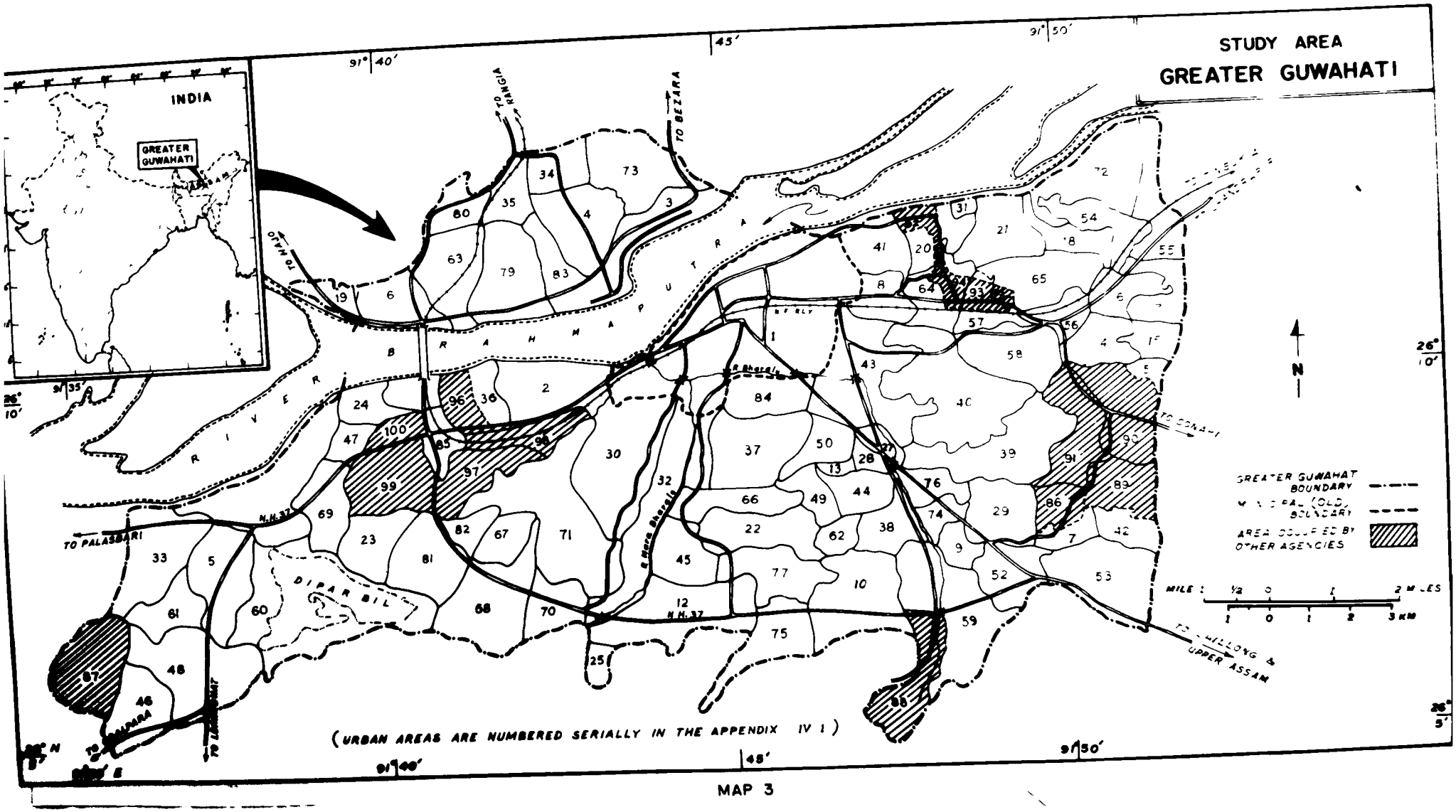
IV.1.a. Location, Relief and Drainage

Location

Guwahati is the largest urban centre of Assam, possessing a strong, cultural, commercial and administrative base. The core of the city is located on the crescent shaped south bank of the mighty river Brahmaputra and lies at the point of intersection of 26°10'45" north latitude and 91°45'00" east longitude (Map 3). The total area of Greater Guwahati is 243.2 Sq.Km (95 Sq.miles) including a small area of 23 Sq.Km (9 Sq.miles) in the north of the river Brahmaputra (Map 3), known by the name North Guwahati. Guwahati City urban agglomerations and their constituent units, includes one Municipal Corporation; two Town Committee, fifteen other areas occupied by Defence Department; Railway Colony, Refinery Colony, University Campus and eighty two villages (Appendix - I). But the present service area of the city is confined to the municipal jurisdiction only.

Relief

The physical configuration of Guwahati City environs exhibits a peculiar structure, unparallel in other parts of the country. The mighty Brahmaputra flows through


STUDY AREA
GREATER GUWAHATI
INDIA
GREATER GUWAHATI
ASSAM
TO KNGIA
TO BEZARA
TO HAJO
B R A H M A P U T R A
R I V E R
N.F. RLY
TO PALASBARI
N.H.37
DIPAR BIL
TO GUWAHATI
TO MILLONG & UPPER ASSAM
TO BARPARA
GREATER GUWAHAT BOUNDARY
AREA DOUBLED BY OTHER AGENCIES
MILE : ½ 0 1 2 MILES
1 0 1 2 3 KM
N
91°40'
45'
91°50'
26° 10'
26° 5'
(URBAN AREAS ARE NUMBERED SERIALLY IN THE APPENDIX IV I)

MAP 3

the alluvial tract dividing into two distinct parts, north and south. In the centre of the river Brahmaputra lies the rocky island in which the famous "Umananda" temple is located. The original city is located within a crescent shaped basin, surrounded by lofty hills. The hills are outliers of the Meghalaya Plateau, predominantly residual in character. They are composed of granites and gneissic rocks with their outer cover of weathered red soil. The hills have steep slopes but from the foot zone, the slopes become gradual upto the river bank in the north. As a result, an undulating plain has emerged with swamps and low-lying areas in between. The original settlement were mostly located on the elevated plain and the foothill zones. Thus, the low-lying areas, smooth terrains and some hillocks of varying elevations present a peculiar relief of the area.

the bench mark of the G.T.S. (Great Trigonometrical Survey) near the Deputy Commissioner's Office is 54.7478 m, while 52.1988 m is recorded near the Railway Station above mean sea level. With an average elevation of 51.3 m in the southern bank of the Brahmaputra, it rises up toward Kharghuli and Chittrachal (Navagraha) hill range in the east (216 m) and Nilachal hill (303 m) in the central part. The average elevation of the low lying areas is

49 m and the lowest is 41.16 m M.S.L. This land gradually rises to Khasi Hills to a maximum elevation of 575 m which forms the southern boundary. Again, there are areas near Chittrachal hills with a general elevation of 182 m toward east and southern plain of 49 m elevation. In between the Khasi Hills and the Brahmaputra river lies the Sarania hills (250 m), the Fatasil hill range (358 m) and the Kalapahar Narakasur hill range (200-300 m). Though the hills are not suitable for development due to their rocky surfaces and steep slopes, in recent years some of these hills have been illegally occupied by many people. This has created many civic problems. Bounded by the hilly range on the north, Meghalaya Plateau on the south and east and the Fatasil hill on the west, lies the broad plain which can be termed as Beltola Plain. This Beltola plain is 15 Km long with an average width of about 4 Km. This is the only potential area for future development of Guwahati City.[1] The present capital Dispur, is located in this Beltola plain. A vast low-lying areas of Dipar bil occupies more than 54 Sq. Km on the western part of the city.[2] Moreover, there are low-lying plain intervened

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1. The Assam Gazette, Extraordinary Issue, No. 129, Dispur, 24th December, 1986, p. 928.
2. A report on "Master Plan for Water Supply, Sewerage and Drainage" for Gauhati Metropolitan District: 1971-2001, recommended by Calcutta Metropolitan Planning Organisation, 1971, pp. 2-8.

by scattered swamps and marshes in between the hills extending east to west. These low-lying areas are often inundated at the time of heavy rainfall.

Though, the North-Eastern India as a whole falls under the seismic zone, Guwahati is situated on hard and stable foundation. The earthquake of 1950 having the magnitude of 8.5 in the Richter scale did not produce any major casualty in the area.[3]

Drainage

The existing natural drainage of the Greater Guwahati is the mighty Brahmaputra, and its tributaries such as Bharalu, Marabharalu, Barapani, Khanajan, Bondajan, Ghorajan and Barnadi. River Brahmaputra flows along the north of the core area of the city. Other rivers drain out the water into the River Brahmaputra. The river Brahmaputra is as narrow as 1.5 Km near the city in comparison to other places where it is of 15 to 20 Km wide.

Though, the velocity and level of water in the Brahmaputra fluctuates often, especially in the monsoon period, the main features like discharge and water level

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3. M.C. Poddar, 1952. "Preliminary Report of the Assam Earthquake", 15th August 1950, Bul. Geol. Surv. India, Vol. 2, pp. 11-13.

of Brahmaputra, are responsible for flood during the monsoon season every year. The maximum and minimum discharges of Brahmaputra is 72,717 cumec and 2,735 cumec while the highest and lowest water levels are recorded at 51.04 m and 40.23 m above mean sea level.[4] It may be mentioned that the flood danger level mark at Guwahati is 49.68 m which also represents the average ground level of the area.

River Bharalu flows through the alluvial depression of Guwahati Municipal Corporation area and flows into the river Brahmaputra at Bharalumukh located on the western boundary of old Guwahati Town.

On the north bank of river Brahmaputra, the river Ghorajan flows from low-lying swampy areas of Ghorajan Bil via Namalijalah Bil and discharges into river Brahmaputra just to the western end of Barbil. The river Barnadi which demarcates the eastern boundary of North Guwahati basin of Greater Guwahati, discharges into the Brahmaputra by the side of Manikarneswar hills. This is also a rainfed river with its catchment area around the northern plain of the Brahmaputra.

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4. Brahmaputra Board, with due permission of Secretary of the Board, Guwahati.

The river Barapani (Basistha) originates in the northern slope of Khasi Hills passes through Basistha on the southern side of Kalapahar and flows into the Maranadi. It drains into the Dipar Bil. Both the Maranadi and Mara-Bharalu are dead rivers of Bijubari area that lies inside the triangle bounded by Fatasil Road, Lakhra Road and National Highway.

The river Khana is another drainage stream of south bank of Brahmaputra which has its source at Dipar Bil (a swamp). It is worth mentioning that Dipar Bil receives enormous supply of water through the river Kalmoni whose sources is in the Khasi Hills. From this point of view, the river Khana is significant, so far as the drainage of the city area is concerned. Similarly, in the eastern boundary the Bondajan having its source in Silsako Bil (a swamp), drains the water of the eastern sector of the city into the Brahmaputra. Truly speaking, the entire course of Bondajan from Silsako Bil to the Brahmaputra is an extensive marsh.

The physical configuration of the city area and the drainage pattern are such that the excess water in the city hardly finds any effective outlet especially during the rainy season. On the contrary, the eastern and western drains namely, Khanajan and Bondajan, help

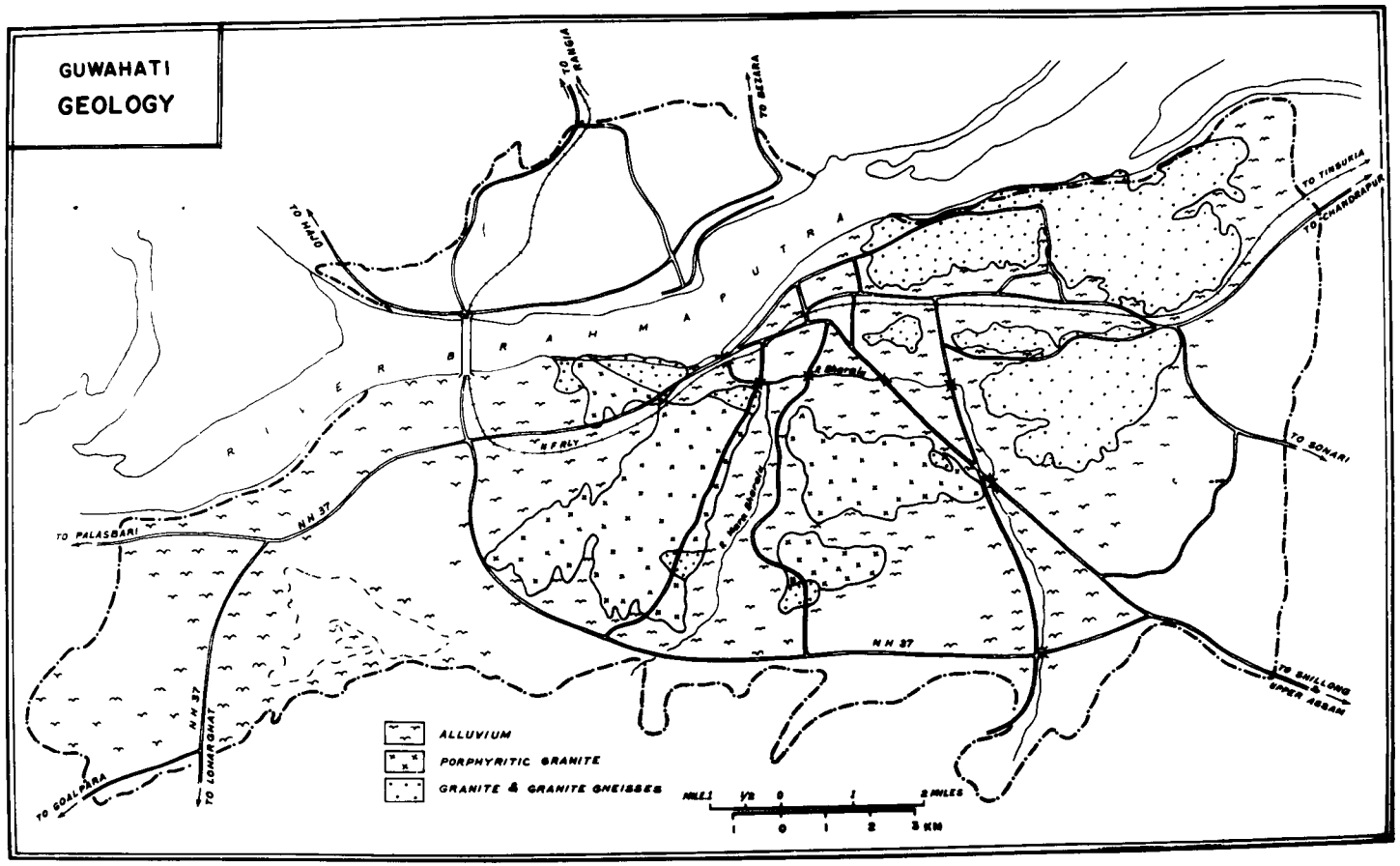
in creating occasional floods in the city by backflow of the water from the Brahmaputra specially in the rainy season.

IV.1.b. **Geology and Soil of Guwahati**

Geology

The old town was located on highlands, composed of the outlier of the Meghalaya Plateau belonging to the precambrian age. The intervening low-lying areas were filled up by alluvium brought by the Brahmaputra, through its back wash, infill was augmented and expedited by the eroded materials from the highlands of the neighbouring areas. So, basically the city area is composed of archaean rocks and but intervening areas are formed of the infilled alluvium. These filled up areas have assumed the plain character where most of the settlements are located.

There are two distinct geological formations in Guwahati and its environs. The flat alluvial plains includes the low-lying and marshy areas. The vast alluvial plain lies on the eastern part of the city known as Beltola plain and marshy tracts of Dipar Bil area on the west. The alluvial plains of Brahmaputra are interrupted by residual hillocks formed by the pre-cambrian gneisses and schists. The gravels, sands, sandy clay, silt and clays of the valley-fill areas vary in texture both vertically and horizontally. The numerous archaean inliers



BASED ON GEOLOGICAL SURVEY OF INDIA'S MAP

MAP 4

are projected scatterdly above the general landscape in and around the city. The Fatasil hill range, Kalapahar - Narakasur hill range and Sonaighul hills are dominated by porphyritic granites. The Kharghuli-Chittrachal hill range, Noonmati, Hengrabari, Madgharia hill range and Sarania hill are formed by granite and granitic gneisses. The Nilachal hill is composed of the continuation of porphyritic granite and granitic gneisses (Map 4). It should be noted that the hard rocks store water in joints, cracks and crevices which perpetually drains out in the form of springs. Such springs are observed in several places in the foothill regions.

From the geological formations, it is quite evident that the transported material constitute the greater part of the habitable land of the city. The pre-cambrian rocks, on the other hand, provide useful constructional materials. Thus, the Geology has restricted the spatial growth of the town considerably. On the other hand, the swamps, marshes and the infilled areas now provide the scope for expansion of settlements.

Soil

The soils of the city depicts a combination of both red soil material, mostly formed a decomposed rocks and the transported materials brought in by the river

Brahmaputra. The hilly areas are composed of purely lateritic soil with poor organic matter whereas the plain region has much fertile soils composed of sand silt, clay or sandy clay. The entire foreshore of Brahmaputra is formed of alluvial sands whereas the inner plains are composed of clay sand or sandy clay soil. The blue clay is exceptionally found at the foothills areas specially in selected parts. The sands are permeable and have better seapage capacity, whereas the sandy clays and clay sand soils have less permeability. However, the later type of soil has got higher water retentive capacity and are suitable for horticultural purposes. The low permeability of the transported lateritic soil of the plain is also a drawback which is responsible for water logging in certain places.

IV.1.c. **Basin Area**

The Basin area of Guwahati includes some more areas beyond the administrative boundary of Municipal Corporation. These areas have direct hydrological linkage with the city drainage system. Hence, a considerable area is added with the present Greater Guwahati for specific study and analysis. On inclusion of the adjacent area, the total catchment area of drainage basin extends to about 183.50 square kilometre .[5]

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5. A Report on "Master Plan for Water Supply, Sewerage Drainage" for Gauhati Metropolitan District: 1971-2001, recommended by Calcutta Metropolitan Planning Organisation, 1971, pp. 17-3.

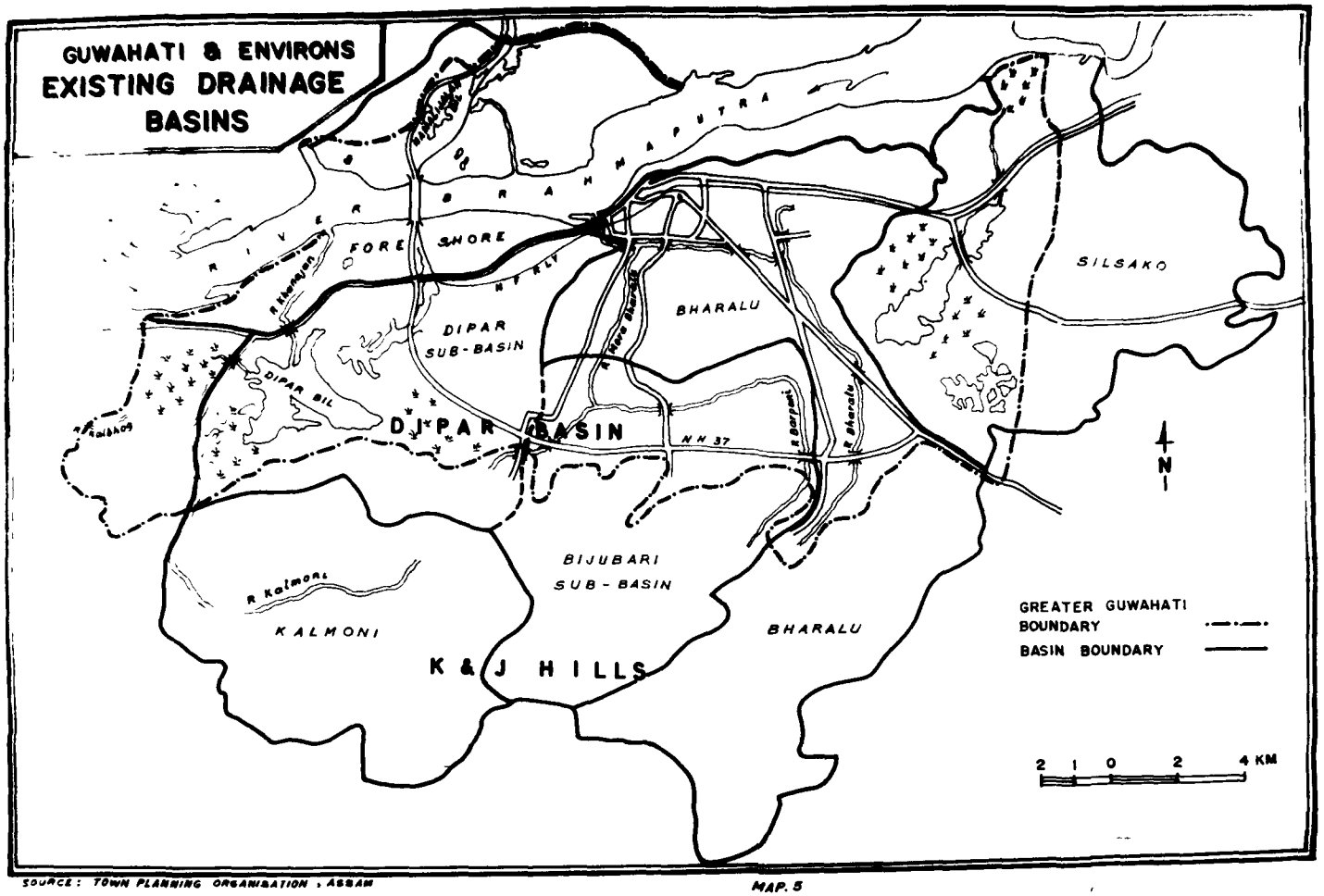
From the physiographic consideration, the catchment area may be divided into six distinct regions. They are i) Silsako Basin, ii) Bharalu Basin, iii) Dipar Basin, iv) Foreshore Basin, v) North Guwahati Basin, and vi) Kalmoni Basin (Map 5). All these sub-basins drain either through or the outskirts of the city due to physiographic convergence of the drains towards the river Brahmaputra.

i) **Silsako Basin**

The Silsako basin is situated in the east of Greater Guwahati. The basin is surrounded by hill ranges on the east, the National Highway 37 on the south, the Assam Trunk Road on the west and the Brahmaputra on the north. The basin area is bounded by hill tracts with large low-lying areas of Silsako Bil. The river Bonda flows through this basin to the Brahmaputra. The total catchment area of this basin is 92.6 square kilometre.

ii) **Bharalu Basin**

The Bharalu basin is located almost in the central part of Guwahati Municipal area. On the east is the Silsako basin, on the south and south-east the Meghalaya hill, on the north the narrow strip of Foreshore basin, and on the west lies the Dipar basin. The river Bharalu originates in Meghalaya hills and is known as Bahini, emerges out into the plain. Taking a meandering course on the



SOURCE : TOWN PLANNING ORGANISATION , ASSAM

MAP. 5

eastern rampart of the Kalapahar, meets the Brahmaputra in its northernly course. The total catchment area of this basin including hills is 120 square kilometre.

iii) **Dipar Basin**

The basin is surrounded by Foreshore basin on the north, Bharalu basin on the east and Kalmoni on the south. The western boundary of this basin is the Kalmoni river. Significantly the basin encloses Dipar Bil (Lake) in the western margin. The stream Basistha (known as Barapani) also flows through the basin which has its source in Meghalaya hills. These two conspicuous landmarks further help in identifying two ditinct features of the basin. The basin thus may be divided into: a) Bijubari sector, and b) Dipar basin is drained out by the Khana river which falls down to the river Brahmaputra and makes the western boundary of the Greater Guwahati. The total area of this basin is 133.5 square kilometre.

iv) **Foreshore Basin**

A narrow elongated patch lies along the south bank of the river Brahmaputra which extend from the foothills of Chittrachal to Garalgaon, is called Foreshore Basin. it is comparatively uniform in elevation along the Brahmaputra. The total area of this basin is 34.9 square kilometre.

v) **North Guwahati Basin**

This is the only isolated basin situated in the north bank of the river Brahmaputra. This basin is bounded by the river Barnadi on the east and the river Brahmaputra on the south. The northern and western sides are bounded by hill ranges. The main feature of this basin is that the river Ghorajan, drains to the Brahmaputra through Namalijalah Bil. The total area occupied by this basin is 32.3 square kilometre.

vi) **Kalmoni Basin**

The whole basin falls outside the Greater Guwahati and situated within the Meghalaya Plateau. As the city drainage area falls under the impact of Kalmoni Basin, it has been included in the physiographic jurisdiction of the city area. The river Kalmoni originates from the innumerable spring, rivulets and streams and drains into Dipar Bil. The total area of this basin is 66.5 square kilometre.

IV.1.d. **Climate and Vegetation of Guwahati**

Climate: The characteristic features of weather and climate of Guwahati is similar to the climate of Assam in a general way. Guwahati, being a micro-region, the local climate is influenced by its physiography and has an individual character of its own. Due to its physiographic structure like scattered hillocks and hill ranges,

extensive water bodies, vegetation etc., plays a significant role on the local climate of city. On the other hand, the latitudinal location together with physiographic conditions of Guwahati apparently modified the subtropical climate of North-East India. The average annual rainfall at Guwahati is 163 cm. About 90 per cent of this rain occurs between April to September. From the trend, tendency and distribution of elements like temperature, rainfall rainy days and fog (Table IV.1), the climate may be divided into four distinct seasons, i) Winter, ii) Pre-monsoon, iii) Monsoon, and iv) Retreating Monsoon.

i) **Winter Season**

The month of December, January and February constitute the winter season at Guwahati. Foggy morning clear night with sunny noon makes the weather cool and pleasant. January is the coldest month with an average temperature of 12.5°C. But in late January temperature occasionally lowers to 8.2°C. High clouds are seen, which are occasionally followed by medium clouds and rain.

ii) **Premonsoon**

The month of March, April and may constitute the premonsoon season. This is a transitional period between warm summer and the wet monsoon. The temperature steadily increases from March (23.25°C) to May (26.35°C). During

TABLE IV.1

Mean Temperature, Rainfall and Fog of Guwahati

(Based on Observations from 1931 to 1960)

Seasons		Mean Temperature (in °C)	Rainfall (in cm)	Rainy Days	Fog (No.of Days)
Winter	- December	18.70	0.51	Less than 1	22
	January	12.50	1.14	1.2	18
	February	19.55	1.83	1.8	3
Pre-Monsoon	- March	23.35	5.34	4.2	1.4
	April	25.95	12.59	8.3	0.9
	May	26.35	27.36	15.1	0
Monsoon	- June	28.10	29.34	14.6	0
	July	28.95	30.15	14.2	0
	August	29.00	26.30	11.4	0
	September	26.65	19.01	9.5	0.5
Retreating Monsoon	- October	26.25	9.01	4.8	5
	November	22.30	1.15	1.3	11
Annual Total			163.73	86	62

Source: Climatological Tables of Observatories in India (1931-1960), India Meteorological Department, p. 325.

the month of late February and middle of March, Guwahati experiences dust storms of local origin. This is due to the prolonged desication and exposure of the ground and lowering of water level of the Brahmaputra channel. The bed of the Brahmaputra is the major source of supply of dust and sands, which make occasional uncomfortable weather in the Guwahati and its suburbs. In late March, local storms of higher intensity visit the area, which are associated with gale and hail. These are locally known as "Bordoichila". Due to peculiar topography the winds sometimes moves from east to west together with north-west wind. The storms may continue for several days and develop fine weather in every evening. The recession of the stormy weather with alternating sunny days, prelude the on coming of the monsoon season over Assam.

iii) **Monsoon**

the real monsoon period starts from the month of June and continues upto the end of September. This is the period of heavy rainfall, which usually cause floods in Guwahati. July is the rainiest month having an average rainfall of 30.15 cm. The month of August records highest temperature for this period with an average temperature 29.00°C. It should be mentioned that the south-west monsoon prevails in Assam by the middle of June. The first spell

of monsoon rain becomes incessant for days together and is locally termed as 'saath'.

It is to be noted that due to adabatic winds, the monsoon weather is associated with thunderstorms and occurs usually during the day time.[6] The annual frequency of thunderstorms at Guwahati is high as compared to other stations of the Assam Valley.

Annual Frequency

Guwahati	119 days	Dibrugarh	113 days
Tezpur	100 days	Mazbat	63 days
Jorhat	83 days	N. Lakhimpur	69 days

iv) **Retreating Monsoon**

The monsoon retreats from Guwahati as well as from Assam in the last week of September or first week of October. In this period the low pressure system becomes weaker and the monsoon current also becomes weaker. For such persistent rain, the temperature falls considerably and the atmospheric pressure increases. With the advance of the season, the ground cooling begins and morning fog appears. The weather progressively clear up with sunny

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6. barthakur, M. "Weather and Climate of Assam", North East India Geographical Society, Extension Lecture, Series, No.2.

days till the end of November. The retreating monsoon constitutes the most comfortable and pleasant weather of the year at Guwahati.

Vegetation

There is practically no big forest or jungles in the urban area of Guwahati. Only the hill ranges and hillocks in surrounding areas are covered with scattered trees, shrubs and grasses. Most of the areas of present Guwahati were formerly covered with forest and jungles, which were subsequently cleared for settlements. The Bamunimaidan, Noonmati industrial estate and the refinery area which constitute the extended part of the city at present, was covered with thick jungles and marshes till the late sixties. The present residual vegetation of the city area may be classified as mixed tropical deciduous forest. Unfortunately very little amount of natural species are left in the city area. This indiscriminate removal of natural vegetation has created ecological problem, which can hardly be mitigated by artificial afforestation. This is because, of rapid expansion of settlements - that has left hardly any space for large scale plantations. The residential areas - exhibit species of arecanut, coconut, mango, jackfruit, banana, neems, etc. In the recent past, the social forestry division of forest department,

Government of Assam has started plantation on road sides, vacant government lands and at the outskirts of the public grounds to meet the deficiencies of vegetation in the crowded city. The schemes of social forestry has duel aims of creating plantation of rapid growing species for providing fuel and to bring back the lost eco-balance.

IV. 2. **Cultural Setting**

IV.2.a. **Settlement Pattern of Guwahati**

Human tendency to settle nearby river side is a common phenomena since prehistoric time. In case of Guwahati too, there are old settlement developed by the side of the river Brahmaputra. The Uzanbazar on the south bank of Brahmaputra is the old nucleus of the town. At the mighty Brahmaputra stands as a rigid barrier, it limits the expansion of settlement on the northern border, but the first phase of the town grew up around a single central axis, i.e. Uzanbazar-Panbazar-Fancybazar axis. The town gradually spread along the main roads towards the east, west and south.

After complete occupation of the highland the people filled up the marshes, and at the same time started encroachment towards the hills defying all statutory provisions under municipal regulation. These unplanned clustered settlement in the city region - has led to varieties of problems.

The Meghalaya hills on the south is the political and physical limit of the city which restrict the expansion of the city towards south. The mushroom growth of unplanned built up of the city townscape in different nuclei have unduly constrained the ideal pattern of the city development. In addition to original urban core of Fancybazar - Panbazar - Uzanbazar, the functionality of the city has spread over to Santipur - Bharalumukh - Machkhowa, Athgaon-Paltanbazar, Silpukhuri - Chandmari - Noonmati, Sarania - Lachitnagar, Ulubari - Rihabari, Fatasil - Ambari, Maligaon - Pandu, Jalukbari, Narengi -Satgaon and Dispur - Khanapara area.

There are significant variations in the clustered settlement sizes in the different parts of the Greater Guwahati. Large size clustered like Dharapur (5593), Ajara (4856) etc. are more common in the western side of the city, while the clustered in the eastern side are relatively small. The Satgaon (2083), Khanapara (2281), Chandrapur (1151) are some of the big size appendages in the eastern side of the city.

The large size commercial nuclei in the northern side are dynamic, while in the southern parts the settlements are varying in size. The sprawling tendency of the city from the core is rather horizontal than vertical.

Marshes and low-lying areas were filled up and occupied by swarms of migrants, causing horizontal spread of settlement in disorganised forms. This is one of the vital cause for frequent water logging in most part of the ramped city plain.

IV.2.b. **Population Structure of Guwahati**

The total population of Guwahati in 1981* was estimated at 4,51,200. The city is one of the most populous city of North-East India. Besides this population (residential) every day approximately a lakh of people commute to Guwahati of which a residual amount remains as floating population in the city. These population are magnetised to the city from Nalbari (71 kilometre), Rangia (52 kilometre), Baihata Charali (33 Kilometre), Sualkuchi (37 Kilometre), Hajo (29 kilometre) in the north, Palasbari (25 kilometre), Bijaynagar (33 Kilometre), Rampur (26 Kilometre), Chayagaon (45 Kilometre), Boko (63 Kilometre) and Rajapara (75 Kilometre) in the west; Chandrapur (26 kilometre), Sonapur (31 Kilometre), Khetri (42 Kilometre), Panikhaiti (15 Kilometre), Jagiroad (55 Kilometre) and Byrnihat (20 Kilometre) in the east.

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* In 1981 Census Operation could not be done due to prolong agitation in Assam on 'Foreign National Issue'. Hence it was projected by Town and Country Planning Department.

Besides, about 59.27 per cent of the total population of Guwahati had migrated to this city (Figure 1) while the non-migration constitute only 40.73 per cent (1971 Census). The source of migration with their percentage to the total migration of population are as follows: from Kamrup, Nalbari and Barpeta district (17.07 per cent), from other district of Assam (15.12 per cent), from outside Assam (16.92 per cent), and from outside India (10.62 per cent). Further out of the total migrants from outside India, about 70.52 per cent come from Bangladesh and 15.50 per cent from Nepal. The migration of population from Bihar (41.90 per cent), West Bengal (12.62 per cent), Rajasthan (10.47 per cent), Meghalaya (10.20 per cent) and Uttar Pradesh (9.61 per cent), constitutes the main source of migration from outside Assam.

Density of population of an area is giving a true picture of landform ratio. In general density of population, outward from the city centre progressively declines as the distance from the city increases. Moreover in the case of Guwahati the physiological or real density* can be measured in terms of habitable areas only. Because

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* Physiology Density or Real Density $= \frac{\text{Total Population}}{\text{Habitable Areas}}$

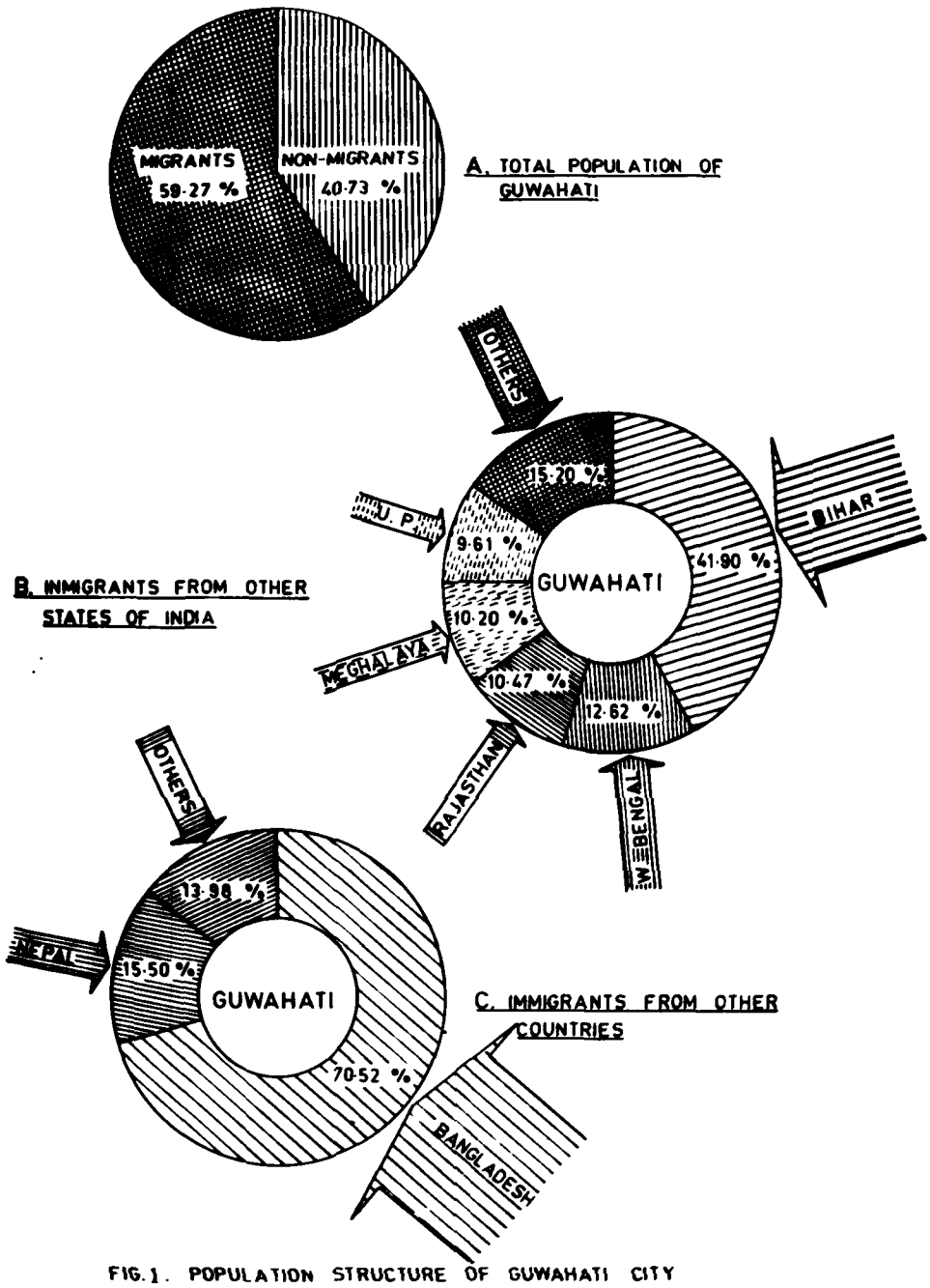

FIG. 1. POPULATION STRUCTURE OF GUWAHATI CITY

large portion of the Greater Guwahati are covered by hills, swamps, bills and other water bodies. The density of population in the urban agglomeration is 4,573 persons per square kilometre,[7] while for the peri-urban village comes down to 2,511 persons per square kilometre. In some pockets the density of population is as low as 75 persons per square kilometre or less. Most of the low density pockets are of scheduled tribes and these are located quite far from the main transport artery. The occurrence of this phenomenon can be attributed to pushing process of the tribals by the non-tribals from the city centre to the periphery along with the growth of the city.[8]

The sex-ratio* of an urban settlement is often influenced by the migrational trends of working force and the housing conditions prevailing in the city. The sex-ratio of Guwahati is 637 female per 1000 males. This ratio is very low in comparison to other big cities in India except Calcutta. This pattern of sex-ratio indicates a greater movement of males from nearby rural areas to

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7. J. Borah, 1985. Spatial Structure of Urban Influence in the Neighbouring Areas of Gauhati City, Inter-India Publications, New Delhi, p. 92.

8. Deepti Das, 1975. "Tribal Population and Settlements in Kamrup with Special Reference to the Concentration in the Southern Region". An unpublished Ph.D. Thesis, Department of Geography, Utkal University.

* Sex-ratio = Number of female per thousand male.

the city besides the flow of males from the distant areas both from within and outside State. It may be attributed that the married male employed in different occupations in the city leaving their families in the rural areas due to scarcity of accommodation in the city area. Thus, the sex-ratio of Guwahati shows the movement and migration pattern of the people and thereby gives an idea about the pattern of rural-urban interaction between the two.

The working population structure in the Greater Guwahati has been shifting remarkably from the primary to the tertiary sector. It is significant to note that the participation of workers in trade and commerce is very high.[9]

IV.2.c. **Land Use Pattern of Guwahati**

Study of the land use pattern of a city is undoubtedly a basic need for fuller comprehension of urban system. The land use pattern, in the town, explicitly speak of an unplanned growth. The present trend is alarming, than it was in the past. This is due to conflicting and competing claims from different users.

The Town and Country Planning Department, Government of Assam had undertaken land use survey of Guwahati

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9. The Assam Gazette, Extraordinary Issue, No. 129, Dispur, 24th December, 1986, p. 935.

in the year 1956, 1974 and 1980 to enable them to make an assessment of the land use variation during the said period. The land under Parks, playground has significantly decreased from 2.0 per cent in 1956 to 0.43 per cent in 1980 (Appendix IV.2). While the percentage of residential land use has progressively increased from 5.5 in 1956 to 45.11 in 1980. This was due to pressure of growth of population throughout this period. On the other hand, land under transportation increased from its formative stage to nearly balanced land use proportion (9.9 per cent in 1956 and 16.62 in 1980). Unfortunately, the multitudes of personal whims and desires of people concerned has worsened the balance of land use pattern in the city. As a result, it has become difficult to clarify the areas of land, zone wise. however, in order to assess the land under different uses, a comprehensive method is applied. Accordingly, the areas under different uses in different zones are identified and summed up. From the summation, the percentage of land under different land categories have been determined.

Guwahati's Master Plan covers an area of about 262 square kilometre of which 61.8 per cent is only usable [10] Unusable land constitutes mainly the hills,

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10. The Assam Gazette, Extraordinary Issue, No. 129, Dispur, 24th December, 1986.

water bodies and low-lying areas etc. Table IV.2 shows that nearly 9,726.58 hectares of land is available for future expansion of Guwahati. Figure 2 shows that about

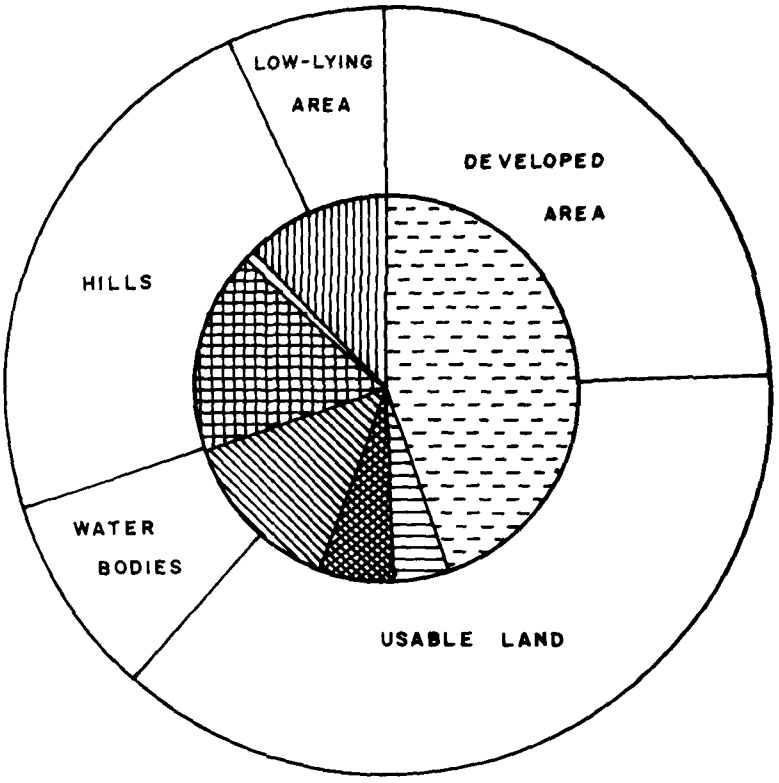
TABLE IV.2

Land Resources, Guwahati Master Plan Area

Sl. No.	Categories	Area (in hectares)	P.C. of total area
1.	Developed Area (Inhabited Area)	6,447.06	24.63
2.	Usable Land (Vacant and others)	9,726.58	37.16
3.	Unusable Land		
	i) Water bodies	2,234.83	8.37
	ii) Hills	6,031.86	19.48
	iii) Low Lying Area	1,737.00	7.72
	Total	26,177.33	100.00

Source: Town and Country Planning Department, Government of Assam.

three-fourth of the total land resources of Guwahati is under unused. Nevertheless, it cannot be ignored that 19.48 per cent hilly area can easily be developed effectively like other cities in developed countries like Japan, United Kingdom and Switzerland. On the other hand, water bodies (like lakes and swamps) inside Greater Guwahati can be developed for the beautification of the city.



RESIDENTIAL
COMMERCIAL
INDUSTRIAL
PUBLIC & SEMI-PUBLIC
TRANSPORT & COMMUNICATION
PARK & RECREATION
SPECIAL USE

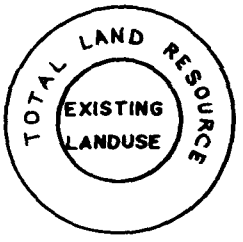


FIG 2 LANDUSE OF GUWAHATI

Any city life and its functional efficiencies are governed by its land use pattern. A recent survey (1980)[11] on developed area (inhabited area) of Greater Guwahati shows that only 4.52 per cent land occupied by commercial farms whereas residential area covers 45.11 per cent (Figure 2). On the other hand, the land utilised for manufacturing industries and associated installation purposes are as low as 6.30 per cent. The public and semi-public institutions occupy 14.17 per cent. The slightly high percentage of land developed for transportation and communication (16.62 per cent) is primarily due to the location of the Headquarter Office of the N.F. Railway at Maligaon. While the extreme deficiency of land under parks and recreation is highlighted by its share of only 0.43 per cent in the land use (Table IV.3). About 2 hectares per thousand residents is an accepted standard for parks and playgrounds, while Guwahati presently has only 0.05 hectare per thousand population which is the magnitude of the problem.

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11. Survey on Land Use of Greater Guwahati had undertaken by the Town and Country Planning Department, Government of Assam.

TABLE IV.3

Existing Land Use in Guwahati Master Plan Area, 1980

Sl. No.	Major Land Use	Area in hectares	P.C. to the total developed area	P.C. to the total planning area
1.	Residential	2,908.09	45.11	-
2.	Commercial	291.92	4.52	-
3.	Industrial	406.21	6.30	-
4.	Public & Semi-public	913.64	14.17	-
5.	Transport and Communication	1,071.74	16.62	-
6.	Park & Recreation	26.79	0.43	-
7.	Special Use	828.67	12.85	-
	Total Developed Area	6,447.06	100.00	24.63
8.	Usable Land	9,726.58	-	37.16
9.	Unusable Land	10,003.69	-	38.21
	Total Planning	27,177.33	-	100.00

Source: Town and Country Planning Department, Government of Assam.

IV.2.d. **Traffic and Transport Network**

'Traffic' as dictionary defines is 'passing to and fro of vehicles' or the business done by vehicles and pedestrians both collectively on a thoroughfare. While transportation, in a broad sense, is the movement of people, goods, power and information. Although the problem of transportation are as old as civilization itself, the utilization of power has revolutionised the whole concept.

Today we have transportation not only over land, water and air but more recently in space also. When we mention about the problems of traffic and transportation, it generally means the problems created by the traffic.

The traffic and transport network within the city is not at all proportionate to the size of the population. The growth of Guwahati in a few limited plain areas and the constraint imposed by the peculiar topography has made its extremely difficult to maintain the barest minimum level of transportation facilities. Problems arising out of these peculiarities needs careful study and approach.

As per one 1984 estimate prepared by the city's traffic police 1500 trucks, 650 long distance buses and 225 city buses traverse the city several times daily.[12] There are many licenced and unlicenced rickshaws and other slow moving vehicles in the city (see Chapter VII.2.b.). This stupendous volume of mixed traffic winds its way through the heavily pedestrianised narrow streets of the city which would be nightmare even for a developed country.

During the decade 1974-1984, altogether 3,633 road accidents in Guwahati has been registered by police in

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12. P.K. Bora, "Case Study of Accident Black Spots in Guwahati', International Seminar on Road Safety, Srinagar, September 17-18, 1986, Preliminary Publication, pp. III, 185-197.

which 464 lives were lost. An analysis of vehicle typewise involvement in fatal accidents reveals that trucks were the number one killer group of automobiles in the city contributing 43 per cent. Buses made a distant second with 21 per cent involvement followed by private cars 11 percent, motor cycles 6 per cent, scooters 5 per cent, jeeps 4 per cent and auto rickshaws 3 per cent. This is mainly because most of roads have no foothpath or insufficient width with no continuity or encroachment of footpath by commercial activities.

Road death per one thousand motor vehicle in Guwahati are many times more than that of many American cities where motor vehicles are much more numerous. The following is a comparison of average annual road deaths per thousand motor vehicles.

New York	-	0.46
Los Angeles	-	0.31
Chicago	-	0.31
Philadelphia	-	0.32
Guwahati	-	1.42

An excellent comparison can be made from the dreaded disease cancer with road accident death of Guwahati over a period of seven years. It indicates that the road

accident death has increased surprisingly than that of death from cancer.

Years	Death from Cancer	Road accident death
1978	55	38
1979	49	47
1980	46	46
1981	43	34
1982	32	49
1983	23	62
1984	Not available	62

Guwahati is having all types of regional transportation system namely, Road, Railway, Air and Water of which the roads, railway and air play the most important role. With the advent of the Broad Gauge upto Guwahati about 70 per cent of the wagons terminate in the city. All major godowns of essential commodities and goods are located in the city itself without a single organised truck terminal. At present about 2021 trucks enter the city and 1808 trucks leaves Guwahati daily. On the other hand, nearly 1097 buses came to Guwahati daily and 1028 leave the city. Long distance bus service is also available between Guwahati and other important towns of the State and North Eastern Region.

The National Highway 37 links Guwahati with Upper Assam and other neighbouring States like Nagaland, Meghalaya, Manipur and Tripura. Except the NH 37, inside the

city, the Assam Trunk Road, Mahatma Gandhi Road (Strand Road) and G.N. Bordoloi Road, the other roads of the city are very narrow and are suitable only for one-way traffic. The greatest drawback of the city road network is that, these were constructed without any foresight to cope with increasing traffic, and without keeping any scope for future expansion. Traffic control by-lanes was not all incorporated in the initial plans. The various residential localities have their own separate road pattern unrelated to each other. The total road length within the Master Plan area is about 800 kilometres of which about 53 per cent of the road are of Kuccha as shown in the Table IV.4. This is followed by black top road of about 35 per cent.

TABLE IV.4

Length of Roads in Guwahati Master Plan Area

Sl.No.	Type of Road	Length in Km	Percentage
1.	Black top	287.44	35.37
2.	W.B.M.	41.88	5.38
3.	Gravel	43.17	5.50
4.	Kuccha	426.28	53.50
5.	Brick paving	1.26	0.25
	Total	800.03	100.00

Source: Town and Country Planning Department, Government of Assam.

The built up areas start from road side leaving the margin for a narrow drain which is often blocked by continuous

silting, resulting overflow of water upon the roads etc. Though footpaths are constructed over the road side drains, the drain because of their low gradient and limited width fail to wash out the usual city waste water. During rains, the shallow drains are often choked up and overflows which form one of the causes of water logging within the city. In fact, it was observed that land available to the city drainage was extremely limited. Sanitary and hygienic conditions has progressively deteriorated with the growth of the city.

Next to road transport, rail transport plays significant role in the development roads in Guwahati. The main railway line passes through the heart of the city. Hence, it becomes a barrier to north-south movement of traffic within the city besides creating constant noise and congestion. There are sixteen level crossing including three overbridges connecting northern and southern halves of the city. The situation has further deteriorated with the new alignment of Broad Gauge line. Beyond Guwahati the Meter Gauge rail line linked the city with Dibrugarh and Tinsukia region in the east. Moreover most of the important cities of the country is also linked with Guwahati.

The river Brahmaputra was used for navigation from Calcutta to Dibrugarh via Guwahati. But only limited goods

traffic was handled by this transport system. There are frequent ferry services linking South Guwahati with North Guwahati (situated both side of the bank of Brahmaputra).

There is only one road cum railway bridge (Saraighat Bridge) over the Brahmaputra connected Amingaon and Pandu which partially improved the traffic system. Since the road connection through Saraighat Bridge is not convenient to daily commuters of north and south bank, another road bridge over the Brahmaputra is of utmost necessary at or near Guwahati. From the point of practicability, construction of the proposed bridge should have the alienment along with the hard rock basement of Karmanasha, Urbashi and Umananda.*

Guwahati is the only city with a major air port at Borjhar in the entire North East India. It has direct connections with the places inside and outside the region. The airport is situated at Borjhar about 22 Km from the main city centre. Another helipad for V.I.P's is also situated at Jawaharnagar near National Highway 37 by-pass.

Tremendous increase of movement of passengers by bus, rail and air in the city has been observed from 1971 to 1981 as shown in the Table IV.5 below.

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*Karmanasha, Urbashi and Umananda are riverine island composed of hard granitic rock.

TABLE IV.5

Daily Movement of Traffic Passengers in the Guwahati City

Year	Bus	Rail	Air
1971	16,000	1,700	280
1981	30,000	8,300	1,200

Source: Town and Country Planning Department, Government of Assam.

A private bus station at Machkhowa is situated very adjacent to the central area of the city. There are two bus stations of Assam State Transport Corporation. One is adjacent to the Machkhowa private bus station while another is in the Paltanbazar. At present there is no truck terminal in the city. Trucks are parked on the roads all over the commercial areas. Loading and unloading activities takes place mostly on roads. Hence it is necessary to earmark a site for these activities.

Besides the fast moving vehicles (including Motor Cycle, Scooter, Auto Rickshaw) there are slow moving vehicles also which form a part of urban transportation system. Rickshaw (tricycle), Bicycle, Bullock and Pony Carts are still used as transportation of goods for distances within the city. This trend is likely to continue because of lack of suitable road infrastructure and other goods carriers for short distances, economy-wise.

The efficiency of the road and railway have to be examined both in terms of intercity and instracity movements of passenger and goods. The growing demands for transportation facilities calls for assessment of the problems, e.g. road geometry, road capacities, accessibility so that remedies can be evolved both in terms of short terms and long terms measures. The concurrent to the discussion, so far, the congestion problem may be viewed from a number of angles, first whether the existing road network is sufficient for growing number of vehicles on the road, 2nd whether the existing road network can be optimally utilized without decreasing efficiency of transport services by some control (through regulation) of movement of private vehicles, 3rd whether the parking facilities and improved improvisation of footpath for pedestrians and fourth - by prohibiting the entry of large lorries through the city.

The passenger transportation within the city is mainly done by city buses and to a minor extent by the state transport corporation. The frequency of service can be increased so that private mode of transportation may be deterred. In the city buses run with more than 100% occupancy rate. Because of the slow movement due to congestion operation costs also are very high. Parking

facilities are negligible. Private motorists park their cars along the road sides, this adds to another dimension of non-productive use of road. Since there is no meter system time variant parking fees are never paid.

The goods caning from other regions mainly come by rail and road. Specially, in case of goods transportation by road some measures can be taken. Before the entry to the city both at Jorabat and north bank of Brahmaputra at the Saraighat bridge point could be considered as the terminal points for heavy trucks as the area around the bridge has adequate space that law be developed into an extensive road transport yard.

IV.2.e. **Market Areas**

The market is the prototypical mode since it involves the buying of goods from a wide variety of sellers, their assembly at a discrete point in space, and their sale to consumers who have travelled to market to obtain the needed goods.[13] The accessibility to the market area, both for buyers and sellers, is dependent on the transport

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13. K.R. Cox, Man, Location and Behaviour - An Introduction to Human Geography, John Wiley and Sons, Inc., New York, 1972.

cost including opportunity cost. The transport cost includes money, time and opportunity cost.[14] Guwahati Railway Station, Fancybazar Ferry-ghat, City's taxi station, local bus station, air terminus and regional bus station, are all located in or nearby the main market centre i.e. Fancybazar. This core area or the CBD draws customers from the suburbs as well as from the nearby satellite towns. Main function of the city is purely administrative and commercial. This latter characteristics is gradually felt in the region's zonal, and politico-economic activities. Recently, the city has gained more importance as it has now replaced Calcutta as the primary tea auctioning centre. Besides, many new small scale and medium industries are coming up rapidly in and around Guwahati.

In fact, there are no systematic functional zones in the Greater Guwahati. It has been observed that sometimes two or more functional zones overlap each other. However, from the point of view of commercial functions the city may be divided into five categories. These are:

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14. K. Bez and S. Sarma, "Spatial Models for Shopping and Residences: A Brief Survey", Seminar Paper presented in the National Seminar Organised by the Department of Geography, Gauhati University (Also under print in the North-Eastern Hill University Journal of Social Sciences and Humanities, NEHU, Shillong.

i) wholesale, ii) wholesale cum retail sale, iii) retail sale, iv) service shops, and v) mixed trade.

i) Whole Sale Market - Delimiting the wholesale market zone is a problem for Greater Guwahati. Since Fancybazar is an old established market, centre, most of the wholesale trading is concentrated in and around it. Categorically there are four kinds of wholesale commodities round in the city. These are foodstuff, cloth, hardware, timber etc.

The wholesale trading of foodstuff is concentrated in the Fancybazar area. As this is one of the essential items, this area is overcrowded and congested. Moreover most of the godown and warehouses have been constructed along the narrow streets. Due to non-availability of parking space for trucks, hand carts (thella) it creates traffic and environmental problems and need alternative arrangements. The wholesale trading of cloth is concentrated in the Fancybazar area. The wholesale of local product of cloth is also seen in the Panbazar area.

Next to food and cloth, the hardware trading, particularly of building materials are predominant in the city. Most of the hardware trades are located in Fancybazar, Athgaon and A.T. Road. Hence overcrowding congestion caused

by truck, pony cart and hand cart are common scene in these areas. Obviously the city needs new market areas with all associated facilities fully developed.

A new wholesale trade area dealing with coal is coming up on both the side of the National Highway By-pass south of Guwahati. At present there are ninety stockyards which are growing up like mushroom. For timber trade, there are no specific wholesale markets at Guwahati. Timber trading is scattered all over the city. In fact, some of the trading centres are spread over Maligaon and Ulubari area also.

ii) Wholesale Cum Retail Sale - The Francybazar area is the oldest centre for trade and commercial activities. Here, some of the wholesale shops have also extended their business through retail shops also. The retail sale of cloth, grocery, building materials and many others retail trades are scattered in this area. The retail trades spread out the periphery of Fancybazar e.g. Machkhowa and Panbazar etc.

iii) Retail Sale - Panbazar, Uzanbazar, Paltanbazar and Silpukhuri area are dominated by retail shops. Cotton College the first and oldest institute of Assam was established in the year 1901 at Panbazar. This has resulted

in a systematic growth of book seller at Panbazar, while the Pharmacy and Pharmaceuticals are seen adjacent to old Gauhati Medical College Hospital which has now been renamed as Mahendra Mohan Choudhury Hospital. This was followed by relocating this from Panbazar to Narakasur hills. Special type of retail shop on cloth of Pat and Muga,* the traditional dress of Assam are seen in the Panbazar area while vegetable cum fish market with grocery shops are observed in all other market of Uzanbazar, Paltanbazar, Silpukhuri, Bamunimaidan etc. After shifting the capital of Assam from Shillong to Dispur the Ganeshguri area becoming a best retail shopping centre as it is adjacent to the capital.

iv) Service Shops - During the last decade there is a sizeable increase in the numbers of fast moving vehicles in the city of Guwahati. Scooters and Motor Cycles have become a popular mode of transportation because of long distances of intracity travels. As a result hàphazard growth of workshop and repair shops have emerged in various part of the city. These types of activities are concentrated along the Assam Trunk Road, Gopinath Bordoloi Road, Radha Gobinda Baruah Road, and part of Sati Jaymati Road.

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*Pat and Muga are Assamese silk from which traditional Assamese dresses of Mekhela and Sadar (two pieces saree) prepared.

Moreover the body building for bus and truck are also seen in Garpandu area of A.T. Road.

v) Mixed Trade - About fifteen retail shopping areas of mixed trade are presently functioning within the Guwahati Master Plan Area. But the threshold* population are not proportionate with these retail shopping centre. Most of these shopping areas hardly fulfil the demand of commodities to the public. In addition, there are few temporary daily categorised markets functioning on the bank of Brahmaputra River. They mainly deal with livestocks, vegetables, bamboo and thatches etc. The bamboo and thatches shops are encroached upon the river Bharalu also. Moreover, the built up areas, Kalapahar, Kahilipara, Noonmati, Narengi, Beltola area are having these types of bamboo and thatches shops.

In the Guwahati Master Plan area, there are about four weekly markets, of which a major weekly market is located at Beltola. This market caters to a large population. The market is held in disorganised manner which spills over the road. Like the Kachari Ghat market, the Beltola market also needs re-allocation of land with appropriate reconsideration. Other markets also require reconsideration for re-allocation of land in proper place keeping their feasibility in mind.

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* The threshold market for a retail goods or service is the minimum size market, comprising the people who shop in a town, capable of supporting that retail goods or service at a profit.

CHAPTER - V

ANALYSIS OF DRAINAGE PROBLEMS

The problems of drainage has been by far one of the important factors that has given way to series of problems faced by the city. In this chapter an attempt has been made to study and analyse the drainage problem in greater detail.

V.1.a. Average Slope Analysis

"The term slope, as used throughout the science of geomorphology, designates some small element or area of the land surface which is inclined from the horizontal".[1] The gradient of the land surface over an area can be analysed from a slope map. The method was used as long as 1890 by S. Finsterwalder and thereafter K. Peucker, J. Tricart, J. Muslin also used this labourious and complicated formula (by measuring the total length of all contours with an episometer).[2] C.K. Wentworth[3] criticized the earlier formula and simplified it in 1930. G.H. Smith (1935), Raisz and Henry (1937), Robinson (1948) attempted with other method to determine the average slope of their

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1. A.N. Strahler, 1971. Physical Geography, Wiley Eastern Private Limited, New Delhi, p. 395.
2. As referred to by F.J. Monkhouse and H.R. Wilkinson, 1967. Maps and Diagrams, Methuen & Co. Ltd., London, p.101.
3. Ibid.

own area. In fact, all the methods have merit and demerit for their particular landform. From the point of landform and its limited extension of Greater Guwahati, the C.K. Wentworth formula* was found suitable for determining the slope of land surface as the formula bears constant**. Hence, Wenworth formula has been applied for the topography of Greater Guwahati and satisfactory results obtained.

The average slope of Greater Guwahati (Map 6) varies from zero degree to 18 degrees. The maximum slope is 18 degrees and is noticed in the Nilachal Hill (6° to 18°), Kalapahar-Narakasur Hill (9° to 18°) and Khanapara hillside (6° to 18°). In the same way Hengrabari N.C., Madgharia N.C., Ramcha hill grant, Sunsali grant, Clarance garden, Noonmati garden all are in the North-eastern part of the Greater Guwahati, where the slope varies from 9 to 18 degrees or above. Both Kalapahar-Narakasur hill and

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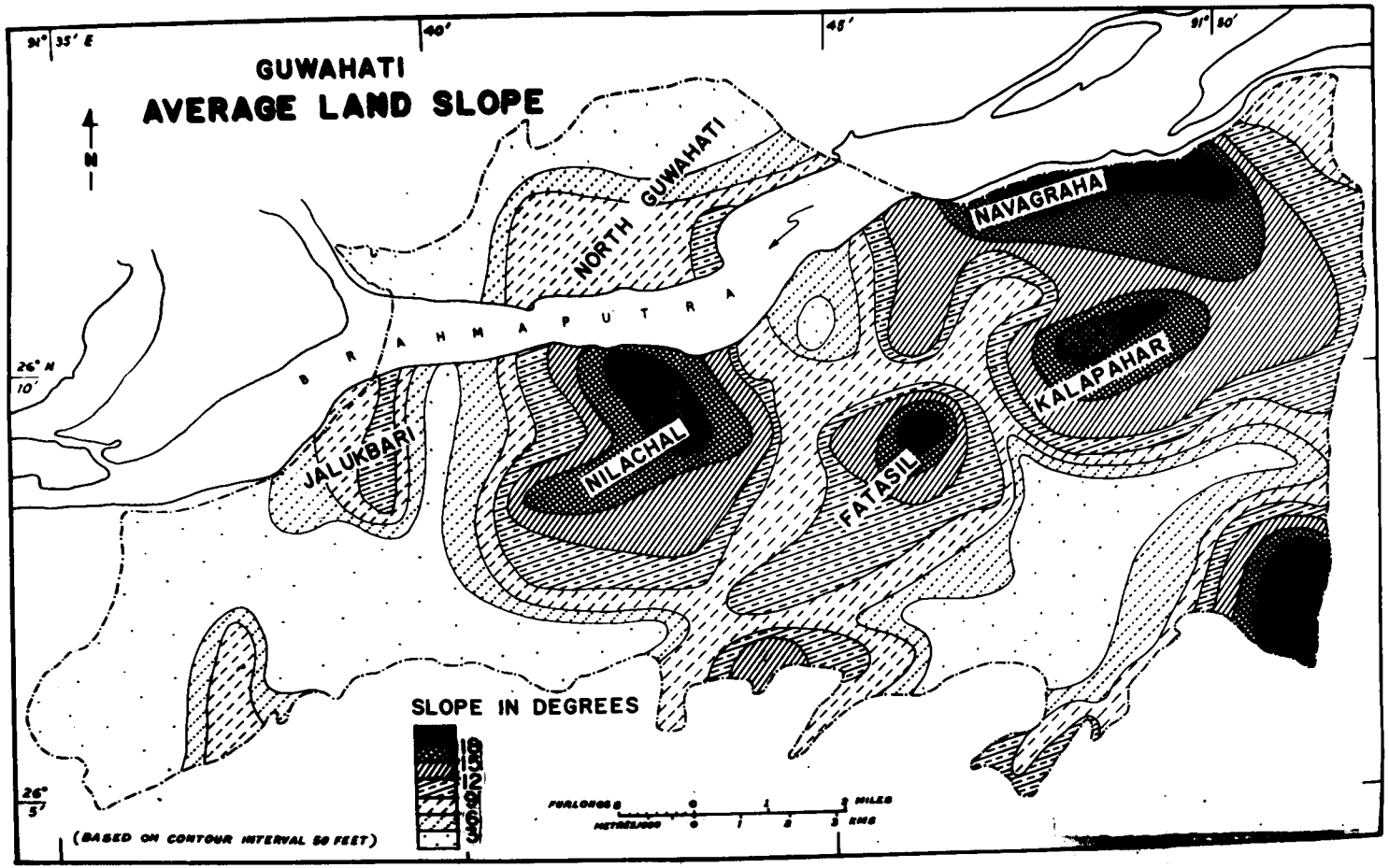
* $\tan \theta = \frac{N \times I}{3361 \text{ (Constant)}}$

where N is the average number of contour crossings per mile, I is the contour interval and θ is the average angle of slope.

** The constant figure 3361 is derived from a formula which is explained fully by Wentworth; it is 5280 x 0.6366, which figure is the mean of all possible values of the Sin θ, where θ is the angle between the grid-lines and contours.

*** Topographical sheet published by Survey of India, Sheet No. $78\frac{N}{12}$ and $78\frac{N}{16}$, scale one inch to a mile.


91° 35' E
40'
45'
91° 30'
GUWAHATI
AVERAGE LAND SLOPE
N
NORTH GUWAHATI
NAVAGRAHA
B R A H M A P U T R A
26° N
10'
KALAPAHAR
JALUKBARI
NILACHAL
FATASIL
SLOPE IN DEGREES
26°
5'
(BASED ON CONTOUR INTERVAL 50 FEET)
MILES
KMS

MAP. 6,

Hengrabari-Madgharia hill area decline to 3 degrees near Ganeshguri. Beyond these areas the plain extends from Saukuchi, Sijubari, Hatigaon to Satgaon. A corridor of less than 3 degrees has been found between the westward slope of Nilachal foothill and eastward slope of Jalukbari hill area long the longitude of 91°40'E. Further, it is noticed that the 3 degrees isopleth encircles the Dipar bil and extend along the Pub Bora-Gaon to Borjhar-Azara area where the western limit of the Greater Guwahati ends. It is also observed that the Mara Bharalu plain area extends south to north between the Fatasil and Kalapahar. An isolated spot near Mikirpara where slope increases from 3 to 6 degrees and another isolated spot near Kakatipara where slope increases from 3 to 12 degrees, are found in the south-west limit of Guwahati. These isolated hills are, actually outliers of the Meghalaya Plateau.[4]

In the north bank region of Greater Guwahati (23 sq.km.) the slope is gentle and it varies from 3 to 9 degrees only. The Char-Majoli-Pam in the western limit of North Guwahati area, Amingaon, Namolijalah, Silemohekhati to Gauripur and Rudreswar in the northern limit,

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4. S. Sarma, 1985. "Drainage and Urban Development - Case Study of the Greater Guwahati Regions", Hill Geographer, Vol. IV, No.2, p. 39.

all these areas fall under the slope between zero to 3 degrees only. The slope gradually increases up to 9 degrees and then abruptly falls towards the Brahmaputra at Aswakrantaghat.

Again, in the south bank of the river Brahmaputra the three river basins are of contrasting characters. The Bondajan basin is found at higher altitude, having 9 degree slopes, Bharalu basin on 6 degrees slope, while Khanajan basin lies below 3 degree slope. Thus, it has been observed that the average slope of the Greater Guwahati gradually falls east to west, with exceptional inter basin high grounds.

The intervening hills, dividing the basins, are the residual outliers of the Meghalaya Plateau. These considerably eroded and exhibit only relict manadnock.

Thus, it is observed that the flood and water logging in the urban complex is absolutely a temporary feature. Hence there are possibilities of identifying physiographic basis of solution to the problem.

V.1.b. **Drainage System Analysis**

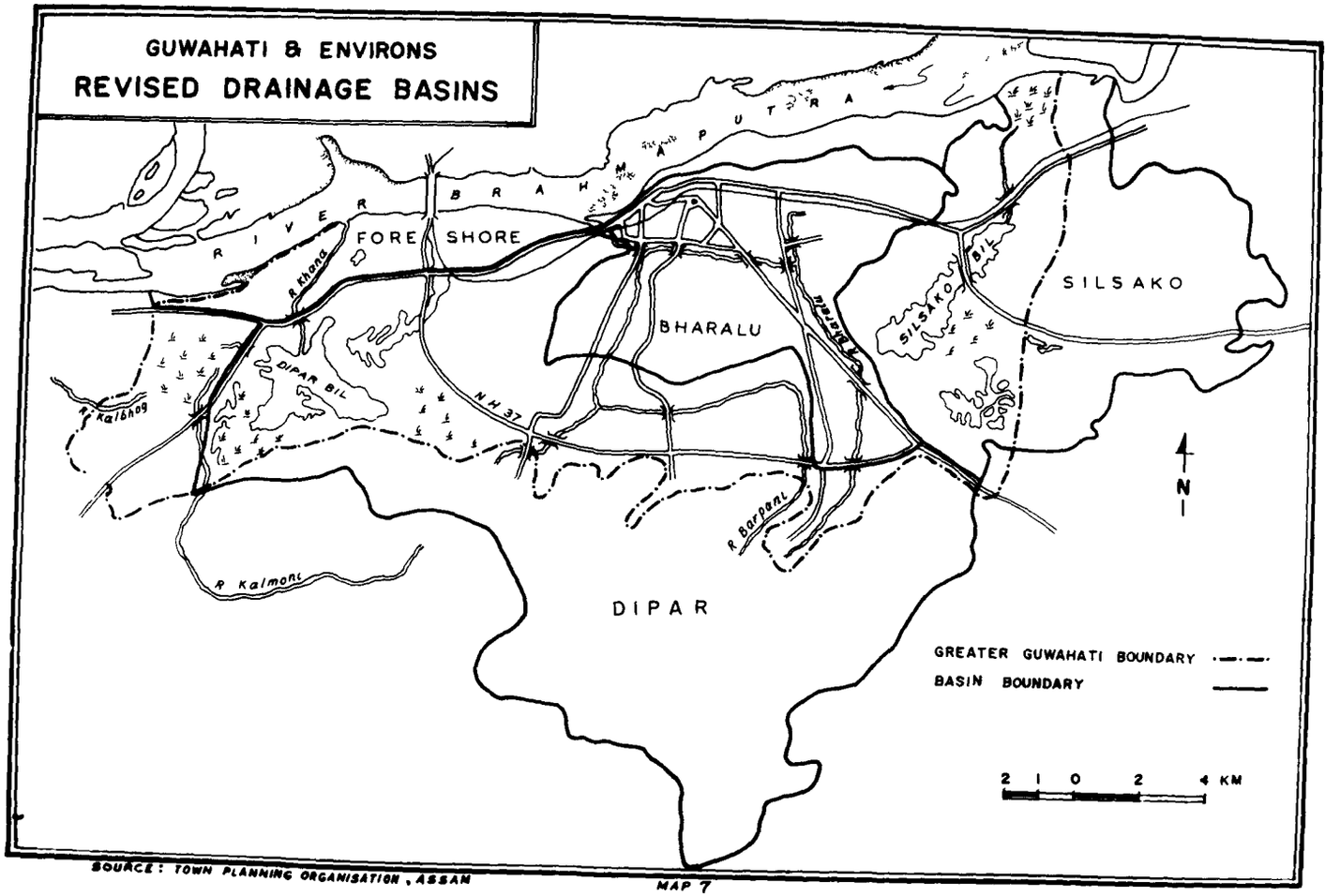
The present analysis on drainage system of Greater Guwahati is purely based on local situations. Here "drainage" primarily means the natural drainage of local origin.

A brief description of existing drainage basins has already been made in Chapter IV.1.c. The drainage areas are divided into four systems. They are: (a) Bharalu drainage system, (b) Foreshore drainage system, (c) Dipar drainage system, and (d) Silsako drainage system.

(a) **Bharalu Drainage System**

The Bharalu drainage system is bound by the Foreshore basin on the north, Dipar basin and National Highway on the south, Silsako on the east and Dipar basin on the west. The area includes the old municipality of Guwahati, industrial part of Noonmati and some parts of Khanapara. The whole area falls under urban agglomeration. The N.F. Railway line passes through the northern part of this basin.

The Bharalu river originates from the northern slopes of the Khasi and Jaintia Hills range and has a considerable tributary area. The total catchment area of the Bharalu is 123.5 sq.km. But the study area covers only 56.5 sq.km. (Map 7) which fall under the intensive study. Though the area is being built up, yet some of the portions are left out as original paddy field. The channel of the Bharalu river is rather narrow. Most part of the Bharalu bank is occupied by recent settlers. Bed of this river is gradually silted up, primarily due to



SOURCE : TOWN PLANNING ORGANISATION , ASSAM

MAP 7

the encroachments caused by the new settlements. As a result, the river channel is rendered incapable of discharging the load of the catchment area.

A surface drain, originating from the refinery area near Noonmati, meets the river Bharalu at a point, 300 meter down stream of the "Siriakhana"* gate. The river then passes through Bhangagarh, Ulubari and Cherap-bhati area and outfalls in the Brahmaputra at Bharalumukh. The sullage water of Barchala bil linked with the river Bharalu at Chabipool point near Goshala. In addition to this, some major drains also discharge sullage water into the river at various outlet points. Some industries are also located on the bank which dump waste materials into the river.

Almost all the low-lying areas have been filled up, buildings are constructed in an unplanned manner within the drainage. Except few isolated hills, topographically this basin area is more or less flat. Average level of the low lying areas inside the basin range between 48.5 metre and 49.5 metre above mean sea level. Roads have been constructed in certain areas at a higher elevation than the adjoining area. These roads with limited number of culverts, usually block free flow of rain water.

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* "Siriakhana" is a local name of Zoological Garden.

The Bharalu drainage system, can, further be divided into four sub-systems (Map 8).

(i) **Sub-system 1** - The whole area of the old municipality of Guwahati falls within this sub-system. The area under this sub-system is 9.54 sq.km. only. Most of the road under this sub-system are inundated during the rainy season. Hence water logging is the chronic problem in this area. The roofs and pavements are highest in this sub-system. The Calcutta Metropolitan Organisation (CMPO) in its master plan report, estimated the roof and pavement to be of the order of 50 to 70 per cent.[5] This has reduced the infiltration capacity to the least. A sluice gate has been constructed near Pragjyotish College to control the flood water.

(ii) **Sub-system 2** - The Noonmati-Bamunimaidan area falls under this sub-system 2. There is an open canal, constructed by the Railway Department for discharging the industrial waste water to the Bharalu. The average discharge capacity of the channel within this sub-system area is 19,300 lps*. The impervious percentage of this sub-system area is less than 35 which is considerable from the point of infiltration capacity.

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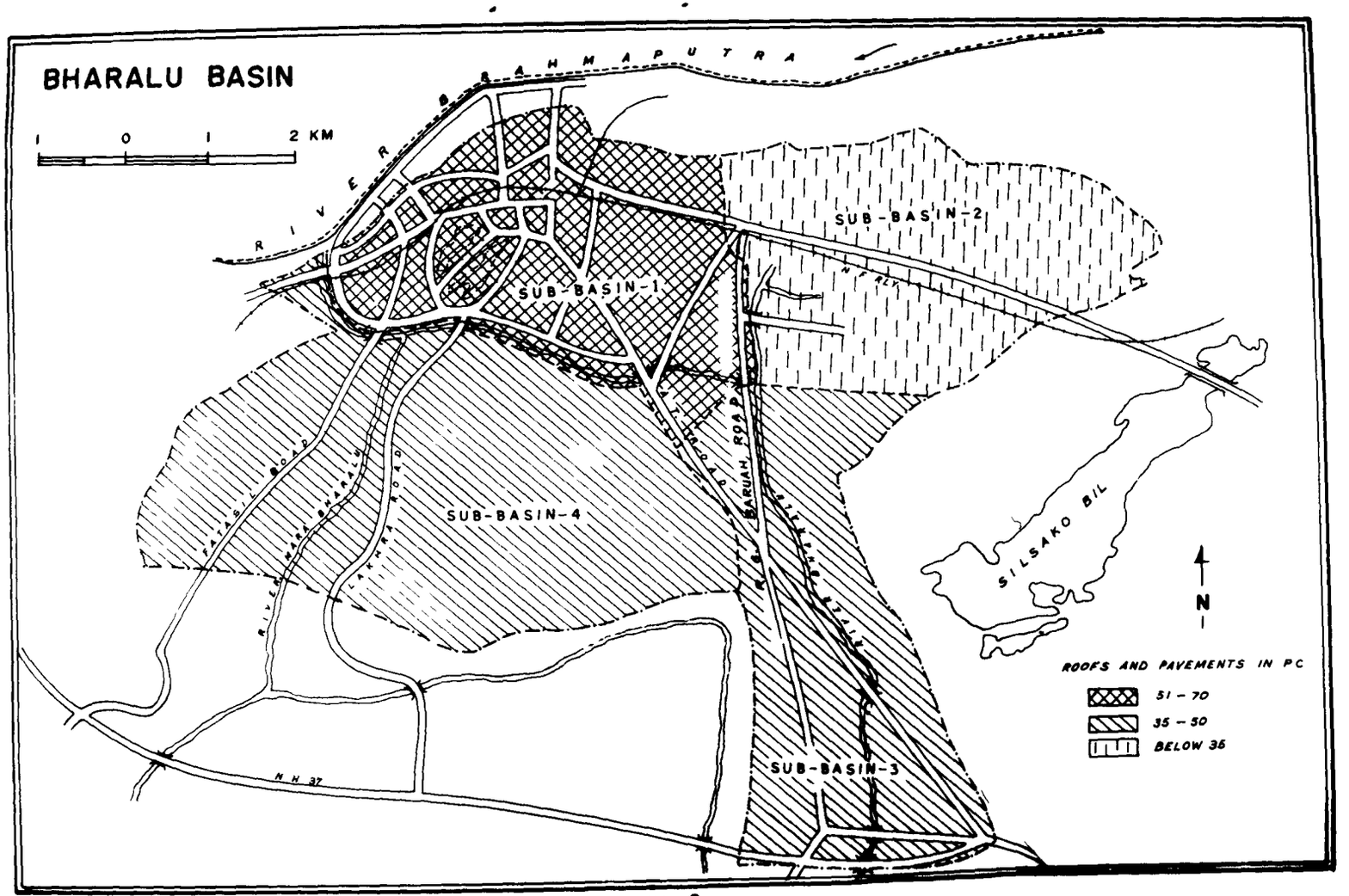
5. A Report on Master Plan for Water Supply, Sewage and Drainage for Gauhati Metropolitan District, 1971-2001, CMPO, 1971, Fig. 18.1.

* lps = Litre per second.



MAP 8

SOURCE : TOWN PLANNING ORGANISATION , ASSAM

(iii) **Sub-system 3** - The upper reach of Bharalu river stretch from National Highway to R.G. Baruah Road is under this sub-basin. Khanapara, Beltola, Dispur to R.G. Baruah Road under this sub-basin are recently developed. The temporary capital of Assam at Dispur has been established in the basin. The estimated percentage of roof and pavement ranges from 35 to 50 in this area.

(iv) **Sub-system 4** - The Mara Bharalu river drains this sub-system. It covers 16.65 sq.km. This system is composed of both hills and plains. Dense settlements have developed along the Lakhra and Fatasil Roads. New encroachers are swamping in the low-lying areas and the Assam Police Battalion has developed establishments on hill areas of Kahilipara under this sub-system.

(b) **Foreshore Drainage System**

The foreshore drainage system is a narrow and elongated patch lies along the south bank of the river Brahmaputra. It extends from western limit of Greater Guwahati to the Silsako basin in the east and from southern shoreline of the river Brahmaputra to Dipar and Bharalu basin in the south. The total area is about 29.35 sq.km. A part, measuring about 8.48 sq.km. of old municipality of Guwahati falls within this drainage system. Moreover, it includes the area north of Assam Trunk Road from Dharapur Charali to Bharalu-Brahmaputra confluence. Besides

Machkhowa, Fancy Bazar, Panbazar, Uzanbazar, parts of Oil Refinery township, fall within this system. The lowest altitude of this system is 47 metre in the west and 50 metre (above mean sea level) in old municipality area.

The municipality area under this foreshore drainage system is the most developed parts of Greater Guwahati. Prominently developed part comprises Uzanbazar, Panbazar, Fancybazar and Machkhowa. These are the main commercial, institutional, residential and business centre of Greater Guwahati.

The roof and pavement of the muncipality area under this system ranges between 50 to 70 per cent, whereas the hilly and open fields have an impervious percentage of 20 to 30.[6] Depending upon the nature and size of the tributary areas, the inlet time of runoff of the area has been estimated to be 5 to 15 minutes.[7]

The foreshore area may be divided into three sub-systems (Map 9): (i) Sub-system 1, (ii) Sub-system 2, and (iii) Sub-system 3.

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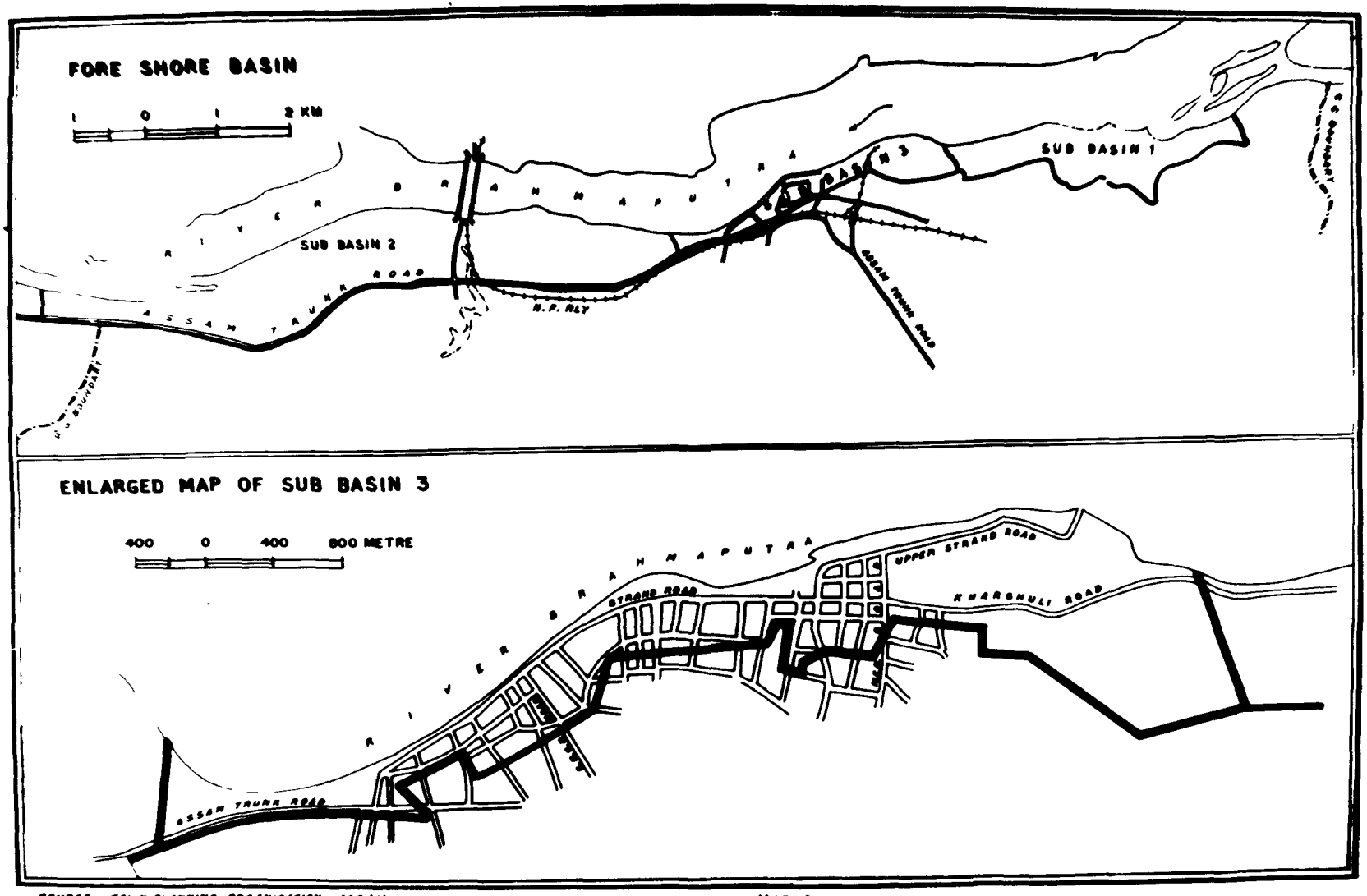
6. A Report on Master Plan for Water Supply, Sewerage and Drainage for Gauhati Metropolitan District, 1971-2001, CMPO, 1971, pp. 18-19.
7. Ibid.



SOURCE : TOWN PLANNING ORGANISATION , ASSAM

MAP. 9.

(i) **Sub-sytem 1** - The eastern most region from Kharghuli to Noonmati refinery area known as sub-system 1. This sub-system covers mostly the hills, excepting the residential colony of the refinery. The residential colony of the oil refinery has got their own storm water drainage system. Remaining areas of this sub-basin, since covered by hills there is no problem of water logging.

(ii) **Sub-system 2** - The western most areas of Dharapur Charali including Jalukbari, Pandu Railway Colony, Kamakhya Town Committee and some areas of Kalipur falls under this sub-system. The Assam Trunk Road also passes through this area. There are no drainage problem except some localised low-lying areas. The Railway Department has developed satisfactory drainage system in their area and the Kamakhya Town being situated at higher elevation has not got any drainage problem. In and around the low-lying areas of the Khana river, the drainage is very poor, however, after renovation of the sluices on the Khana river and construction of combined bridge and sluices at Dharapur, Garal and Bhatapara, the situation has been improved.

(iii) **Sub-system 3** - This sub-basin covers the area of Machkhowa, Fancybazar, Panbazar and Uzanbazar. Though this sub-basin is the oldest part of Guwahati yet some of the area of Panbazar experience water-logging during heavy rains.

(c) **Dipar Drainage System**

The catchment area of this basin is the largest among all the basin of the Greater Guwahati. It is located at the southern most part of Greater Guwahati. It lies between the Foreshore and Bharalu basin to the north, Meghalaya Hills to the south and east, the National Highway No. 37 on the west. This drainage system (Map 7) includes an additional area of 65 sq.km. of the Bharalu basin for convenience. Now the total area of the present drainage system is about 198 sq.km. The whole catchment area slopes down from Khasi Hills range from an approximate elevation of 456 metre to 61.3 metre in the valley. The Dipar bil is the prominent low-lying areas that covers 10.1 sq.km. (2500 acres). The total area of Dipar bil and Bijubari bil is about 3500 acres. In addition the Silapahar, Fatasil and Sonaighul hill falls under this basin. Except few pockets of Gotanagar, Jalukbari, Khanapara and Basistha (Military area), almost all areas are rural in character. The whole catchments, being a vast open area, the percentage of the roof and pavement is approximately 20 only.

(d) **Silsako Drainage System**

The Silsako basin is located in the eastern most part of the study area. The mighty Brahmaputra is on the north, the Meghalaya hills on the south, Narengi-Chandrapur

hills on the east and Bharalu, Foreshore and Dipar basin on the west, is the boundary of Silsako basin (Map 7). The total catchment area of the basin is 92 sq.km. A large low-lying area with the Silsako bil is centrally located in this basin. The Silsako bil has an outlet through Hahchora bil to the Brahmaputra. The outlet is called Bondajan (river Bonda). The average elevation of the low-lying areas within the bil is about 48 metre, while 50 metre is the lowest level of the built up area. Backflow of the Brahmaputra water through Bondajan enters into the city and submerges the higher land around the bil area up to the R.G. Baruah Road and G.S. Road adjoining the municipality area. To stop the backflow of the Brahmaputra river, a sluice has been constructed on the river Bonda.

A large portion of the Silsako basin is occupied by the Military establishments, industries, and educational institutions. Remaining portion of this area is predominantly rural in character. About 48 sq.km. of this catchment area lies outside the city. The industrial township and the military cantonment have developed local drainage system for this area.

The Silsako basin inside the Greater Guwahati has industrial establishment. Since the whole area slopes towards, the Silsako bil, the runoff water is received by this bil.

V.1.c. Discharge Capacity of the River Brahmaputra and Bharalu Tributary

"The quantity of water that passes a given point in unit of time is called discharge".[8] Discharge is generally measured in cubic meter per second (m^3/s or cumesec). Discharge varies not only from one stream to another but also within a single stream from time to time and from place to place along its course. Discharge usually increased down stream as more and more tributaries add their water to the main channel. The river Brahmaputra has many tributaries from its source to mouth. This river in Assam Valley section receives many tributaries from both north and south bank.

The river Brahmaputra is one of the largest rivers of the world which flows through a distance of about 2290 Km. through Tibet, India and Bangladesh. It drains about 580,000 sq.km. from source to mouth. This mighty river flows down through Assam Valley from east to west for a distance nearly 1159 km with its channels oscillating from side to side and forming many islands. The channel pattern of the Brahmaputra is braided instead of being either straight or direct. The channel width ranges of

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8. L. Don Leet, et al., 1982. Physical Geology, Prentice-Hall, Englewood Cliffs, New Jersey, p. 259.

9.6 Km. the average gradient of the entire river is about 1:11400, but there is considerable variation in actual slopes at different reaches. The mighty Brahmaputra (as mentioned earlier) passes through Guwahati master plan area dividing North Guwahati and a large part of south bank of Guwahati. The river flows east-west direction for about 24 Km along Greater Guwahati. The gradient between Noonmati (upper reach of Greater Guwahati) and D.C. Court site (middle reach) is 1:7000.

The rainy season extends from May to September, however, maximum precipitation occurs in the month of June and July. The Brahmaputra river carries more water and move more swiftly during flooding season. During the flood, the river becomes wider, the level rises and the depth increases. Naturally there is a relation of the width, depth and velocity with its discharge capacity.

Discharge = Channel width x Channel depth x Water velocity.

Discharge data of the Brahmaputra river for 15 years were obtained from the flood records of "Brahmaputra Flood Control Department" at Pandu site. It is noticed that the maximum average discharge of water is 46,291 cumesec during the monsoon season, while minimum average discharge is only 4,049 cumesec in the lean period. From the Table V.1, it is observed that in the year 1980 (19.8.80)

TABLE V.1

MAXIMUM AND MINIMUM DISCHARGE AND LEVELS OF

BRAHMAPUTRA AT PANDU SITE

1968-1982

(Danger Level 48.77)

Year	Maximum			Minimum		
	Discharge (Cumecs	Water Level (m)	Month and Date	Discharge (Cumecs)	Water Level (m)	Month and Date
1968	36,193	48.99	25.7.68	2,510	40.71	22.2.68
1969	40,480	49.35	21.7.69	2,529	40.72	3.3.69
1970	49,386	49.66	27.7.70	2,239	40.66	23.2.70
1971	34,880	48.17	14.7.71	3,238	-	30.12.71
1972	47,734	49.00	31.7.72	3,052	40.60	4.2.72
1973	51,100	49.22	8.8.73	2,591	40.55	16.2.73
1974	53,286	49.28	3.9.74	3,301	40.64	25.2.74
1975	47,861	48.85	1.8.75	2,904	40.44	7.2.75
1976	45,542	48.45	5.7.76	4,160	40.53	6.2.76
1977	53,389	49.53	19.8.77	4,954	40.48	21.2.77
1978	51,188	49.36	27.6.78	7,822	40.20	25.2.78
1979	46,856	49.13	10.10.79	5,513	40.61	26.2.79
1980	55,092	49.65	19.8.80	4,947	40.47	11.2.80
1981	42,024	49.02	6.7.81	6,199	41.23	8.2.81
1982	39,354	48.72	28.7.82	4,778	41.06	6.2.82
Average	46,291			4,049		

Source: Brahmaputra Flood Control Department, Guwahati.

the maximum discharge of Brahmaputra was 55,092 cumesec while the lowest discharge was recorded at 4020 cumesec in 1978 (25.2.78), Figure 3 shows the second largest discharge occurred twice during the last 15 years. This is quite obvious that the water level has a close relationship with the discharge of the river. The water level and discharge both increases from the month of May to September (Figure 4). From the Figure 4, it is noticed that the highest peak of water discharge is in the last part of July. The second highest peak of discharge is observed in the month of September, while third and fourth peak of discharges are recorded in the months of June and May. During these peaks period of discharge the Brahmaputra water level rises up and even crosses the danger level. When water level crosses the danger marks, the existing sluice of the Bharalu, Bondajan and Khanajan are closed to stop backflow. The water received from the catchment area of the Bharalu, Bondajan and Khanajan automatically accumulates and if the water level of Brahmaputra remains constant for few days, the surrounding areas are flooded. As a result of which the low-lying areas of Greater Guwahati are normally submerged during these periods.

It is seen that the valley section of the Bharalu is not large enough to carry the entire load of water

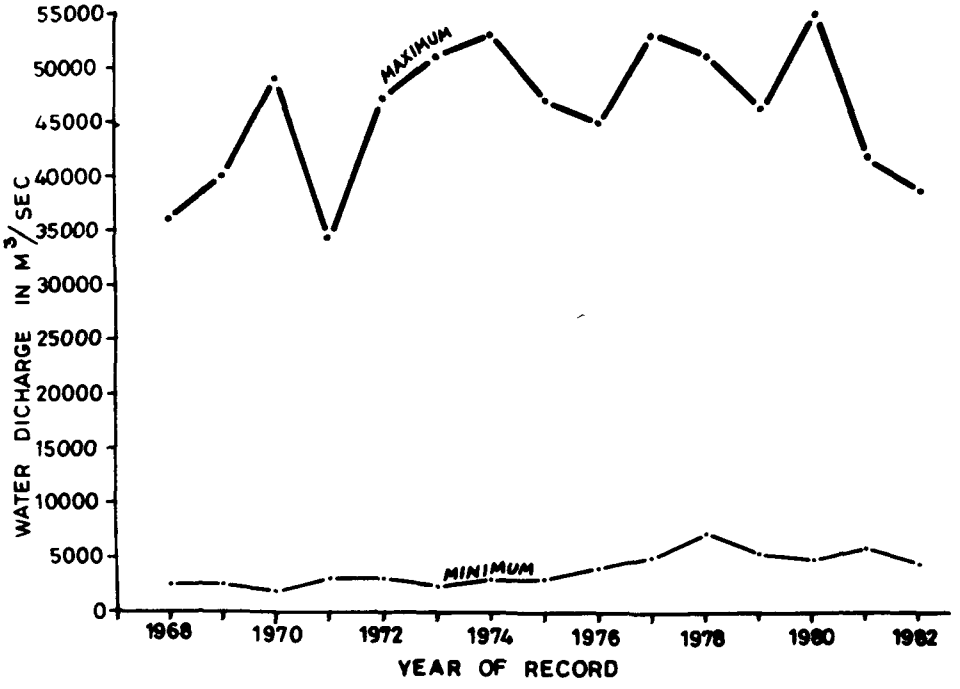

FIG 3. MAXIMUM AND MINIMUM DISCHARGE OF THE BRAHMAPUTRA AT PANDU SITE

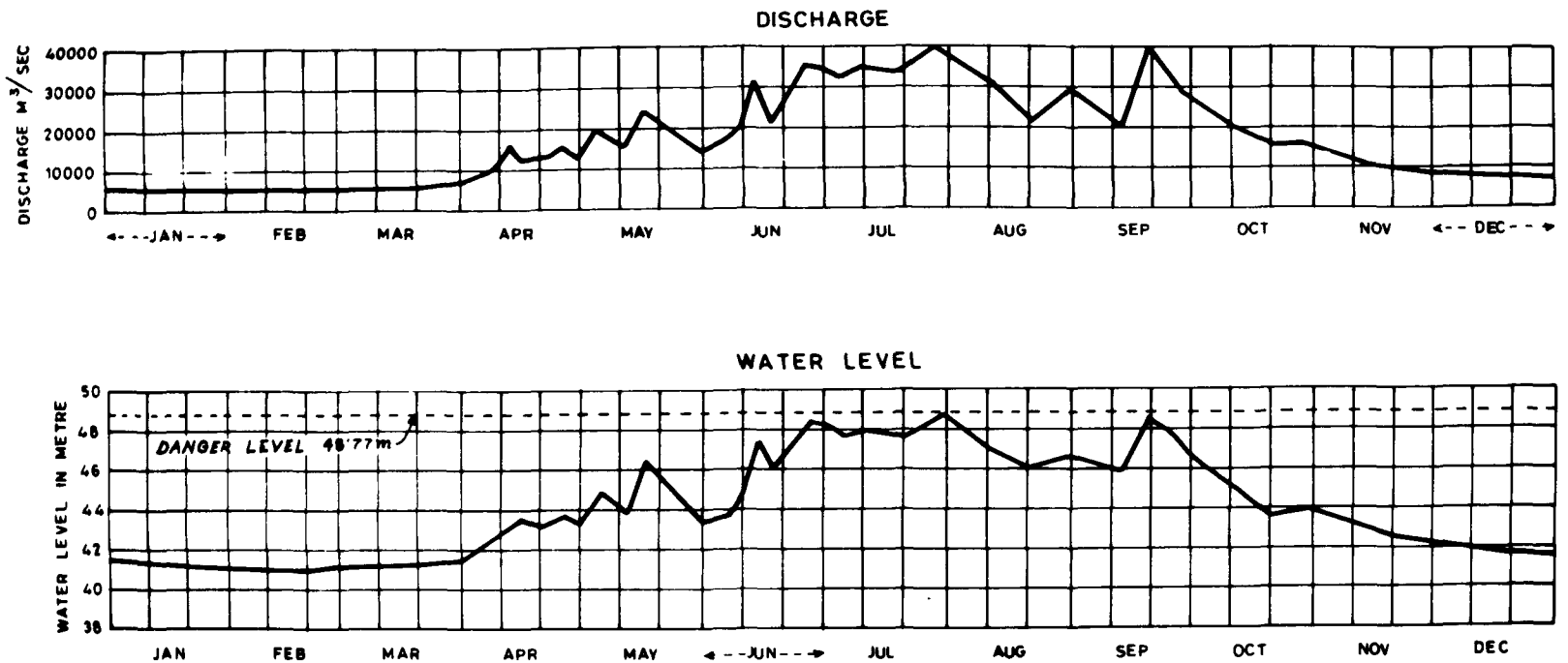

FIG 4 WATER DISCHARGE AND WATER LEVEL OF THE BRAHMAPUTRA AT PANDU SITE, 1982

of its catchment area. In addition to this, the industrial waste water from Noonmati area considerably increases the load. Moreover the bed of the Bharalu river is being silted up and its banks are encroached upon by settlers. Hence, discharge capacity of the Bharalu river inside urban stretch has been progressively reduced (Plate I a and b).

From the Tables V.2 and V.3, it is clear that the minimum water surface elevation of Bharalu is 47.0 metre above mean sea level, however, the drain can discharge to a level of 48.7 metre above mean sea level without creating ground flood. Because the average ground surface level is 49.5 metre within the municipality. At the level of 48.0 metre above m.s.l. the Bharalu can discharge towards Bijubari bil through the Mora Bharalu channel. Therefore, the yard stick of flood in the Municipal area of the city, is the 48.7 metre level. As soon as the water crosses this level, flood and water logging becomes imminent.

V.2.a. **Water Level of the Brahmaputra During Monsoon Period**

The behaviour of a river during its flood stage is very different from its low water stage. Continuous rise of water level is a precursor of imminent flood on the river banks. The tributaries of the Brahmaputra inside Greater Guwahati are rendered inactive in discharging

a) East of Cherapbhati

b) West of Cherapbhati

Plate 1: Discharge capacity of Bharalu river has been reduced due to silt up of its bed and encroachment.

TABLE V.2

Hydraulic Elements of Bharalu River

Reach	Length	Catchment Area (acres)	Design Water Level G.T.S. Datum (m)		Bed Width (m)	Depth of Flow (m)	Bed Level in G.T.S. Datum (m)		Designed Hydraulic Slope m/m	Velocity m/sec	Discharge L/Sec
			at start	at end			at start	at end			
B-1	1,452	934	51.29	51.00	5.18	2.44	48.85	48.56	. 0002	0.76	14,300
B-2	3,120	3,460	50.50	48.70	9.15	3.06	47.44	45.64	.00014	0.76	28,600
B-3	4,650	10,041	47.70	47.10	9.15	3.66	44.04	43.44	.00013	1.07	57,200
B-4	1,011	14,345	47.10	46.90	9.15	3.66	43.44	43.24	. 0002	1.37	71,500

The Reach B-1 will remain undisturbed, m = measurement in metres

Source: Report of Calcutta Metropolitan Planning Organisation.

TABLE V.3

Hydraulic Elements of Mara Bharalu River

Reach	Length (m)	Catch-ment area (Acres)	Design Water Level G.T.S. Datum (m)		Bed Width (m)	Depth of Flow (m)	Bed Level in G.T.M. (m)		Hyd. Slope m/m	Vel. m/s	Discharge L/Sec
			at start	at end			at start	at end			
MB-1	3,600	4,100	47.6	47.1	9.15	3.06	44.54	44.04	.00014	.76	28,600

Source: Report of Calcutta Metropolitan Planning Organisation.

their water load because of higher water level in the master drain. On the contrary backflow from the river Brahmaputra enters through the outlets of the natural drainage and increases both the level and volume of water in the tributaries. Normally, backflow through Bondajan on the east, Khanajan on the west and Bharalu in the central part causes flood inside the Greater Guwahati almost at every spate of high water in the Brahmaputra.

From the Table V.1 it becomes clear that the Brahmaputra water level rises above danger level in twelve years out of fifteen years time at Pandu site. On the other hand, water level of Brahmaputra at D.C. Court site (Table V.4)* rises seven times in ten years duration. It means hardly three years were free from flood out of ten years.

Monthly water level of the Brahmaputra for D.C. Court has been studied and it is plotted in the Figure 5. From this curve, it is observed that the water level crossed the danger mark twice in 1980, once in 1981, thrice in 1984 and twice in 1985. In the year 1982, 1983 and 1986 the water level did not cross the red mark (49.68 m) at all. The water level that crossing the danger level generally, in between July, August and September only, the study revealed.

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*Data available of ten years only at D.C. Court.

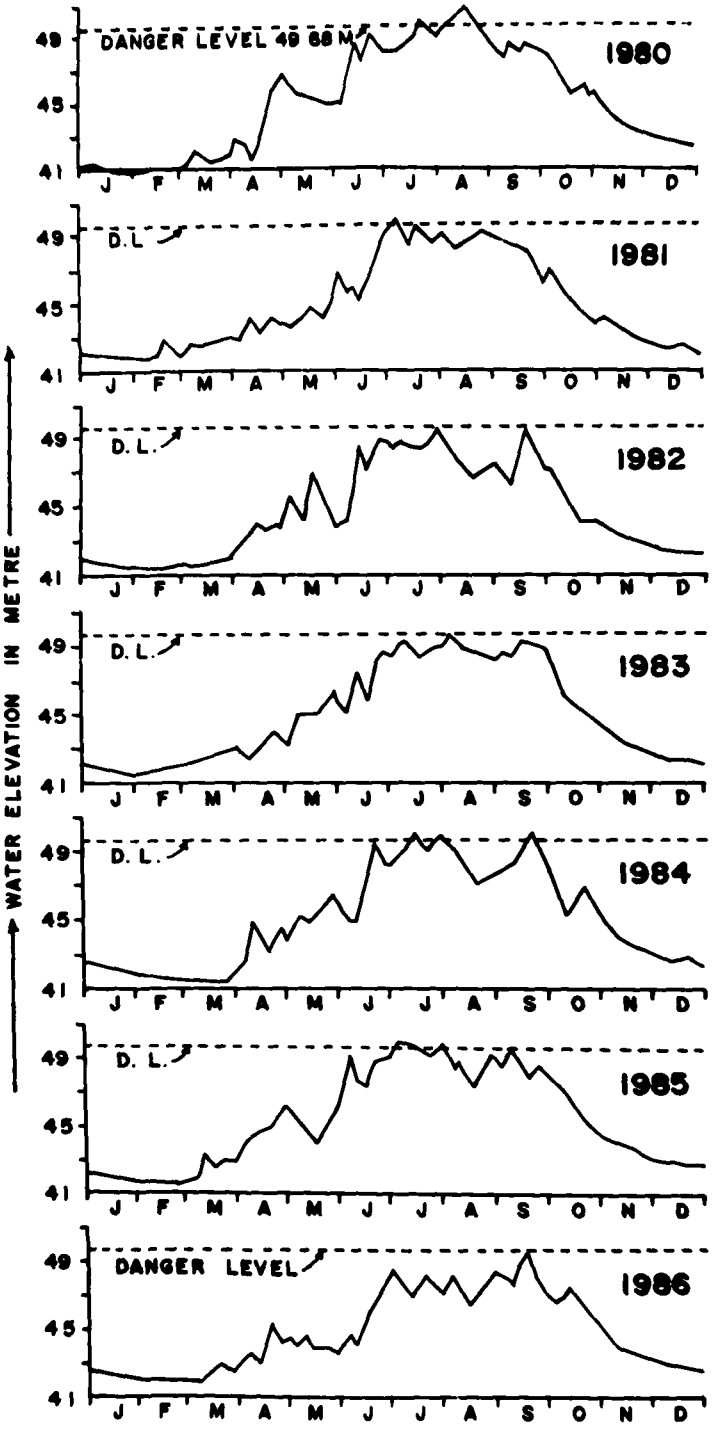


FIG. 5. WATER ELEVATION OF THE BRAHMAPUTRA AT D. C. COURT SITE

TABLE V.4

Maximum and Minimum Water Level of Brahmaputra at D.C. Court Site, 1977-86 (Danger Level - 49.68)

Year	Maximum		Minimum	
	Water Level (m)	Month & Date	Water Level (m)	Month & Date
1977	50.57	19.8.77	40.81	21.2.77
1978	50.17	27.6.78	40.84	25.2.78
1979	49.95	10.10.79	41.03	26.2.79
1980	50.87	19.8.80	40.79	11.2.80
1981	49.91	6.7.81	41.81	8.2.81
1982	49.67	28.7.82	41.40	6.2.82
1983	49.59	3.8.83	41.53	31.1.83
1984	50.16	14.7.84	41.40	25.3.84
1985	49.82	5.7.85	41.68	27.2.85
1986	49.65	19.9.86	41.95	13.3.86

Source: Brahmaputra Flood Control Department, Guwahati.

For detailed study, daily water level data of the Brahmaputra have been collected from the "Brahmaputra Flood Control Department". Seven years data (1980 to 1986) of D.C. Court has been taken for this study. The water level data for the last consecutive years were arranged at every one meter interval between 45 and 50 metres. On this basis, the average of the rising water level for each metre rise has been calculated. The results of the

observation has been tabulated in percentage (Table V.5) for 150 days (May to September) and represented in cumulative graph (Fig. 6).

This curve shows that about 7 per cent of 150 days (or 10.5 days) the water level of Brahmaputra equals the danger level or exceeds it during the monsoon period. During this period when water level exceeds or equals the danger level, the sluice of Bharalu is closed to stop the back flow from the Brahmaputra (see Chapter V.1.c) in order to avoid inundation of the city area.

An analysis of Brahmaputra within Greater Guwahati alone does not help to avoid flood in the city. The factors responsible for the floods owing to heavy silt deposition should be studied from the source to the mouth. An expert committee report says that the silt got deposited along the river course and elevated its bed by about six inches every year. This reduce its carrying capacity and thus causing widespread floods.

It may be suggested that the construction of a series of reservoirs on the north bank tributaries of the Brahmaputra specially in Arunachal Pradesh to arrest the fury of the mighty river. These reservoirs would help reduce silt deposit (about 6 inches every year) in the

TABLE V.5
Number of Days the Water Level was above M.S.L. (1980-86)
(Danger Level 49.68 m)

River = Brahmaputra
Site = D.C. Court

Year	50m	49m	48m	47m	46m	45m
1980	8	27	65	13	5	32
1981	0	27	60	4	18	16
1982	0	14	50	25	27	10
1983	0	22	65	22	15	39
1984	10	37	35	31	28	40
1985	0	44	50	36	6	17
1986	0	6	33	59	32	7
Total	18	177	358	190	131	161
Average Days	2.6	25.3	51.1	27.1	18.7	23.0
P.C. of Days	1.7	16.8	34.1	18.1	12.5	15.3
Cumulative P.C.	1.7	18.5	52.6	70.7	83.2	100

Computed by the author.

river thereby preventing floods, generate hydro-electric power, besides providing stable irrigation for agricultural field.

V.2.b. **Gradient of Bharalu and Mora Bharalu**

A major part of Guwahati city particularly in the eastern and southern parts are drained by a rivulet called

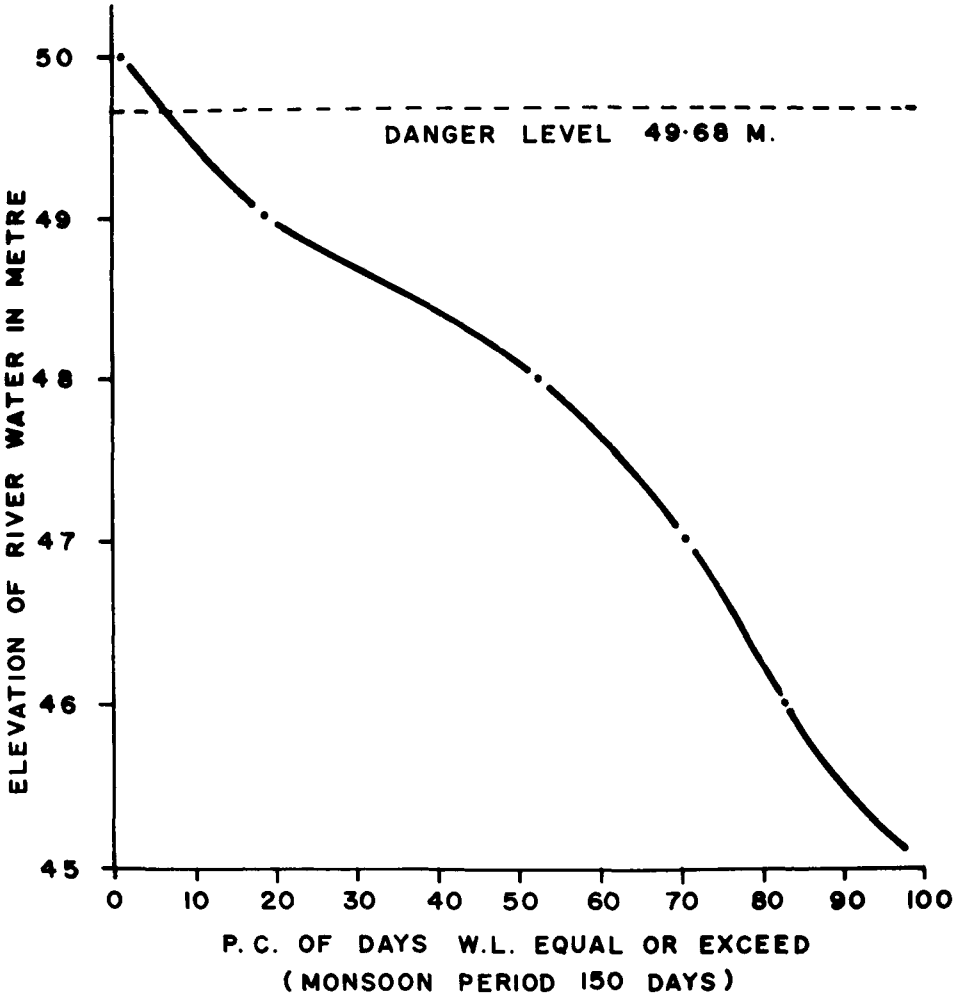
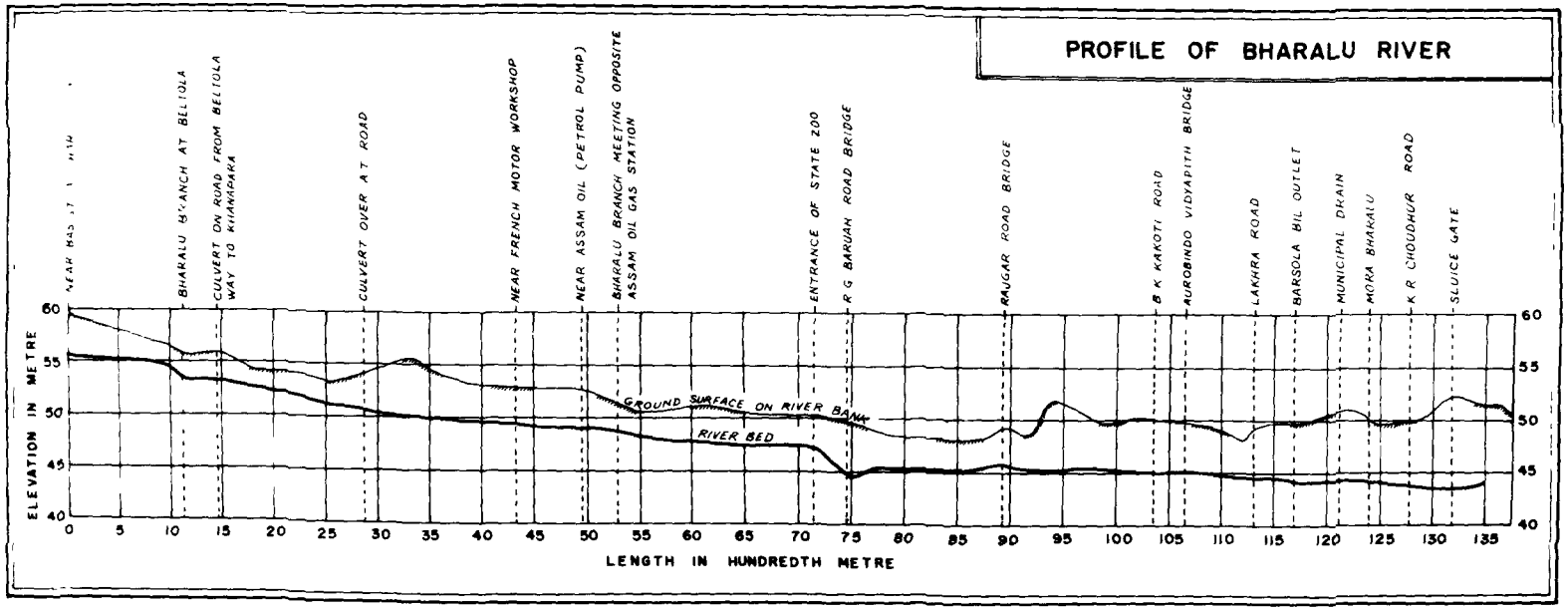


FIG. 6. WATER LEVEL DURATION CURVE OF THE BRAHMAPUTRA AT D.C. COURT, 1980-86

the Bharalu. The source of this rivulet is in Meghalaya hill ranges. It enters the Guwahati city from south-eastern part, where it is known as Bahini upto Guwahati-Shillong road crossing near Rukminigaon. At Rukminigaon it is joined by local drainage channel, and thereafter it is known as Bharalu. The Bharalu flows parallel to G.S. Road and flows through the city across Dispur, Zoo road, Lachitnagar, Ulubari, Cherab-bhati, Bishnupur and outfalls to the Brahmaputra at Bharalumukh. The Bharalu channel is affected to a great extent by large scale encroachment and unchecked dumping of garbages throughout its length. When the Brahmaputra is in high spate (see Chapter V.2.a) and there is heavy rain in Bharalu catchment area, the combined flow of normal drainage and excess rainwater overflow the channel (see Plate 1, a and b). As noted earlier, being lower than the Brahmaputra bed, there is a strong backflow. As a result a vast area of the city in Bharalu basin get submerged.

Generally, gradient or slope of the stream channel is the angle between the water surface and the horizontal plan. A stream's gradient decreases from its source towards the mouth. But in case of Bharalu, some abnormality has been observed. The gradient of the river bed does fall progressively - but at certain meandering points, the



TOWN PLANNING ORGANISATION ASSAM

FIG 7

river bed is found to be of higher elevation than the upper course. The profile of Bharalu channel (Figure 7) from source to mouth clearly indicates that the points between R.G. Baruah road crossing to Aurobindo Vidyapith bridge (at Ulubari) the bed level is higher instead of normal gradient. This is mainly due to sluggish movement of the water in lean season and deposition of enormous silt. Hence this portion should be regraded and resectioned with proper design.

On the other hand, the Mora Bharalu (dead river) is also inadequate in its section and gradation. Hence, it also cannot instantly drain out the impounded water. Flood damaged caused by Mora Bharalu alone was Rs. 130.26 lakhs in 1983 (Table V.6). This was continued about 15 days with depth of 1.75 metre. About 200 houses damage and 20 cattles lost in that flood.

TABLE V.6

Flood Estimation of Mora Bharalu Basin

1. Year of flood - 1983.
2. Probable depth of inundation - 5 to 6 feet.
3. Duration of inundation - 15 days.
4. Damage to crops area - 0.016 lakh acres.
5. Lost of crops - Rs. 0.20 lakh.
6. Damage to house - 2,000 Nos.

7. Lost to damage house - Rs. 120 lakhs.
8. Cattle lost - 20 Nos.
9. Value of lost cattle - Rs. 0.06 lakh.
10. Damage public utilities - Rs. 10 lakhs.
11. Total Damage - Rs. 130.26 lakhs.

Source: Brahmaputra Flood Control Department, Guwahati.

The Bharalu which spilled over on 15th August 1987 has forced a large number of families to leave their houses and take shelter at the relief camp opened at the Kaliram Baruah Girls' High School. The camp housed a total of 450 inmates.[9]

Of course, a careful study has been carried out by Brahmaputra Flood Control Department and designed both Bharalu and Mora Bharalu for its remedial measures. If the design criteria can be maintained for the Bharalu channel then the entire low lying areas in an around the channel can effectively be drained to Dipar bil through Mora-Bharalu even at the time when Brahmaputra is in high stage and Bharalu sluice is closed.

V.3.a. **Rainfall Analysis**

The high intensity monsoon rainfall the city receives is normally associated with thunderstorms, massive

9. A news report captioned "City Areas Flooded" published in The Sentinel, 17 August 1987.

cloud bursts, etc. This causes serious land erosion, flash floods and water-logging in a dispersed but congested city like Guwahati. A study in this parameter provides adequate background information not only on the climatological processes and hydrological forcastings but also for city planning. It provides a focus on which the problems related to water management, drainage, and so on, can be better understood.

The characteristic features of weather and climate of Guwahati is more or less similar to the weather and climate of the region as a whole. However, Guwahati has its own distinct micro-climate that has been influenced by its unique physiographic conditions and location. The city and its environs is dominated by scattered monadnocks and hill ranges, extensive shallow water bodies, vegetation, etc. These significantly alter the micro-climatic conditions. yet, the overall pattern of weather and climatic conditions of the region (and the city) has been included in the category of sub-tropical climate.[10]

Meteorologists, scientists and researchers of allied field have analysed (with the available data) different elements of weather and climate as well as on its

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10. M. Barthakur, "Weather and Climate of Assam", Extension Lecture, North-East India Geographical Society, Series 2.

impact on the city planning. But, no concrete work(s) on the urban centres of the North-East India seems to have been attempted so far. The diurnal variation of monsoon rainfall at an inland station in the Brahmaputra valley has been estimated for five years with a gap of six years (between 1969-1971 and 1978). The results of this estimation has often brought confused results.[11] The consequent attempt has been made with trienium data of rainfall on Guwahati to solve the water logging problem inside the city.[12] Rainfall data for each hour was collected from the rainfall records of Indian Meteorological Department, Guwahati. The recent data for seven years 1980-1986 has been used, because it observed that the city inundated frequently since last decade. Average hourly variation of rainfall during monsoon period has been calculated by the following formula:

$$R = \frac{r}{n}$$

Where R = Average rainfall per hour

r = Total rainfall of hour of the month

and n = Total number of rainfall occurrence of the hour of the month.

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11. S. Kalita & S.K. Sarmah, 1982. "Diurnal Variation of Monsoon Rainfall at an Inland Station in the Brahmaputra Valley", Current Science, Vol. 51, No.18, pp.881-83.

12. S. Sarma, 1986. "Cartographic Representation of Waterlogged Areas in the Guwahati City and Its Development Planning", Proc. Symp. Landuse Mapping, NATMO, p.32.

Using this formula, average rainfall for each hour, for the individual monsoon months May to September and for the season as a whole are calculated and presented in Table V.7. The average rainfall per hour for each monsoon months and for the season has been plotted in the Figure 8. The graphs are not smooth and show many primary and secondary peaks. To make the curve smooth three point moving average (Appendix V.3) has been used. Yet some of the smoothed curves have shown oscillatory character (Figure 8). In order to adopt a pragmatic approach, standard deviation and co-efficient of variations of mean hourly rainfall data have been calculated (Table V.8). These are calculated on the basis of the following formula:

$$(I) \quad \sigma = \sqrt{\frac{\Sigma (x - \bar{x})^2}{n}}$$

where σ = Standard deviation

x = Hourly rainfall

$\bar{x}$ = Mean hourly rainfall

n = Number of observation

and (II) $CoV = \frac{\sigma}{\bar{x}} \times 100$

where CoV = Coefficient of variation of mean hourly rainfall

σ = Standard deviation

$\bar{x}$ = Mean hourly rainfall

TABLE V.7

Average Variation of Rainfall Per Hour for the Monsoon Season 1980-1986

Rainfall in mm

Hours	May	June	July	August	September	Seasonal (Monsoon)
1	3.9	3.7	3.4	3.2	3.6	3.6
2	5.0	3.0	6.5	2.9	2.0	3.9
3	3.1	2.7	3.4	3.4	5.5	3.6
4	3.3	2.1	1.3	1.2	3.0	2.2
5	2.9	1.9	1.7	4.0	1.7	2.4
6	1.7	1.5	1.9	4.4	1.1	2.1
7	3.0	1.2	2.1	3.3	1.0	2.1
8	1.2	1.0	2.1	3.1	2.7	2.0
9	2.5	2.1	2.9	3.4	1.6	2.5
10	1.5	2.6	2.4	3.0	1.5	2.2
11	1.8	3.0	3.1	2.3	2.0	2.4
12	1.6	4.3	1.9	2.5	2.3	2.5
13	1.7	3.4	1.1	2.6	1.5	2.0
14	1.2	10.0	1.2	1.4	1.1	3.0
15	2.9	1.7	1.6	1.8	1.9	2.0
16	1.0	5.8	1.3	2.5	1.7	2.5
17	1.2	5.0	4.6	2.4	3.3	3.3
18	2.1	1.4	1.5	3.7	1.4	2.0
19	2.6	1.3	2.3	1.9	2.2	2.0
20	2.8	2.0	2.4	2.1	4.1	2.7
21	1.4	2.0	5.1	4.1	4.5	3.4
22	3.0	5.1	2.4	3.2	3.0	3.3
23	8.8	1.8	3.3	2.2	4.0	4.0
24	4.8	2.2	2.7	2.5	2.0	2.8

Computed from the Data of Indian Meteorological Department, Guwahati.

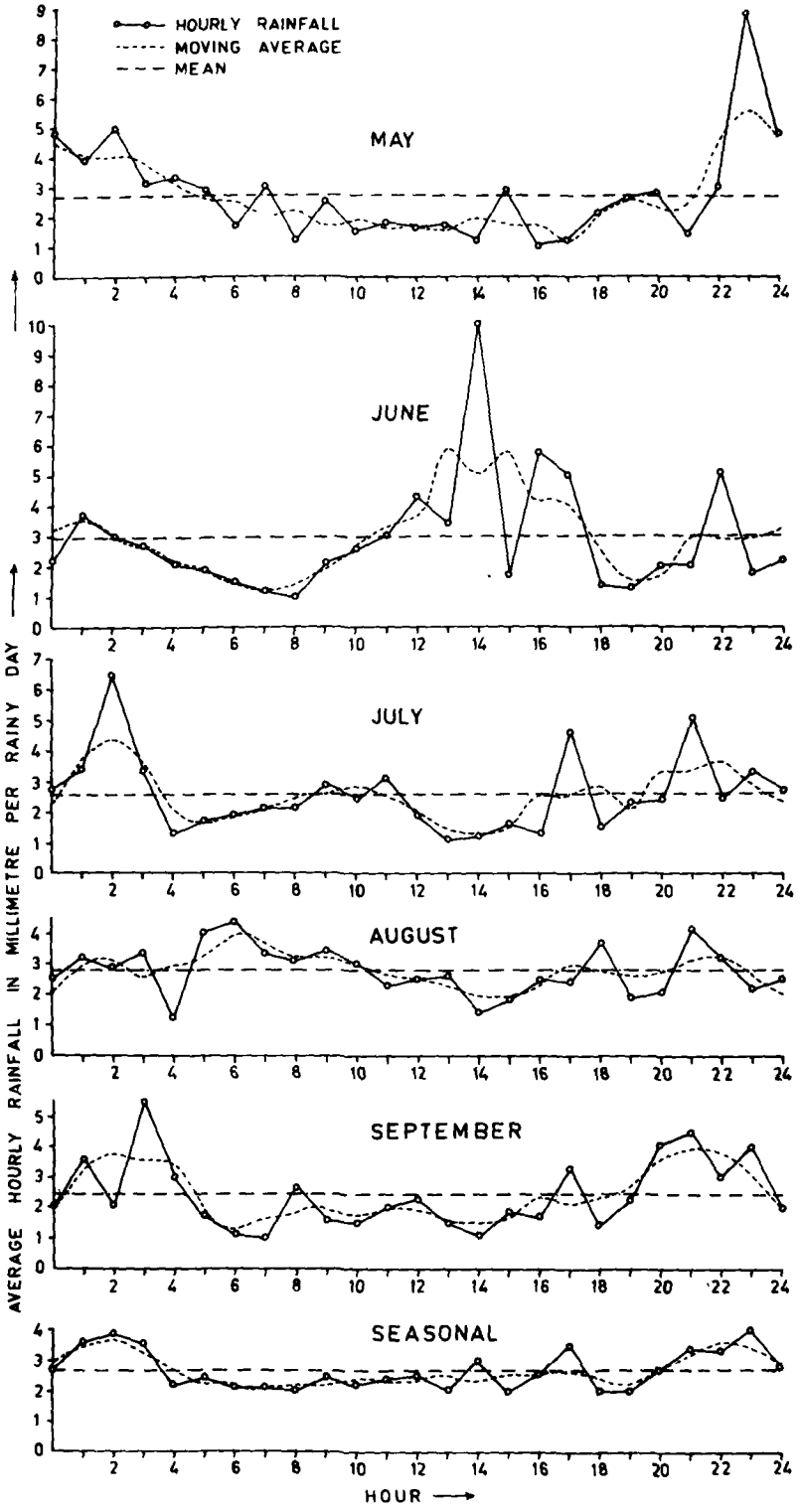

FIGURE 8 HOURLY VARIATION OF RAINFALL AT GUWAHATI

TABLE V.8

Mean, Standard Deviation and Coefficient of Variation of Rainfall per hour per rainy day for the months of May to September and for the season 1980-1986

Months	Average hourly rainfall in mm ($\bar{x}$)	Standard Deviation of ($\bar{x}$) (in mm)	Coefficient of variation of $\bar{x}$ in %
May	2.70	1.69	62.59
June	2.95	1.99	67.45
July	2.59	1.31	50.57
August	2.79	0.82	29.39
September	2.44	1.19	48.77
Seasonal (Monsoon)	2.68	0.66	24.62

Computed by the Author

Results

The average rainfall of five monsoon months, i.e. May to September shows a distinct variation pattern (Figure 8). The average hourly rainfall is lowest in September, while is highest in June. The co-efficient of variation of the mean hourly rainfall is highest in June, 67.45 per cent as compared to the lowest in August, 29.39 per cent.

The May curve indicates few peaks, out of which, two are greater than the mean rainfall of 24 hours. May,

June and July curves show prominent peaks. The characteristic feature of high peak of May 2300 hour IST corresponds to afternoon peak of June 1400 hour IST and then to early hour peak to July 0200 hour IST. The peak is conspicuously absent in the month of August. Significantly both early peak 0300 hour IST and late peaks 2000-2300 hour IST occur in September. During the monsoon season as a whole the rainfall curve shows three prominent peaks each at 0200 hour IST, 1700 hour IST and 2300 hour IST. Along with these three prominent peaks, there are five other mild peaks which are above mean rainfall. It means that the average rainfall per hour above mean rainfall occur in eight occasions. Because of its amphitheatre like structure (of relief), the surface runoff flowing down from Meghalaya Plateau gushes into the city environs causing havoc and hazards during the peak hour of rains.

The coastal region like Goa, Bombay, Cochin and Trivandrum have morning maxima.[13] On the other hand, inland station like Nagpur[14] and hill stations like Mahabaleswar and Kodaikanal[15] have reported an afternoon rainfall.

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13. R. Ananthakrishnan; S.S. Aralikathi and G.M. Pathan, 1979, Proc. Indian Acad. Sci., A 88, p. 177.
14. G.R. Mulky, 1958, Indian J. Met. Geophys, Vol.9, p.403.
15. B. Prasad, 1970. Indian J. Met. Geophys, Vol. 21, p. 443.

Cherrapunjee in Meghalaya which has very heavy rainfall indicates night and early morning maxima.[16] At Guwahati, diurnal variation of rainfall varies for each of the monsoon months. earlier results show that the dirunal variation of rainfall at Guwahati was less erratic than that of Gao, Bombay, Mangalore and Trivandrum. Even country's capital New Delhi has experienced water logging in the streets with an hour heavy down pour (22nd September, 1986). This is due to nearly hundred per cent roof and pavement in and around city where runoff rate is higher.

The diurnal variation of rainfall in micro regions are obviously different than that of macro regions. Hence diurnal variations of rainfall observed in micro region is dependent on its local physiographic conditions. However, the workers engaged in this field, suggested that rainfall variation is due to surface heating and associated local atmospheric circulation. Sometimes, the rainfall is also caused by cyclonic storms or depression wherein, the diurnal variation is comparatively small.[17] The prevalence of anabatic winds and the associated thunderstorms cause rainfall during day time in monsoon region.[18]

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16. Ibid., 1974, Indian J. Met. Geophys, Vol.25, p. 245.
17. E.E. Foster, 1949, Rainfall and Runoff, The Macmillan Company, New York, p.121.
18. S. Sarma and R. Gopalakrishnan, "Impact of Hourly Rainfall on Guwahati City (Assam)", 12th Annual Conference of N.E. India Geographical Society, Jorhat, Dec. 28-29, 1987.

The midnight (2200-2300 hour IST) maxima observed in May and June, perhaps, due to delayed ground radiation and convection (the ceiling effect of cloud delays rapid radiation).

In June, maximum of rainfall occurs at noon and afternoon. Atmospheric thermal condition produces instability of air temperature. Air temperature rises steeply during this month at 1200 hour IST. The steep rise of temperature leads to the development of convection resulting in thunder showers from 1200 hr to 1700 hr in the months of June.

In the month of July, occurrence of rainfall shifts beyond 1700 hr to late night (0200 hr IST). The ground radiation is delayed progressively in this month. Therefore the thermal peak is recorded at afternoon and convective process begins in the evening. This delay is further enhanced by the ceiling effect of the high humidity in the air and the clouds. This effect lead to night shower which continues till late night.

Morning and evening maxima of rainfall observed in the month of August, may be due to the radiational cooling of the cloud layers; wherein the evening rainfall is due to convective activity. During the day, surface

heating leads to an increase in the convective activity which produces instability in the atmosphere, this leads to katabatic winds during the night, and results in a rainfall maxima in the evening and night of August.

September is also a wet month for both Guwahati as well as for entire North-East India. During this month insolation is high between 1400 hr to 1600 hr IST. This is normally due to delayed convection processes and rainfalls at night.

The average hourly rainfall per rainy day is maximum and becomes incessant in June, and a minimum in September (Table V.8). The coefficient of variation of average hourly rainfall is a maximum in June. The curve (Figure 8) clearly depicts that most of the rainfall occur in afternoon and during night whereas it is less between 0400 hr to 1300 hr IST.

From the above analysis it is apparent that Guwahati experiences about 8 peaks hours of high intensity rainfall periods in one monsoon season. At times, surface runoff together with silt eroded from surrounding hill slopes inundates the low lying areas of the city.

Though there are many peak hours in the month of May, only one peak of rainfall maxima (2300 hr IST) is significant. As the monsoon begins in May, the secondary

peak hour of rainfall is normally absorbed by the soils which reach into the saturated point. The other peaks (primary and secondary maxima) from June to September, is a sensitive period with full of potential of flooding the city through runoff water. The intensity of hourly rainfall is maximum in June and is always alarming as it exposed the inherent drawbacks of the Guwahati's drainage system.

Rainfall occurrence and intensity is a natural phenomenon which shows the impact of environmental degradation. It has enhanced water logging hazard over last decade. This problem can be resolved by restoring the natural drainage to its original extent and adding up to it, the artificial drainage system that will carry out the excess water during the peak hours. Pattern of rainfall data taken in limited time perspectives will prove effective tool for periodic assessment of requirements and appropriate planning of the drainage channels and transport system. This will also require modifications in designs of drains and roads which have to be mutually exclusive and related.

This is, therefore, an initial attempt to study the problems of water logging in Guwahati city and its immediate environs that forms the part of Guwahati Municipal Corporation. In fact, the analysis concludes with

a question. That is, whether the proportion between the drainage density and the inhabited area of the city is adequate and its impact on providing adequate urban facilities to the inhabitants of the city.

V.3.b. **Water Logging and Inundation Problem of Guwahati**

Water logging is a colossal and continuous problem of Guwahati. In order to locate and verify the vulnerable water logging spots, constant personal observation was made in the last few consecutive monsoons.[19] Empirically few causes may be attributed to this phenomenon:

i) Topography of Guwahati is significantly undulated.

ii) Both natural and artificial drains are not capable of carrying the storm water due to their shallowness and narrowness.

iii) Encroachment over the low-lying areas by new settlers on either side of the natural drains have blocked the natural flow of flood water to the drains.

iv) Construction of building and roads over the man made drains are also responsible for bottlenecking the drainage.

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19. S. Sarma, 1985. "Drainage and Urban Development - Case Study of the Greater Guwahati Region", Hill Geographer, Vol. IV, No. 2, p.41.

v) Indiscriminate cutting of hill-sides for filling up low-lying areas are also responsible for sheet wash and blockage of drains. The hills are exposed to heavy rain which supply enormous loose soil and silt up the drains rapidly.

vi) The filled up areas possess low seepage capacity because of lower compactness and saturate at a faster rate and, therefore, do not allow flow of flood water.

vii) Most of the original swamps and natural water reservoirs are filled up for residential, official, industrial and institutional purposes. Consequently the rain water spread over the built-up areas causing flash flood.

viii) Rising of ground water table with the rise of the Brahmaputra level which saturates the entire plain area and reduces the percolation rate subsequently.

The topography of Guwahati controls the natural drainage. The relief of the city gradually slopes from east to west. Two major natural drains of Greater Guwahati originate in the hills and the other two major drains originate from lakes. Mushroom growth of settlement on either sides of the perennial drains in and around Guwahati restrict easy flow of water. In between the natural drains, the presence of depressed area usually prompts

the tendency of collection of water in scattered areas after every heavy shower.

The cultural morphology of the city, on the other hand, has brought a change in the structure and shape of Guwahati city in connivance of the necessity of proper drainage. Within the busy functional areas of the city, drain-cum-foothpaths are not adequate to carry all the storm water from the adjacent and neighbouring areas. Besides, most of the drains are relentlessly constructed in connivance of the physical slope of the land (see Chapter V.1.a).

In addition, the broad gauge railway line has been constructed through the heart of the city which constrains the existing inadequate drainage system of the city. Ignoring the Master Plan (prepared by CMPO) of the city and construction of broad gauge line across the natural courses have added to the problem.

Enormous sheet wash from Navagraha hill slopes constantly fill up the existing drains and floods the road from Silpukhuri to Flood Control Commission Office at Chandmari. Similar situations also arise in the compound of Assam Engineering Institute. The east side of Chandmari fly over the areas along with residences and offices are submerged with 3 to 4 feet deep water. The

Plate 2: Water submerges the Office of the Chief Engineer, Inland Water Transport, Chandmari.

Plate 3: A tragic view of Bhaskar Vidyapith High School after heavy rainfall.

Office of the Chief Engineer, Inland Water Transport (Plate 2), Chandmari has been frequently submerged after heavy rain.

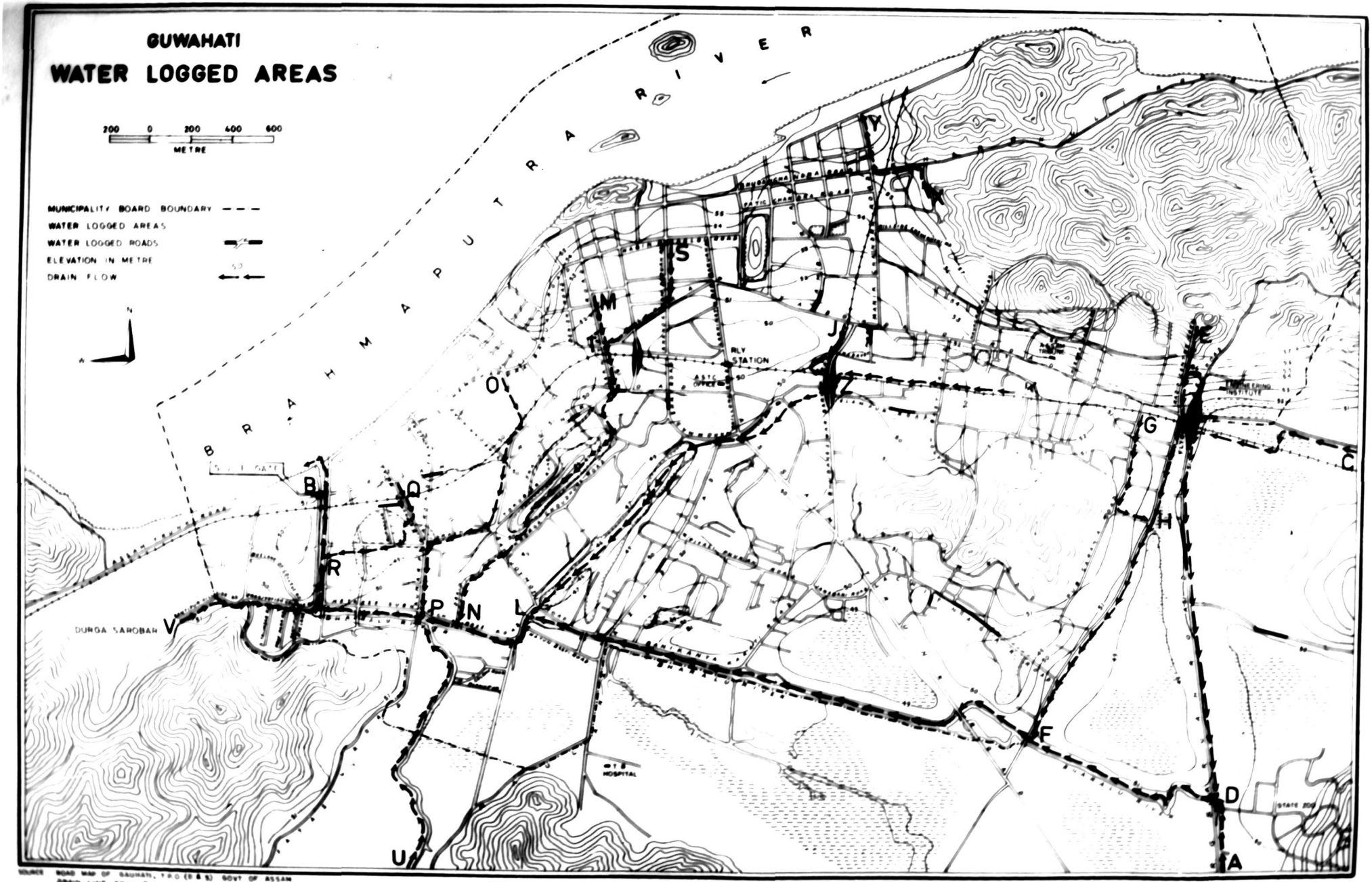
In matters of water logging, the composition of the soil in the city area has a major role to play. One one hand, the depressed areas are composed of transported soil from the hilly areas and on the other, much of the built-up areas have come up over the newly filled soils. The rain-water, in absence of effective soil conserving cover, erode the high land and deposit the materials over the low-lying areas. The water percolation rate reaches the lowest point during the monsoon period. Two specific reasons may be attributed to this phenomenon:

1) The low-lying areas are composed of transported soil or silt, 2) Widespread saturation of the soil takes place as noted earlier, due to rise of Brahmaputra level and for its soil composition. Consequently, the surface flow progressively increases with the advance of the monsoon season. The rampant surface flow, obviate the collection of rain water in the depressed regions and the ineffective drains fail to flush out the water with expected rapidity. The best example of such a situation may be cited from Kumarpara area. The elvation of this area is comparatively low (49 m above mean sea level whereas danger level of Brahmaputra is 49.68 m at D.C. Court site).

Being nearer to the Brahmaputra and the Bharalu, soil of the area is rapidly saturated with the advancement of monsoon. The subsoil of this region hardly gets time for complete desiccation in between the wet seasons and the monsoon, coupled with high water in the Brahmaputra, completely stops percolation. hence, the entire Kamarpara area (Map 10) is submerged during heavy shower.

Most of the natural water reservoirs of Greater Guwahati are filled up by illegal encroachers. The swampy areas in between Fatasil and Lakhra road are packed with settlements. The Bishnupur area, and the low-lying areas of Gopinath Nagar are also filled up for construction of residential quarters, resulting permanent blocade of rain water.

The area bounded by R.G. Baruah Road on the east, Rajgarh Road on the west, Bhaskar Vidyapith on the north and Bharalu rivulet on the south (Map 10) lies significantly below 49 m contour (which is below danger level 49.68 m). This area specifically is subjected to continuous earth filling for new construction of residential houses. The drain from Bhaskar Vidyapith to Tinali is narrower. As a result even water from a moderate rainfall spills over the area and gets itself discharged in the form of a sheet flow into the drain on the eastern side of Rajgarh Road. It is observed in last consecutive year


GUWAHATI
WATER LOGGED AREAS
200 0 200 400 600
METRE
MUNICIPALITY BOARD BOUNDARY
WATER LOGGED AREAS
WATER LOGGED ROADS
ELEVATION IN METRE
DRAIN FLOW
BRAHMAPUTRA RIVER
RLY STATION
DURGA SAROBAR
A
B
C
D
E
F
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MAP 10

when Bharalu maintained a low level, R.G. Baruah Road, Rajgarh Road and adjoining area was water-logged after just a moderate storm. The Bhaskar Vidyapith High School (Plate 3) is being worst affected and has to close down the school for many days every year.

There are many instances, observed elsewhere in the city that irresponsible citizens have encroached upon the drains and thereby endangered the civic life of the city. The Natunbasti by-lane, adjacent to Arya Vidyapith College, is overtopped by sewage water constantly throughout the year for absence of roadside drains. The Rehabari area faces, water-logging, primarily due to blocade of the local drains.

Hundred per cent roof and pavement with considerable elevation leading to the adjacent low ground is another cause of water-logging. Examples can be cited from the two overbridges of the city. Cent per cent impervious roof of the long overbridge near stadium, together with high road and rail-crossing pavements, the runoff accumulate in the Guwahati Club (Plate 4), and in Hadayetpur by-lane (Plate 5). So also, both ends of Panbazar overbridge experience water-logging after heavy downpour. The north end of this overbridge and the road in front of the State Text Book Production Corporation (Plate 6) faces knee-deep water-logging. Similarly, the south end

Plate 4: A scene of Gopinath Bordoloi Road at Guwahati Club.

Plate 5: Water overtopped at bylane of Hadayetpur.

Plate 6: Road in front of the Office of the State Textbook Production, Panbazar, has been submerged.

Plate 7: Waterlogged road in front of Saraf building.

of the same overbridge, a few meter down to the west, the roads in front of Saraf building (Plate 7) and Police Reserve (Plate 8) are subjected to water-logging after heavy rains.

The natural drainage of Guwahati has already been discussed in Chapter V.1.b. In order to elaborate the drainage links, in the Map 10, alphabetical nomenclature has been used. Here A B is the main natural channel known as Bharalu river. A D is the upper part of Bharalu river, U P is an abandoned channel of the Bharalu, called Mora Bharalu, has a peculiar reversible course. The closure of the sluice gate (Plate 9) near Pragjyotish College, reverses the flow of water in the Bharalu (during high water level) to the Dipar bil.

Numerically, there are many countable drains in the city area. From the Map 10, it is very clear that river Bharalu is the main natural outlet which absorbs many artificial drain loads of the city. As shown in the map, the drain C D extends from Noonmati Refinery and passes along the R.G. Baruah Road to meet the Bharalu near Zoo-gate. It carries all the industrial waste water of the Refinery along with the rain water from Bamunimaidan, Jyotinagar, Krishnagar and Narikal basti, Hengrabari and Japarigog hilly area supply enormous runoff that inundate parts of R.G. Baruah Road (Plate 10) and the Narikal basti area with great speed during monsoon.

Plate 8: Waterlogged road between the State Police Reserve gate and Ram Mandir.

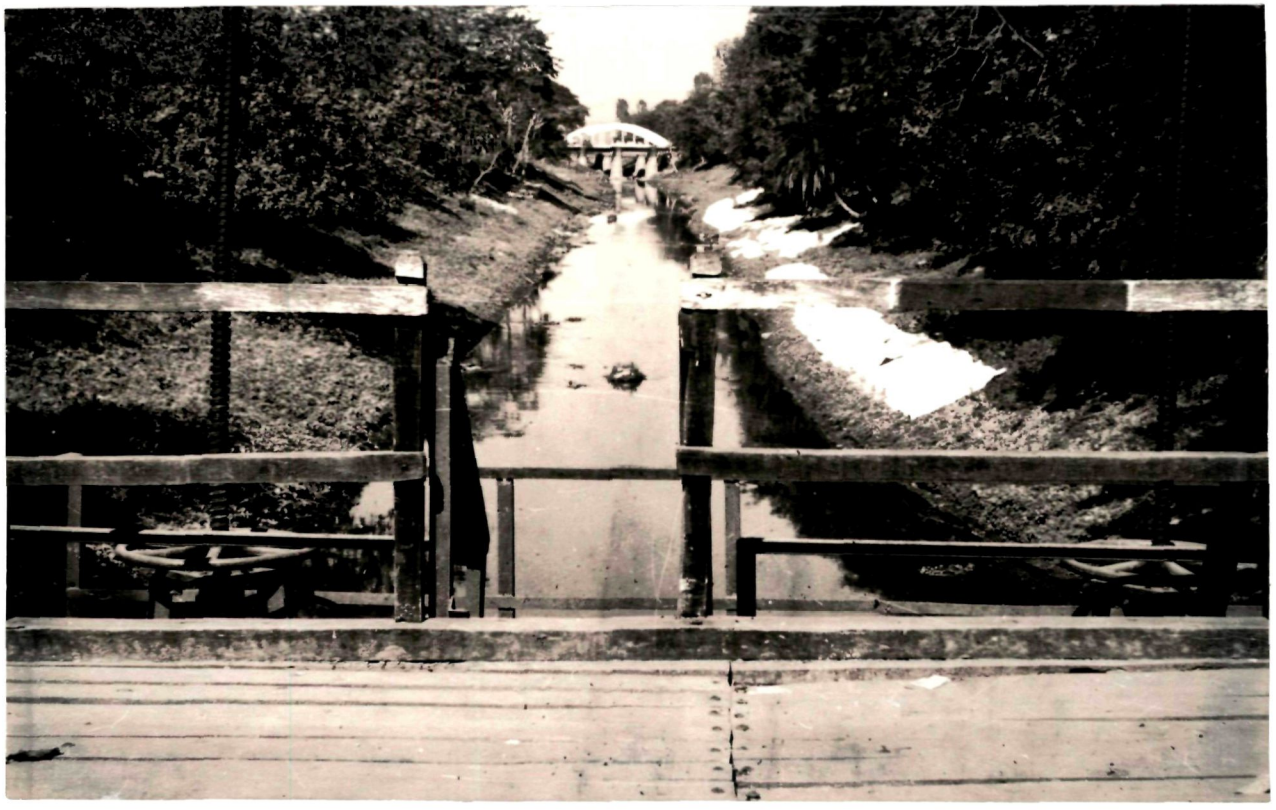

Plate 9: A sluice gate at Bharalu river, near Pragjyotish College, Santipur.

Plate 10: Overflows of rainwater on R.G. Baruah Road.

Plate 11: Waterlogged road in front of Gauria Math, Paltanbazar.

The drain E F extends from the All India Radio Complex along with the Rajgarh road and outfalls into the Bharalu. It carries storm water from All India Radio Complex, Chandmari area, Krishnagar and a part of Japarigog area. An underground drain G H is connected with Bharalu via Rajgarh link road. It carries storm water from Pub Sarania, part of Gandhi basti and Rajgarh road area.

The drain K Z runs along the northern side of Railway line, crosses the Stadium overbridge and extends up to the point L to meet the Bharalu. It carries water of entire Navagraha area and casually inundates Hadayetpur area. J Z L drain extends from Gopinath Bordoloi road at Ambari to Barchala bil. It carries water from Ambari, Paltanbazar, Manipuri basti area and passes through the bridge of Nepali Mandir, reaches the Barchala bil and ultimately outfalls into the Bharalu.

Another drain S T N, also extends from Nabin Bordoloi Road through Chalabil (Satribari swamp) to Bharalu river. It receives water of Panbazar area, Police Reserve area and flows through Ram Mandir underground drain and Chalabil to the Bharalu. The drain M carries water from Lakhtokia and meet the underground drain near Ram Mandir. It receives water of Panbazar and Lakhtokia area and falls into the Bharalu.

The drain O extends from Fancybazar meet the Bharalu at P through Fakirtola (Athgaon). It carries major part of water of entire Fancybazar, Kedar Road and Athgaon area. The entire length of the drain passes through the heavily built-up area which obstructs free flow of water.

The drain Q R extends from Assam Trunk Road through Kumarpara to the Bharalu. It carries water from Biren Ram Phukan road, Kumarpara and Bharalumukh area. This drain, because of its usual wet condition fails to wash out the accumulated water as the water seepage capacity is the lowest.

An open drain V flows from Durgasarobar to the Bharalu. It carries rain water from Durgasarobar and Santipur area along with the spring water from Santipur hillside and outfalls in the Bharalu.

All these drains falls into the river Bharalu except the drain X Y, which independently falls into the Brahmaputra. It starts at Happy Villa passes through Uzanbazar, to meet the Brahmaputra at Y. It carries water of Kharghuli, Happy Villa area and parts of Uzanbazar.

All these drains, described above, are not capable of flushing out the rain water effectively for many reasons, viz. i) Drains do not follow the natural slope, ii) Drains are constructed without taking into account

the volume of flush, iii) The gradient of drain is extremely low, iv) Adequate manhole are not provided, v) Inlet holes are either smaller or constructed not at proper level of the road.

The inadequacy, ineffective and undersize of the drains, as noted above, miserably fail to drain off the rain water during monsoon season. The worst affected areas are Silpukhuri, Gandhi basti, Islampur, Rehabari, Lachitnagar, Paltanbazar (Plate 11), Tokobari, Santipur and Lamb Road (Plate 12). Even death* due to land slide and flash flood is not uncommon in city area.

The flash flood not only create hygienic and sanitation problem in the city area, at times the city life is completely paralysed at a great social cost. Looking into the growth momentum of the city, establishment of industrial areas and the capital complex in and around the city, various government agencies have offered suggestion for alleviation of this problem. The notable suggestions offered by the Town Planning Organization, Assam, and the Brahmaputra Flood Control Department, perhaps, would ease the situation to a certain extent, provided

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* Six killed in Landslide after heavy downpour of rain on 14th August, published in The Assam Tribune, 15th August, 1982.

Plate 12: Lamb Road opposite to Assam Textile Institute over flooded after heavy shower.

these schemes are effectively implemented. Nevertheless, it seems the problem will persist unless a long drawn project is taken up with immediate effect.

V.4. Towards Solution of Flood and Drainage Problems of Guwahati City

The characteristic features of the natural drainage of Greater Guwahati (see Chapter V.1.b.) and internal drainage links inside the congested city (Chapter V.3.b) have elaborately been discussed earlier. In addition, the other components like average slope (Chapter V.1.a), rainfall (Chapter V.3.a), discharge and water level of the Brahmaputra and Bharalu (Chapter V.1.c & V.2.a.) have also been analysed.

Further analysis is also necessary to study the Kalbhog river near Palasbari and Kulsi river near Kukurmara which lay beyond the western end of Greater Guwahati. This is because these have direct link with city flood and drainage problems. In the light of the problem, the Brahmaputra Flood Control Commission took up survey and investigation in the year 1977 for preparing a comprehensive plan to solve the flood and drainage problem of the city and its suburbs. Parts of the scheme are being executed in phases.

Hydrological Observation

From the hydrological point of view, this problem encompassed the consideration of Bondajan, Bharalu, Khanajan along with the Brahmaputra and the bils of Silsako, Barchala and Dipar. There is a scope for resolving flood and drainage congestion, by taking into account the Kalbhog, Kulsi rivulets and Dora bil beyond the western part of the Greater Guwahati. Hence to understand the hydrological problem associated with the drainage congestion of the city, a large number of hydrological observatory stations were established during the flood season of 1977 by the Brahmaputra Flood Control Commission.[20] During that year the worst condition of drainage in the city was recorded on August 18, 19 and 20. Average sheet flow of water during those days at different reaches are shown in the Table V.9.

An effective drainage system depends on the quickness of disposal of the drainage water from the area. All the drainage outfalls inside the Greater Guwahati are on the Brahmaputra river. But nowhere from Bondajan to river Kalbhog outfall condition of the drainage channels functions properly. This is particularly so during

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20. H. Gohain and S.K. Nath, 1980, "Solution of Flood and Drainage Problem of Guwahati", The Assam Tribune, Guwahati, Sept. 7, pp. 4,5.

TABLE V.9

Average Water Surface Grade from Bahini to Kalbhog

Station No.	Location (from)	Location (to)	Average water surface grade
1.	Bahini at NH 37 crossing	Bahini at Beltola-Khanapara Road crossing	1:119
2.	Bahini at Beltola-Khanapara Road crossing	Bahini at Guwahati-Shillong Road crossing	1:1636
3.	Bahini at Guwahati-Shillong Road crossing	Bahini at Down stream of French Motor Co.	1:1153
4.	Bahini at Down Stream of French Motor Co.	Bharalu at R.G. Baruah Road crossing	1:1719
5.	Bharalu at R.G. Baruah Road crossing	Bharalu at Guwahati-Shillong Road crossing	1:80000
6.	Bharalu at Guwahati-Shillong Road crossing	Mora-Bharalu Timber bridge	1:13333
7.	Mora-Bharalu Timber bridge	Kotabari NH 37 RCC bridge	1:5494
8.	Kotabari NH 37 RCC bridge	Garali Timber bridge crossing	1:25000
9.	Garali Timber bridge crossing	R.C.C. bridge crossing at Dharapur	1:21276
10.	R.C.C. bridge crossing at Dharapur	Additional approach to Airport	1:36364
11.	Additional approach to Airport	Kalbhog at Palasbari	1:7936
12.	Kalbhog at Palasbari	Kulsi at Kukurmara	1:3604

Source: Brahmaputra Flood Control Commission, Guwahati-3.

flood season when the Brahmaputra attains a level higher than the adjacent drainage basins. This is clear from the flood water profile of river Brahmaputra (see Table V.10).

TABLE V.10
Flood Profile of River Brahmaputra

Chainage in Km	Location	Average bank level (m)	Observed High Flood level (m)
0	D.C. Court	54.15	50.55
2.4	Bharalumukh	51.22	50.45
6.8	Pandu Railway Colony	48.78	49.52
12.62	Khanamukh	48.78	48.93
24.70	Kalbhog river outfall	-	47.73

The water levels are recorded on 19.8.77.
The Extreme High Flood level is 51.04 metres.

Source: Brahmaputra Flood Control Commission.

It is an established fact that the outfall condition is unfavourable at Bharalumukh. Hence alternative outfall downstream had to be found to improve the discharge of Bharalu channel. Though the municipal corporation had installed pumpsets (Plate 13 a & b) for pumping out the water during high flood, it is economically prohibitive. The downward grade between the river Kalbhog and Kulsi

a) Pumpset power house

b) The pipe line by which excess inundated water pump out after closed down the sluice gate of Bharalu river in front of Pragjyotish College.

Plate 13: Pumpset on Bharalu river.

satisfactory situation even when the river runs at its high flood level. So this downward grade will allow the passage of the impounded water of Dipar bil by a regular canal joining the bil area of Dipar and the river Kulsi at Kukurmara through Dora bil.

In view of the overall drainage problem, the state Flood Control Department had taken urgent steps. These were: (i) Stopping the backflow from river Brahmaputra into the city through the existing channels, culverts in the roads acting as bund and open spaces between the discontinuous dykes. (ii) Reconstruction of Dipar basin at higher level by adding the upper part of the Bharalu basin to relieve the lower part of the river in the Guwahati Municipality of the flash floods. This is caused by the upper hilly catchment areas that are now added to the Dipar basin, (iii) Draining and the impounded water of Bharalu sub-basin and reconstituted Dipar basin by gravity flow to river Kulsi and ultimately to the river Brahmaputra at Nagarbera.

The proposal towards solution of flood and drainage problems prepared by the State Flood Control Department is as follows:

Reconstituted Dipar Basin

The upper part of Bharalu basin causes flood in

the main city due to hilly nature of the basin. The upstream of Bharalu river at National Highway where it is known as river Bahini has already been diverted by a canal to the river Basistha near the Military Hospital, upstream of the National Highway (Map 11). This canal joined the river Basistha at downstream point of much lower level. As a result, the Bharalu basin in the city area is relieved of the impact of the flash flood caused by the hilly drainage area of river Bahini. The combined discharge of Bahini and Basistha is then passed through the river Basistha with resectioning and regrading to have the hydraulic capacity. This canal again is diverted near Dispur capital area to shorten a loop. This is joined with Mora Bharalu river near Kotahbari RCC bridge of the National Highway 37. Then the canal runs along the course of river Basistha upto Dipar bil by crossing the National Highway RCC bridge at Kotahbari with required resectioning and regrading. The design of high flood level of canal (as estimated by Brahmaputra Flood Control Department) reduces from 58.62 m at the Bahini diversion point to 47.1 m at the confluence point with Mora-Bharalu river near National Highway R.C.C. bridge at Kotahbari.[21] High

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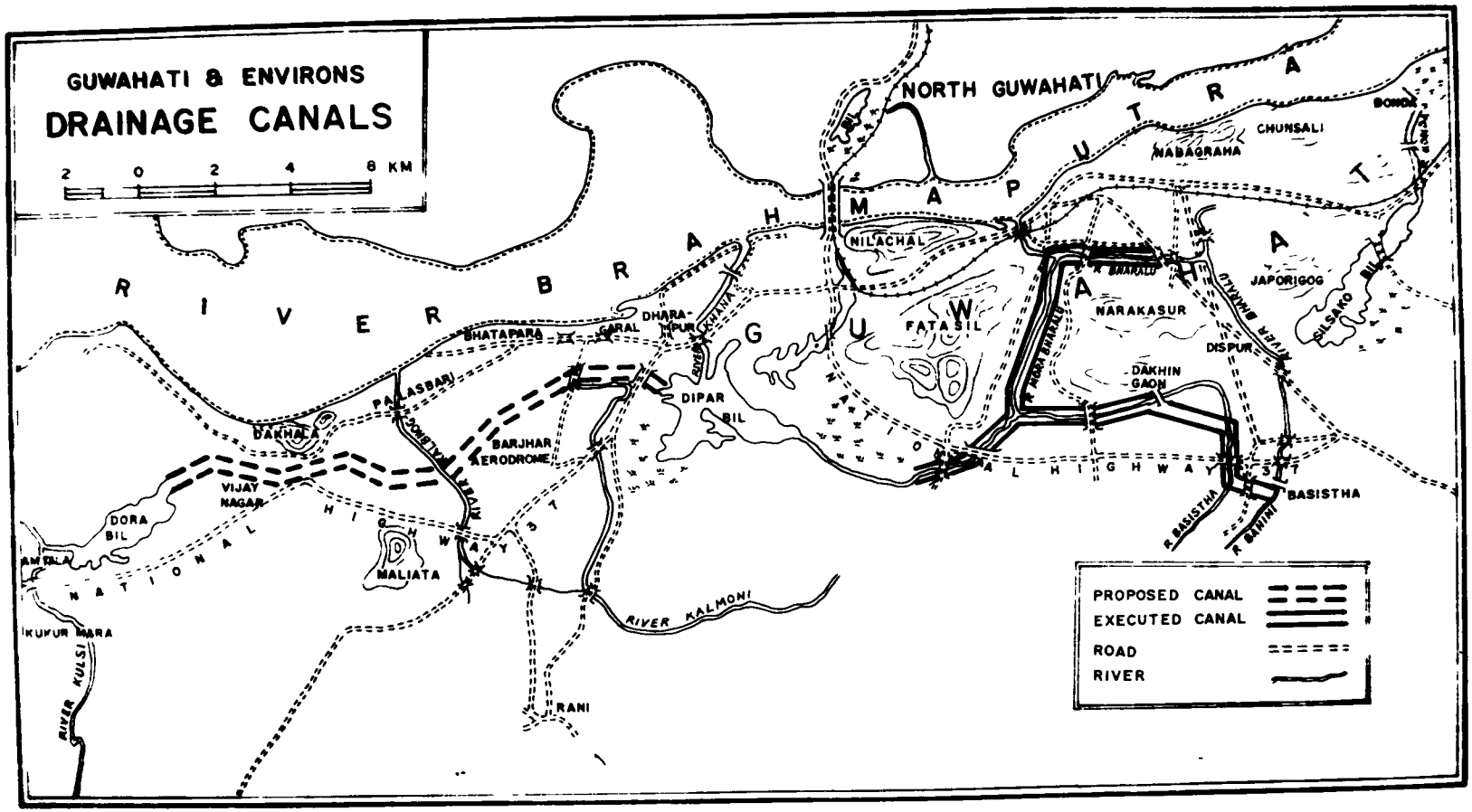
21. G.C. Changkakati and A.K. Deka, 1982, Development of Drainage of the City of Guwahati, Seminar Proceeding, The Institution of Engineers (India), Guwahati, Sept. 14-16, p. (i)-9.



SOURCE BRAHMAPUTRA FLOOD CONTROL DEPT

MAP II

flood profile of the canal from Bahini diversion point to river Kulsi at Kukurmara through Dipar bil is given in Table V.11. The design high flood level of 47.1 m at the Basistha mora Bharalu confluence to Dipar bil of 46.68m gradually graded down and executed accordingly. The size and sections of the canals are given in Table V.12.

The Dipar bil is connected to river Brahmaputra through river Khana. An existing sluice controls the back-flow of river Brahmaputra. Necessary guide bunds to the sluice are built in vulnerable area to join the missing link of Brahmaputra dyke.

Dipar Bil to Kulsi Link Canal

It is observed that high flood level of Dipar bil at Garal timber bridge near Kotahbari 48.33 m and at Dharapur Chariali 47.80 m. It is already maintain the gradation of water level. Only after reconstitution of the basin area, the level is raised to additional height. The proposed canal linking Dipar bil to river Kulsi at Kukurmara where high flood level is recorded 44.90 m. It is estimated to reduce the high flood level of Dipar bil to the design high flood level of 46.83 m and 46.68 m on the east and west junctions of the canal with the bil (Map 11). This reduction of high flood level of Dipar bil by the down canal is necessary. Thus, it attracts the Bharalu river to flow through river Mora Bharalu to

TABLE V.11

High Flood Profile of Canal from Bahini Diversion Point to River Kulsi

Chainage in Km.	Location	Average level of the point (m)	Ground level at Canal Axis (m)	Depth of canal (m)	Design High Flood level (m)	Observed H.F.L. (m)
0	Bahini Diversion Point	60.0	60.05	1.42	58.62	-
0.73	End of Bahini Diversion and Confluence with Basistha river	59.3	56.84	-	58.48	-
2.23	Bhatapara 2nd Diversion starts	53.0	52.93	2.12	54.94	-
4.83	Dakhingaon 2nd Diversion ends	50.0	48.32	2.12	50.45	-
5.83	Jatia hill	50.0	48.49	2.12	50.37	-
8.93	Basistha-Mora-Bharalu Confluence	47.5	48.05	2.12	47.10	-
9.73	Katabari bridge on NH way	47.5	47.56	2.12	-	48.52
10.77	Timber bridge on river Basistha	46.9	46.33	2.12	46.83	48.33
18.77	Canal start at Dipar bil, Dharapur Chariali	45.7	45.73	1.4	46.68	47.80
30.77	Near Dhakhala hill	45.1	45.14	1.4	46.54	-
35.97	Canal end at Dora bil	42.4	42.41	1.4	45.65	-
39.97	Dora bil Kulsi river junction at Kukurmara	-	-	-	-	44.90

Source: Brahmaputra Flood Control Department, Guwahati.

TABLE V.12

Hydraulic Elements of Canal from Bahini to Dora Bil

Sl. No.	Particulars of Canal	Bed width (m)	Depth of water (m)	Side Slope
1.	Diversion canal from R. Bahini to R. Basistha upstream of NH 37	7	1.42	1:1
2.	Canal from end of the above diversion canal to Dipar bil	11	2.12	1.5:1
3.	Resectioned Bharalu and Mora Bharalu river	29	-	1.5:1
4.	Canal from Dipar bil to Dora bil	15	1.4	1:1

Source: Brahmaputra Flood Control Department.

Dipar bil. By this the Guwahati Municipal area will be free from inundation during the monsoon period - provided the foothpath cum drain inside the Guwahati are managed properly.

Implementation of the Drainage Scheme

The problem of drainage of Greater Guwahati is clear. In view of the problem, to remove the flood hazard inside the city, a comprehensive scheme has to be implemented phase wise on priority basis (work in some of the phases has already been executed). The scheme is divided in seven phases.

Phase I

Construction of a sluice at Bonda across Bondajan river, construction of other two sluices at Garal and Bhatapara on the open culverts on the Guwahati-Goalpara P.W.D. Road, construction of guide bund at Khanajan sluice and the link bund from Dharapur Chariali to Dhoptola Bazar to build with the existing Brahmaputra dyke. The works of this phase is completed. Hence there is no chance of backflow from Brahmaputra river.

Phase II(A)

Diversion of river Bahini to the river Basistha at upstream of the National Highway near Military Hospital by constructing 732 m canal with the provision of a sluice on river Bahini just down stream of the diversion point.

Phase II(B)

Construction of the lower part of Dipar-Kulsi link canal from low lying area near Dakhala hill to Dora bil of length 5200 m.

Phase III

Resectioning is the main task of this phase. River Basistha from Bahini diversion point on Basistha to Bhatapara near the Dispur capital area and from Dakhingaon to Jatia hill have already resectioned. The embankments on both sides with the provision of sluices at several points have been constructed.

Phase IV

It consists of diversion of river Basistha from Bhatapara to Dakhingaon to shorten the length of the course. It relieves Dispur capital area from flood. The length of the diversion canal is 2625 m. Excavation of the canal is also completed.

Phase V

It consists of resectioning and regrading of river Basistha from Jatia hill to Dipar bil.

Phase VI

It consists of resectinoning of river Bharalu from G.S. Road crossing (near Bora service petrol pump) to Bharalumukh and regrading and resectioning of Mora Bharalumukh to its outfall on the Basistha drainage canal near Kotahbari R.C.C. bridge of the National Highway.

Phase VII

It consists of construction of canal from Dipar bil to the near Dakhala hill.

After completion of all these phases, the total area of Greater Guwahati will be free from flood congestion at about 33,400 acres.*

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*Estimated by Flood Control Department, Assam.

It may be mentioned that the above phases except Phase II(B) and VII all the phases have been executed so far. The other two phases are being executed with required modification of priority.

In addition, a new proposal for drains impounding flood water at higher level in the hill side, north of G.N. Bordoloi road covering the hill ranges from Uzanbazar Kharghuli and Nabagraha hills to the hill ranges near Guwahati refinery has also been incorporated. A long canal of 1700 metres joining Silsako bil to river Bharalu near Rukminigaon is also under consideration, as a part of the last phase of the project. This canal is to pass the spill over of the Silsako bil at time of requirement to the river Bharalu.

One main component which was neither included in the above scheme nor by the Municipal Corporation or Town Planning Department was considered in their proposal. It would be necessary to stabilize the entire Brahmaputra dyke from Bondajan to Kalbhog, so that breaches in this embankment system during high floods are minimised if not eliminated. It has been noticed that there was a difference of opinion between the Municipal Corporation and Flood Control Department regarding the installation of pump sets at Bharalumukh sluice gate. After implementation of almost all the scheme proposed by Flood Control

Department, still most of the part the city areas are submerged during monsoon period. At the time of inundation pumpset must have to operate until the floods subsided. There are many other factors mentioned by author in the earlier Chapter V.3.b. Unless there is close coordination between the Flood Control Department, Guwahati Municipal Corporation, Guwahati Development Authority and State Town and Country Planning Department, the problems will remain unchanged.

CHAPTER - VI

ECOLOGY AND HUMAN INTERFERENCE

Ecology is the study of plants and animals in relation to their environment. These plants and animals are found in varieties of environmental conditions over the surface of the earth. Among all, man is an inseparable element of the ecosystem. Man, using nature in the process of development, does induce certain changes in the environment. If these changes are not fully orchestered to preserve the harmony of nature and the ecological balance, it increases the risk of escalating the cost of development. But imbalances may prove serious as to reduce his living conditions instead of enriching it. It is this imbalance which creates pollution.

Environmental pollution has been defined as the unfavourable alteration of our surroundings, partly or largely due to the impact of increasing industrialisation and related human activities. With increasing industrialisation, air, water and soil pollution have grown in alarming proportions which have raised serious concerns about the survival or urban dwellers. Environmental pollution is not only associated with the pressure of population on scarce natural resources. Urbanisation without proper (towns) planning is one of the causes of land pollution. Lack of basic civic amenities such as sanitation, water

supply, housing in urban complex lead to problems of waste disposal. Guwahati city is not an exception. It has its own serious pollution problems. Improper location of industries, the use of "polluting" technologies, and inadequate waste treatment facilities and technologies, are chiefly responsible for deterioration in air and water qualities. Other indirect stresses on the environment are enhanced by the locations of slum colonies.

Environmental pollution can be classified under three broad headings depending on its nature:

i) Air pollution,

ii) Water pollution, and

iii) Other factors of pollution.

In addition to these, the ecology in totality has been impaired by clearance of original vegetation (wanton clearing of shrubs, bushes and trees). Hence it is necessary to study the degree of deforestation inside the city to assess the ecological imbalance of the Greater Guwahati.

VI.1. **Air Pollution**

Atmosphere pollution is due to the presence of gaseous matter (e.g. sulfur oxides, nitrogen oxides, hydrocarbons, carbon monoxides) and due to particulate matter (e.g. solid particles or liquid suspended in the air causing smoke, mists etc).

Though, it is difficult to make definite statements about the health effects by air pollution, but its impact on human life (from the petro-chemical complex and emission of smoke from vehicular traffic for example) are decisively harmful.[1] The calcination unit for calcining Raw Petroleum Coke (R.P.C.) a by-product of Guwahati Refinery has also created a health hazard in one part of the city.[2] The tall chimnies of such units blows up small particles of coke dust along with smoke. It spreads throughout a large area in the city as in Noonmati area. These micro-mini particles are so tiny, that people around this area inhale it. Regular inhaling of such particles has led to tuberculosis, lung cancer, asthma and eye diseases. Measures suggested by National Environmental Control Board has been implemented by the industries under the general direction of Guwahati Municipal Corporation. However, the benefits of such acts is felt only by the employees rather than the general public which continues to suffer from ill-effects of pollution.

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1. National Academy of Sciences (NAS), 1975. Air Quality and Stationary - Source Emission Control, Washington.
2. World Environment Day, June 5, 1985. Presidential Address, Chief Administrator, G.M.C., Guwahati.

Besides, the most harmful of the contaminants is carbon monoxide resulting from incomplete combustion of carbon. The atmosphere of the city becomes more pullted by emission of carbon monoxide, oxides of nitrogen, aldehydes etc. during rush hour as too many vehicles are plying on the road. This leads to lung cancer. Unfortunately there are no such devices installed in the city to measure and control the rate of pollution by vehicles.

Decomposition of organic matter, sewage, petroleum industries, refineries etc. are the main source of sulphurited hydrogen gas (H_2S) emission. Barchala bil of heart of the city becoming the reserviour of sulphurited hydrogen gas which polluted the air nearby residents.

VI.2. **Water Pollution**

The water body is fluid in nature which contain physio-chemical and biological equilibria and normally active waterway has a large capacity to assimilate wastes. This capacity of assimilation is either being reached or exceeded so that water body are becoming increasingly contaminated. Broadly speaking water bodies are subjected to entry of pollutants by:

1. Direct discharge into the system.
2. Runoff and/or seepage with subsequent transport.
3. River flow transport etc.

Under all circumstances of entry, the contaminant will be in either dissolved or particulate form by reactions in the water body. The fate of either form depends to a large extent on its reactivity and on the availability of reactive sites, whether physical, chemical or biological.

The urban sprawl and small industrial units in and around Guwahati are responsible for releasing undesirable effluents and pollutants, even in the stagnants pools in and around the city environment. The estimates of industrial effluent of six different points in 1987 of Greater Guwahati are given in Table VI.1. These samples indicates that the effluent drained from those points are very strong. Most of the effluents are drained out openly through human habitation in the city. Unless these drain are covered or the affluents flow through underground pipes, people cannot escape the hazards created by such open affluent drains.

The river Brahmaputra is the only source which receives all 'foul water' from the built-up areas of the city. The contaminated water not only adversely effect the human health and hygiene but also reduce spawning of fish in the river; thereby creating an imbalance of the fresh water ecology. Contamination of water sewage is the principal cause of water-borne diseases including

TABLE VI.1

Physical and Chemical Analysis of Effluent at Different Points of Greater Guwahati

Source of Effluent	Main outlet, Industrial Estate	Kamrup Paper Mills	Indian Oxygen Ltd.	Discharge Water Associated Industries (Chem. Unit)	Nezone Tube Ltd.	G.L.Industry before discharge in the bill
Place of Collection	Bamunimaidan	Amingaon	Dispur	Chandrapur	Pachim Boragaon, Jalukbari	Dispur
Date of Collection	1.8.84	20.9.84	20.9.84	19.10.84	6.11.84	21.12.84
PHYSICAL CHARACTERISTICS						
Appearance	Turbid	Blackish & Turbid	Whitish turbid & thick slevery	Not very clear	Turbid	Turbid
pH	7.1	6.32	11.7	2.4	7.1	5.15
Temperature in °C	30	26	28	35	34	20
Weather	Sunny	Cloudy	N.R.	Sunny	Sunny	N.R.
CHEMICAL CHARACTERISTICS						
B.O.D.	-	Not examined	-	-	9.2	-
C.O.D.	142.0	360.0	172.0	8.0	120.0	16,560.0
Suspended Solids	1043.0	1674.0	-	6.0	35.0	-
Oil and Grease	Sample insufficient	Nil	Nil	Nil	Nil	-

(Table VI.1 Contd.)

Source of Effluent	Main outlet, Industrial Estate	Kamrup Paper Mills	Indian Oxygen Ltd.	Discharge Water Associated Industries (Chem. Unit)	Nezone Tube Ltd.	G.L.Industry before discharge in the bill
Phenolic Compd. as C_6H_5CH	Sample insufficient	Nil	Nil	Nil	Nil	301.13
M - Alkalinity as $CaCO_3$	232.0	212.0	170,000.0	Nil	143.0	1700.0
P - Alkalinity as $CaCO_3$	Nil	Nil	170,000.0	Nil	Nil	Nil
Total Acidity as $CaCO_3$	Nil	Nil	Nil	470.0	Nil	Nil
Amonical Nitrogen as NH_3	20.0	0.48	10.4	0.08	0.04	160.0
Chloride as Cl	62.0	22.0	15.0	12.0	10.0	Nil
Residual Chlorine as Cl	Nil	Nil	Nil	Nil	Nil	-
Sulphate as SO_4	8.5	330.0	92.0	175.0	8.5	-
Remarks						Very strong effluent

Source: State Public Health Laboratory, Assam, Guwahati - 21.

cholera, typhoid and para-typhoid, dysentry, and infectious hepatitise.[3] Bio-chemical oxygen demand (B.O.D.), measurement of the quality of water, does not accurately indicate the risk of disease. Hence, more specific indices are required. One of the most common factor is the number of coliform bacteria (sometimes specifically, fecal coliform-intestinal bacteria, especially of the genus 'Escherichia') per unit volume of water.*

Table VI.2 shows water quality trends in the Brahmaputra between 1980 and 1986. It is, compared with standard recommendation (recommended by Environmental Protection Agency) specifically with coliform bacteria and other indicators for the samples. The population of coliform bacteria in the Brahmaputra was significantly higher than the standard recommendation (Table VI.2) in all the year except in 1986**.Even after processing in municipal water-

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3. Paul R. Ehrlich, et al, 1977. Ecoscience: Population Resources, Environment, W.H. Freeman and Company, San Francisco, p. 556.

* United State Public Health Service (USPHS) drinking water standard for coliform organisms specifies that the most probable number (MPN) shall not exceed 10,000 coliform organisms per 100 millilitres of water.

** Monthly data for the year of 1983, 1984, 1985 collected from Board for Prevention and Control Water and Air Pollution, Assam, but the data for 1980 and 1986 are the average of six and five months respectively.

TABLE VI.2

Water Quality Trends of Brahmaputra River, 1980-1986

Sl. No.	Indicator	1980	1983	1984	1985	1986	Standard recommendation*
	CHEMICAL CHARACTERISTICS						
1.	D.O.	-	6.45	8.36	7.10	7.94	-
2.	B.O.D.	-	1.66	1.67	1.65	0.85	-
3.	C.O.D.	-	9.04	7.78	10.30	5.76	-
4.	Total Nitrogen (NH_3 + Org.N)	0.19	0.75	0.67	0.63	0.49	0.89 mg/l
5.	Nitrogen (NO_2 + NO_3)	0.08	0.08	0.07	0.13	0.06	0.9 mg/l
6.	M-Alkalinity as $CaCO_3$	76.80	63.20	61.80	67.00	84.50	-
7.	Total Hardness as $CaCO_3$	64.40	62.00	71.60	66.25	68.00	-
8.	Calcium as $CaCO_3$	44.80	44.00	52.00	45.75	47.00	-
9.	Magnesium as $CaCO_3$	19.40	16.80	19.60	20.50	16.62	-
10.	Sodium as Na	-	5.03	4.27	4.94	5.90	-
11.	Chloride as Cl	5.00	4.16	7.03	5.00	5.08	-
12.	Sulphate as SO_4	34.4	8.48	10.50	11.12	13.60	250 mg/l
	BACTERIOLOGICAL CHARACTERISTICS						
13.	Total Coliform (M.P.N. per 100 ml)		50,155	30,473	11,504	8260	10,000/100 ml
14.	Fecal Coliform (M.P.N. per 100 ml)		3,932	5,975	1,606	850	2,000/100 ml

Source: Calculated from the data of Board for Prevention and Control Water and Air Pollution, Assam, Guwahati - 7.

*Standard recommendation source is C.E.Q. Environmental Quality, 1974, p.366.

treatment plants, the water supplied for drinking in Greater Guwahati is not always safe. The increased contents of chlorine in water may be due to the improper management of water-treatment which may lead to the water toxicity. The increased quantity of mutagenic and carcinogenic compounds in drinking water may cause death due to cancer as happened in Louisiana.[4]

The river Bharalu flowing through the city is the dumping ground of industrial wastes and domestic sewerage of the city. The colour of water (Table VI.3) and smell emitted by it, indicate to be highly polluted river. Fresh water of river Bharalu originally, oozes out from the three holy springs, namely Sandhya, Lalita and Kanta. But, it completely changes while crossing the city area. A comparative statement of composition of water at different reaches (A to F) of the Bharalu is given in the Table VI.3. Significantly Chlorine (Cl) Sulphate (SO_4), Oil and grease increase towards the downstream of the river. This is due to drainage of domestic used water and industrial waste water into the river. The average of twelve months data of 1985 and 1986 (Table VI.4) indicates high bacterial

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4. R. Tardiff and M. Deinzer, 1973, "Toxicity of Organic Compounds in Drinking Water", E.P.A. Water Supply Research Laboratory, Cincinnati.

TABLE VI.3

Physical and Chemical Analysis of Water in Bharalu River

Date of Receipt : 9.7.70

Date of Collection : 8.7.70

Sample Points	A	B	C	D	E	F
Tech. No.	42/70	43/70	44/70	45/70	46/70	47/70
Colour	Slightly Brownish	Slightly Yellowish	Not very clear	Slightly Yellowish	Gray	Slightly Yellowish
Turbidity	Turbid	Turbid	Not very clear	Turbid	Turbid	Turbid
Smell	No smell	No smell	No smell	No smell	No smell	No smell
Sediment	Present (Iron)	Present (Clay)	Present (Silicious Matter)	Present	Present	Present (Clay)
p^H	6.9	7.3	6.9	7.1	7.0	6.8
Total Solid	197.0	213.0	138.0	258.0	267.0	281.0
Total Soluble Solid	118.0	109.0	61.0	127.0	157.0	184.0
Total Hardness	40.0	19.0	19.0	32.0	58.0	51.0
Cl	6.0	5.5	5.0	12.0	5.5	13.0
SO_4	Trace	0.82	Trace	1.97	8.24	6.76

Table VI.3 (Contd.)

Sample Points	A	B	C	D	E	F
Dissolved Oxygen	4.24	7.47	5.75	7.37	7.17	8.98
B.O.D.	26.66	17.90	21.00	9.11	14.03	12.92
Oil and Grease	Trace	4.0	4.8	7.2	6.0	5.2
Phenolic Compound	Trace	Negligible	Negligible	Negligible	Negligible	Negligible
Chlorine Demand	3.1	3.0	2.9	3.1	2.6	2.9
Acidity as $CaCO_3$	5.25	-	-	-	-	5.25

A = Water sample at U/S concrete bridge, west of Coca-Cola Factory, Narengi
B = Water sample at U/S of concrete bridge of Bharalu, A.t. Road Crossing near Khanapara
C = Water sample at U/S of concrete bridge, near Basistha on the N.H. Diversion
D = Water sample at D/S of wooden bridge near concrete bridge of N.H. Diversion
E = Water sample at U/S of Concrete bridge on A.T. Road (outlet of Dipar Bil)
F = Water sample at D/S of Bharalu Sluice gate

Source: Data Collected from T.P.O., Assam, Guwahati, Analysed in the State Public Health Laboratory, Assam, Guwahati.

N.B.: U/S - Upstream
D/S - Downstream

TABLE VI.4

Water Quality of Bharalu River 1985-1986

Sl. No.	Indicator	1985	1986	Standard recommendation
1.	p^H	6.86	7.04	-
2.	Turbidity	191.11	51.40	-
3.	Conductance	250.71	227.09	-
4.	D.O.	6.03	2.26	-
5.	B.O.D.	13.01	9.81	-
6.	C.O.D.	39.82	35.90	-
7.	Total Nitrogen (NH_3 + Org.N)	4.20	1.24	0.89 mg/l
8.	Nitrogen (NO_2 + NO_3)	0.18	0.04	0.9 mg/l
9.	P-Alkalinity as $CaCO_3$	Nil	Nil	0.001 mg/l
10.	M-Alkalinity as $CaCO_3$	114.00	106.00	-
11.	Total Hardness as $CaCO_3$	83.75	91.27	-
12.	Calcium as $CaCO_3$	58.00	31.23	-
13.	Magnesium as $CaCO_3$	25.75	12.78	-
14.	Sodium as Na	12.08	22.92	-
15.	Chloride as Cl	18.20	24.54	-
16.	Sulphate as SO_4	17.50	15.27	250 mg/l
17.	Total coliform MPN/100 ml	81042	45210	10,000/100 ml
18.	Fecal coliform MPN/100 ml	22660	5272	2,000/100 ml

Source: Calculated from the data of B.P.C.Q.A.P., Assam.

coliform as against the standard recommendation quality. This polluted water has endangered the survival of the living creature in and around the river.

VI.3. Other Factors of Pollution

It is worth mentioning, that within the Greater Guwahati no sewage-treatment plants* exists except in three townships maintained by various organisations i.e. Railways, the Refinery, Medical College etc. Most of the houses inside the city are equipped with ordinary septic tanks. These septic tanks do not function during the rainy season because of high water table, thus polluting surface water as well as ground water around the area. Hence civic authorities should ensure that either a proper sewage disposal system should be provided for in the cities with large population or special septic tanks should be designed to ensure that pollution is minimised. It is necessary to provide for a civic authority with legal powers that will equip it with stringent power, so that it can ensure the city from further deterioration in respect to air or water pollution.

Originally municipal area of Guwahati was rich in ecological endowments of mixed vegetation, uneven topography of hills, plains, bils etc. The total environment of Guwahati (natural and cultural) had an overall adjustment. As the rural Guwahati is being progressively transformed

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*Sewage-treatment plants are intended to bring domestic and industrial waste up to a quality suitable for discharge into rivers, lakes or coastal waters.

into Semi-urban satellites of Guwahati, the city environs is infested with unplanned and indiscriminate growth of settlement.

The ecology in totality has been destroyed by clearing original vegetation by wanton felling of trees, shrubs, bushes etc. Moreover, blasting of the hills and removal of rocks for various constructions, augmented the deterioration of the natural landscape at a faster rate. The natural habitat of animals is completely obliterated from Greater Guwahati area. On the other hand, hill cutting by man followed by natural erosion brings out undesirable condition inside the city area. Navagraha is the example of such indiscriminate disturbances.

The construction of the Broad Gauge Railway line through the heart of the city, has further caused a death blow to the ecosystem of the congested city. For example, the high pavement of the railway track has blocked the free movement of water. Rather it helps for water logging due to old age meter gauge culvert amalgamate with Broad Gauge line.

Population of Guwahati city (see Chapter VII.2.b.) has abnormally increased during last two decades. Though man is a social and rational animals, yet among the different racial groups there are attempts to annihilate the

other. An example can be cited in this case. Some of original ethnic group of settlers of Guwahati City are compelled to migrate to natural abodes, due to congestion and destruction of natural landscape and its ecology. Only an insignificant percentage of the original settlers are found in Ulubari and Dispur area at this moment.

From the above discussion it can be summarised that all these happened due to the following reasons:

i) The development and growth of science and technology failed to maintain the balance with environment - the real gift of nature.

ii) The industries based on utilization of some deadly chemicals have not provided neutralisation plants for the affluents.

iii) Non-monitoring of ambient air quality in different industrial areas of the city for lease line data.

iv) Guwahati with such a huge population is devoid of green belt, natural park, recreational parks etc.

v) Most of the original cultivable land has been converted into residential area.

vi) The encroachment on natural landscape through construction and unplanned development had further deteriorate the city environs. This had resulted in deterioration in the hygienic life of the city

dwellers. The problems experienced by the developed countries will recur in and around Guwahati before long in absence of effective control devices.

CHAPTER - VII

ANALYSIS OF URBAN GROWTH

VII.1. Planned Growth

Urban planning can be defined as the welfare of the urban people for the future. It means the utilization of human intelligence in foreseeing the possible future in making rational adjustments to or controlling the eventualities that arise in a town or city. However operations are essential for urban planning in which direction it should grow. Hence background study of a town is a necessary requirement. As planning over a town is accomplished over a period of time, provision must be made for updating information by regular review of the programmes as circumstances change. In fact, every urban planning programme must rest on a lease of extensive knowledge of at least the physical area, population structure, landuse, transportation and municipal amenities etc. (as noted in the Chapter IV). For all practical and analytical purposes, history, socio-economic, and locational (in the regional context) characteristics of the city as well as immediate environs must be studied. This is because urbanisation is normally taken as a composite indices of development.

As Guwahati city is growing with time and space, the study of origin of growth, its functional activities and peripherial growth must be taken into consideration. Hence this sub-chapter deals with following factors:

VII.1.a. **Origin of Growth**

When one views the width of the river in its entire course from Sadia to Dhubri, one finds that point near Guwahati was the narrowest. Moreover, the location of temples on both sides of the river near this point bears with the tradition of the people of the region. In addition to this, even during the Ahom period their constant defence against frequent Moghul invasion, clearly illustrated the strategic significance of this point near Guwahati city.

It was through this significance that made this city vital for the region both for its isolation as well as for interaction that resulted in the region getting its multi ethnic, multi religious and multi linguistic characteristics of the Guwahati city clearly exhibited this in a miniature form. This established a socio-economic and cultural frame on which perhaps, the development of the city took place.

Earlier analysis, clearly relfects this in no uncertain terms. This advantage enable the city to develop its administrative set up, academic and educational centres which functioned for the need of the north-east. In addition, it catered to the regional economy of focal commercial centre of the North-East India. But, it is an established fact, that it is a city of integration of all

the factors that were mentioned above. The name of Guwahati is a derivative from Pragjyotishpura (ancient name and is mentioned in Mahabharata when Bhagadatta who led the elephant brigade in Kurukhetra and fought on the side of Duryodhana).

So far as history is concerned, it was a capital town of Pre-Ahom and administrative town in the Ahom period. During the Ahom period, Guwahati (both north bank and south bank) was systematically surrounded by chowky (camp) which was set up as a defence barrier against the Moghal invader in 1671 A.D. (Map 12)[1] which would probably be a unique example unparalleled in history.

At the time of British annexation (1826) it was a headquarter of administrative unit with its capital town at Shillong. At that time Guwahati consisted of areas like Panbazar, Ujanbazar and Fancy bazar with an area of about 7.5 Sq.Km. only around the ferry ghat points. Within this limited area, they managed to set up administrative buildings (e.g. Commissioner Office, High Court, Police Thana), educational institutions (Cotton College and its hostels), medical facilities (at present Mahendra

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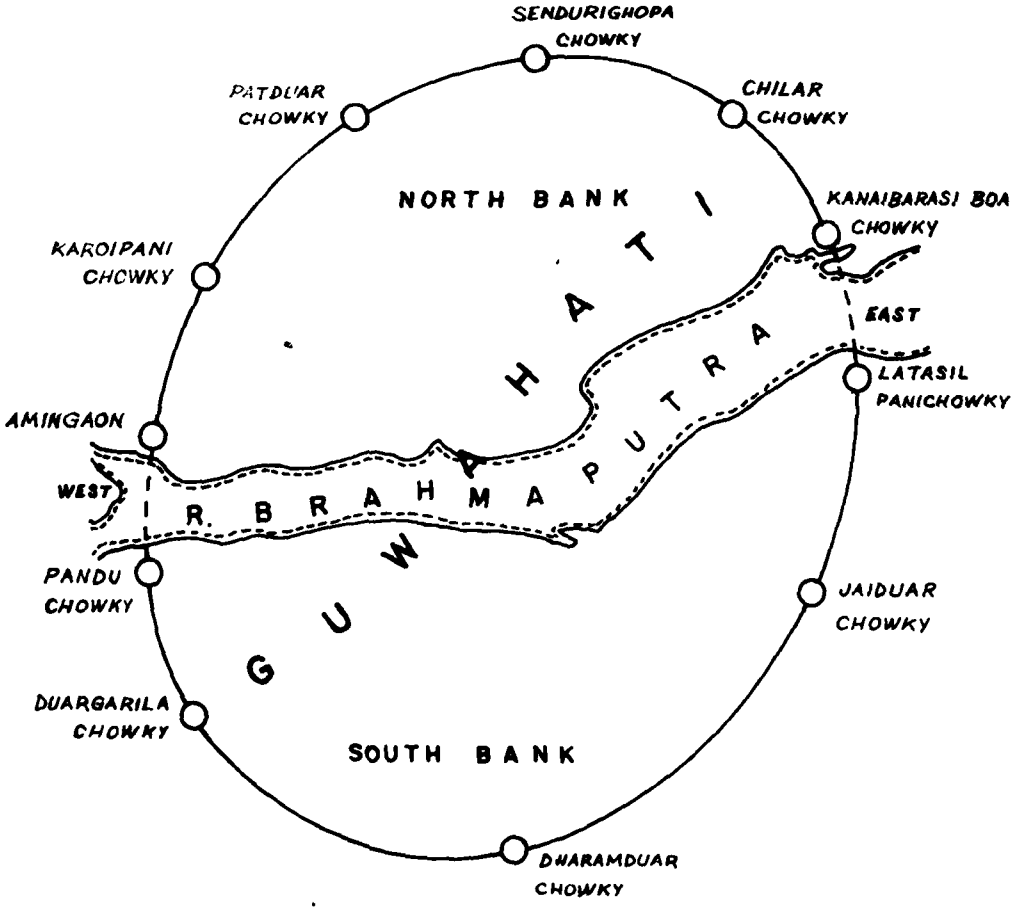
1. M.C. Das, 1978. "Yuge Yuge Guwahatir Ruprekha", Paura Bichitra, An Annual Journal of Guwahati Municipal Corporation, p. 15 of Assamese Section.



MAP. 12. SCHEMATIC MAP OF GUWAHATI AND ITS CHOWKY (CAMP) DURING AHOM PERIOD.

Mohan Choudhury Hospital), Head Post Office, Water Supply, recreation and public hall etc.

All these functional activities were particularly concentrated in Panbazar. The Ujanbazar, the oldest residential area (east of Panbazar) exhibits some remnants culture of the earliest inhabitants such as fisherman. Seemingly, it can be stated that the then Guwahati town expanded in phases. This indicated the growing need of the inhabitants and that of the administrators to provide for the facilities.

VII.1.b. **Functional Classification**

The city grew at a rapid pace especially after 1941 and during the Second World War. The zone of influence increased considerably with the influx of new wave of migrants and additional areas were brought under Guwahati. The recurring addition of small villages that clustered around old tiny Guwahati made the spatial expansion look natural. Even upto the middle of the present century the town area was divided functionally into five categories. These were: (i) religious, (ii) administrative, (iii) educational, (iv) commercial and industrial, (v) cantonment, and (vi) residential.

The Navagraha temple in the Chittrachal hill and Kamakhya temple in Nilachal hill along with other temples

like Umananda, Sukreswar etc. still bear witness to the religious evidences about the present city. All the temples are in the hillock which originally attracted the people from rest of the country.

The then capital town of Pre Ahom and Ahom period, the capital encircling by 'garh' (high embankment) to defend from invader (see Map 1), the relics of those still bear the evidences of the capital and administrative town. Later, the Commissioner Office, High Court, Police Thana of Panbazar on the south bank of the Brahmaputra added to the testimony of administrative function of British period.

Further, the academic institutions e.g. Cotton College at Panbazar of pre-independence, Medical College in Narakasur hills, Gauhati University, Engineering College, Assam Ayurvedic College, Assam Forest School at Jalukbari in the west, Agricultural University (Veterinary Science) of Khanapara in East were established just after the independence indicating systematic functional activities, each independent of its own. This thus led to spatial expansion of urbanization.

Fancybazar and its extension to Kedar Road, Machkhowa, Athgaon, Tokobari and upto Paltanbazar is the trade and commercial area of the city. A new addition of Gauhati

Oil Refinery with its ancillary industries became an industrial centre in the Noonmati area.

With the progression of political consciousness in the country, the army and airforce cantonment were growing up much rapidly for its strategic reasons. These areas are Azara Airforce Cantonment in extreme west of the city; Narengi, the army cantonment in the extreme east of the city; the Khanapara and Basistha of C.R.P.F. group headquarter and army cantonment in the extreme south-east of the city.

As the city expanded, due to diversity of activities, the natural inclusion of contiguous regions without the pronounced design from the authority, makes the unplanned expansive growth more critical for planning at a mid-stage for useful and efficient allotment of land. Evidently the places lying vacant were occupied by the people for their residential purposes. Hence, the residential area cannot be clearly demarcated as the functional area. However localities, such as Zoo Road, Hengrabari, Hatigaon, Beltola and Kalapahar are the major residential area that are developed within last two decades.

VII.1.c. **Peripherial Growth**

Peripherial expansion of an urban node is a common phenomenon and Guwahati is no exception. With an initial

area of 7.5 Square Kilometer, Guwahati expanded in phase manner. This made it look as if this expansion had taken place in an organised manner. This was reinforced by peripherial locations of the educational institutions and military cantonments as well as the airport. So much so that, this expansion has now covered an area of 216.19 Square Kilometer which indicentally also forms the territorial limits of the Guwahati Municipal Corporation. With such an area, exhibiting diverse physiographical attributes and constraints, there is an urgent need of a master plan that takes into account all the major characteristic of problems of the municipal area.

This later aspect is reinforced by the fact that the area between the core and periphery is occupied by residential complexes. Of recent, an industrial complex has also emerged near the periphery. This, then clearly suggests a distinct need to re-orient and re-adjust the patterns of landuse in the Guwahati city and its immediate environs.

VII.2. **Unplanned Growth**

Unplanned growth of cities in India as in other Third World countries has become common phenomenon. Wherever cities have emerged and expanded, they have tended to become identified with the problems which seem inevitably to accompany them. Many of these problems are the

results of rapid and haphazard growth, excessive population density and little or complete absence of public health facilities. Guwahati is the premier city and a developing node of North East India, it has become a focus of rural to urban migration. The centripetal force in the form of socio-economic developments attracted a huge amount of population where planner had to fail in this unnatural growth in respect of its limited geographical area.

VII. 2.a. **Origin of Growth**

Years of neglect, lackadaisical attitude of administration, lack of awareness among the majority of the citizens and absence of punitive measures, all combined to bring the city to the brink of environmental disaster. Growing tendency of urbanisation and increasing migration of the rural population to the outskirts of the city has only added more to this nightmare.

The present chaos in the city areas primarily stems from the ineffectiveness of the Guwahati Municipal Corporation administration. The Guwahati Municipal Corporation has found itself to be coping with the growing problems of the city than it can handle. In its defence it must be said that the Guwahati Municipal Corporation has perpetually been short of funds. The reason behind it is perhaps due to the nature of revenue collection policies and implementation. In short, the Municipality perpetually finds

itself in alleviating its priorities that the feasible to its available resources. As a result most of the development work framed by the Town and Country Planning Department could not be implemented.

In this regard, it can also be mentioned that the help of Calcutta Metropolitan Planning Organisation was sought to frame a sample master plan for Guwahati city. This was approved without giving due consideration to the amount of financial requirement needed to implement such a plan. Consequently a modified master plan was prepared by the Town and Country Planning Department. This was approved by the Government of Assam on 25th September, 1986. Despite the presence of Guwahati Municipal Corporation, Guwahati Development Authority and Town and Country Planning Department to look after the problems of the city, there hardly seems to be any coordination between them. As such, it look that the city itself had to find solution for its problems one way or the other.

Developing as an important commercial centre of the region Guwahati depicted numerous lanes and bylanes that served as important transport artery. After independence with the growing importance of socio-economic activities and development in the state and the region this transport arteries proved to be inadequate. This was also strengthen the greater rate of migration of population

pressure. This strained the existing networks to the maximum.

Moreover with the expansion of the city and dispersion of various sectors of the urban landscape introduced numerous problems. It resulted in heavy traffic congestion unsatisfactory nature of over extended and badly maintain transport infrastructure and network. In addition to this the rapid increase of density of vehicles further exposed the inadequacies of urban planning in the city.

Similarly, urban waste disposal have also been over extended inadequate, and mostly located in congested areas. This later aspect has become a big sanitation and health problem that has often compounded by crude method of disposal. In fact, these daily urban wastes can be better utilised to reclaim land as has been normally done other Indian cities like New Delhi, Bombay and Madras. This reclaim lands have been put to various land uses such as construction of residential complexes, parks and playground etc.

The enactment of urban land ceiling act has been theoretically a bold step for the Guwahati city. The act has put as ceiling of 2.5 bighas of urban land. However, unfortunately there has been no seriously follow up of the urban land ceiling policies; so much so that such

surplus lands have become easy target of encroachment and formation of slum areas. Thereby further compounding the problems and over stretching the function of Guwahati Municipal Corporation.

In addition to this, many dubious dealings to overcome and to find loopholes in the urban land ceiling act have complicated the matter further. This has directly encouraged unauthorised and illegal urban development which incidentally puts pressure on the resources and manpower of Guwahati Municipal Corporation and Town and Country Planning Department.

The above points as well as the detail field observation made by the author clearly suggest numerous instances of encroachment of Government land illegal construction and presence of numerous slums within the Guwahati Municipal Corporation area. Though the reasons and motivations for such as discussed above are outside the purview of the analysis, it is fear to state that the commitment to give greater facilities to the inhabitants of the Guwahati Municipal Corporation area should remain foremost for any organisation that looks after the urban planning of the city.

Encroachment in Greater Guwahati area has assumed a menacing proportion during the last few years causing

hazards to the growth of the city. The valuable government land in Machkhowa which is a small river port has now been covered with encroachment which were once cleared by the district authority. Due to lack of foresightedness and ignorance of follow-up measures to be taken by the authority concerned, the cleared lands all over the city have been re-occupied now. The situation is worst in the newly sprung residential areas in the eastern fringe of the city at Beltola, Basistha and Kahilipara where drains and bylanes have also been encroached. A vast areas of Gopinathnagar, Birubari and lowlying areas of backside of Aurobindo High School (Plate 14a & b) has also been encroached upon in a hazard manner. This very area though spacious already wears the look of ugly slum.

The big stretch of land all along the G.S. Road from Ulubari to Khanapara which was free earlier is occupied now, giving the entire portion a slum look where repairing shops, tea stalls, junk yards have sprung up, the most conspicuous portion being the Bhangagarh area.

The road side land at Bharalumukh especially the portion from Maligaon to Bharalu police point has been encroached upon. Encroachment has been noticed on both sides between Jalukbari police point and Maligaon overbridge. This illegal occupation has not only become great traffic bottleneck but also checked the future prospect

a) Settlement of Gopinath Nagar (backside of Aurobindo High School). As they construct their house on temporary basis they have to use boat on the overtopped waterlogging approach roads.

b) Same area of (a), here they constructed bridge of bamboo to approach their houses.

Plate 14: Encroachment upon the land in the city by foreign nationals.

of road expansion. In view of rapid growth of traffic movement inside the city, the existing road network appeared to be too narrow and inadequate for even the medium traffic. The peeled roads could be seen all along which is a common feature.

Hence, the recent eviction (March-April, 1988) carried out by the Guwahati Municipal Corporation authority with the help of Kamrup district administration and police. The Guwahati Municipal Corporation has so far demolished a good number of unauthorised and illegal constructions on Government land which had greatly hampered widening of Guwahati Shillong Road.

There were persistent demands from citizens to take stern action against those who illegally occupied roadside Government lands. It can be pointed out that on both sides of the busy Gopinath Bordoloi Road and some roads of the city there was large scale violation of building construction rules.

The present public health (sanitation) situation in Guwahati is deplorable and deteriorating day by day. One may be inclined to feel that the citizens of Guwahati are helpless against preventing this deterioration, as the Guwahati Municipal Corporation has clearly shown its inadequacy both in resource and manpower.

In fact, what should be done is the creations of water treatment plants to clean the urban waste, before they are allowed to drain into the rivers. The by-products can be used profitable for improvements of land.

Due to lack of strict vigilance of the authority the manholes cover on foothpath-cum-drain of the city stolen way. As a result it remains uncovered for months together. (Plate 15) and it becomes easy death trap for footpath passer. Subsequently there were two incidents where valuable human life lost, one in Panbazar (1986)[2] and another in Machkhowa (1988).

As far as garbage is concerned, these can be properly and economically used, e.g. to tap them for producing energy (bio-gas), as manures, etc. Moeover, these wastes can be used to fill many of the low lying areas that get flooded in the rainy seasons.

VII.2.b. **Rate of Growth**

The rate of growth of an urban area depends upon its physical setting and by cultural setting on which the population, its size and their activities act. The

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2. The Assam Tribune news report "City's Manhole Claims First Victim", Guwahati, 27th December, 1986.

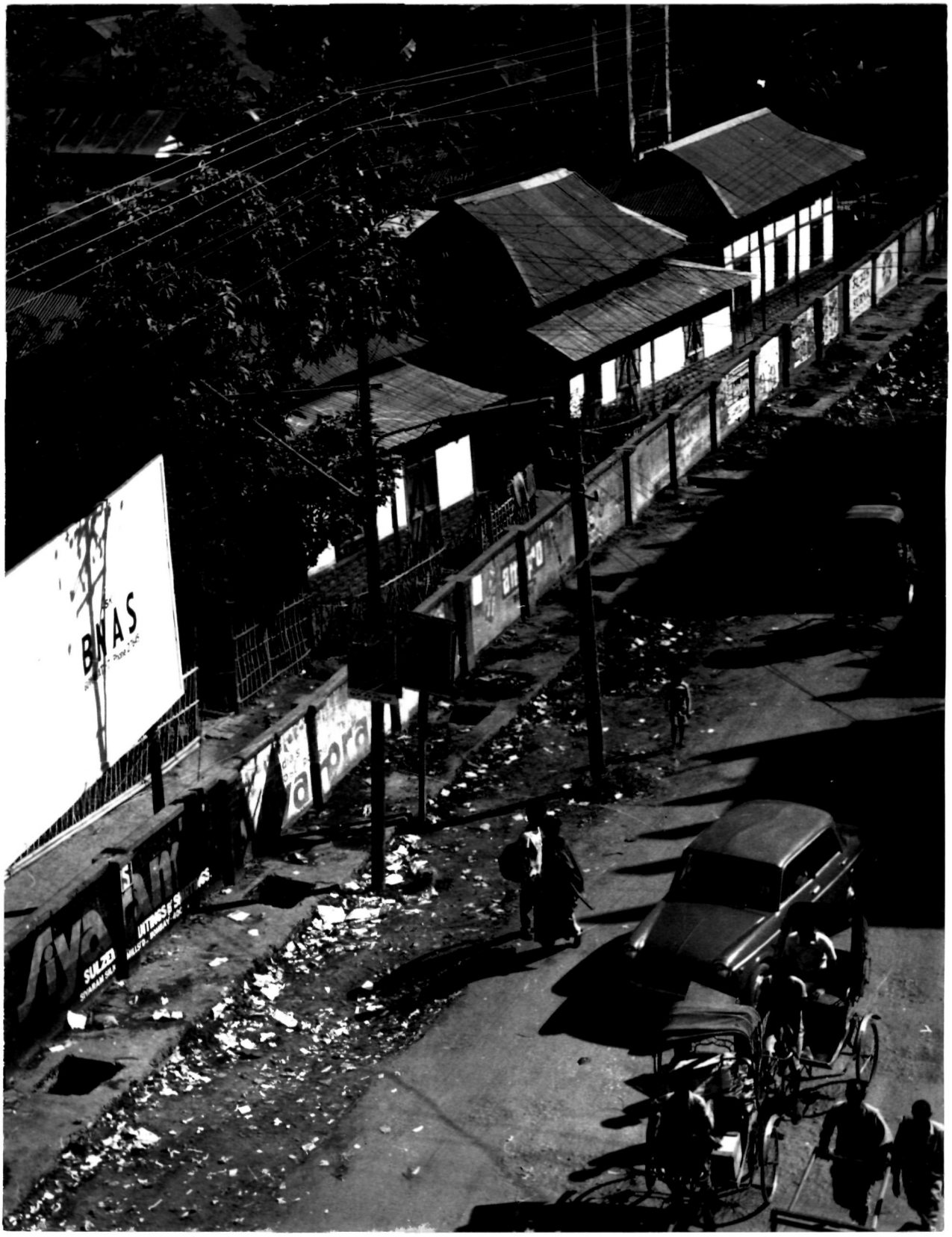

Plate 15: A series of uncovered manhole in front of the road of Kelvin Cinema Hall.

trend and tendency of growth of such urban area may be either in planned manner or in unplanned manner.

(a) **Physical Growth**

Urban spread has its own limitation. It is often controlled or encouraged by the (i) physical landform like hills, water bodies, forests etc., (ii) human interference like railway line, roads, canals etc. Neither the Burgess' concentric zone model nor the Hoyt's sectoral model or Harris and Ullman's multiple nuclei model can be applied for the Guwahati city. However, Greater Guwahati with the inclusion of North Guwahati can be divided physiographically into following division.

1. C.B.D. area or Guwahati plain (Fancybazar, Panbazar, Ujanbazar upto the railway line in the south.
2. Central plain (Paltan bazar, Rehabari, Ulubari, Bhangagarh upto Ganeshguri Charali).
3. Southern plain (Fatasil Ambari, Santipur upto Kamakhya corridor).
4. Western plain (maligaon, Jalukbari and Azara).
5. East plain (Khanapara, Satgaon and Birkuchi).
6. Hill Ranges (Ramcha Hill, Narengi, Japorigog, Narakasur, Sonaighuli, Fatasil, Nilachal Hill).
7. The river Brahmaputra.
8. Swamp Area (Dipar bil, Silsako bil & Salabil).
9. North Guwahati.

It may be mentioned that the southern plains of Guwahati has a potential for rapid growth although the Khasi Hills of Meghalaya limit the scope for the expansion. Thus, the northern bank of Brahmaputra across Guwahati becomes a major zone for future expansion.

(b) **Population Growth**

The rapid increase of city population in Guwahati during last few decades is a challenge to the ingenuity of legislators and administrator. To some extent, they were aware of this challenge, though their main concern was to alleviate distress and discomfort by providing minimum standard of civic eminities.

The growth of population in Guwahati since 1901 to 1911 has been rather steady (Table VII.1). The variation, during the decade was 7.03 per cent. The rate of growth of the population was rather low from 1911 to 1951 (Figure 9). But, the decades - 1951 to 1961 and 1961 to 1971, show tremendous increase of population - amounting to 130.90 per cent and 198.07 per cent respectively. The total population of Guwahati in 1971, of course, comprises Gauhati Municipality, Kamakhya Town Committee and Pandu Township only.[3] In 1981, census could not be held due to prolong agitation in Assam on foreign national issue.

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3. Census of India, 1971, Assam, Series 3, Part VI-B, and Statistical Hand Book, Assam, 1980.

TABLE VII.1

GROWTH OF POPULATION OF GUWAHATI 1901-1981

Year	Persons	Decade Variation	Percentage of Decade Variation
1901	11,661	-	-
1911	12,481	+ 820	+ 7.03
1921	16,480	+ 3,999	+ 32.40
1931	21,797	+ 5,317	+ 32.22
1941	29,598	+ 7,801	+ 35.78
1951	43,615	+ 14,017	+ 48.35
1961	100,707	+ 57,092	+ 130.90
1971*	200,377	+ 99,670	+ 198.07
1981**	451,200	-	-

* Includes Gauhati Municipality, Kamakhya Town Committee and Pandu.

** Estimated by Town Planning Organisation, Government of Assam, Guwahati.

Source: (i) Censust of India, 1971.
(ii) Town Planning Organisation, Government of Assam.

So the population was projected by Town and Country Planning Organisation, Government of Assam on the basis of the growth in previous decades and was estimated at 4,51,200 (though unofficial source estimate it to be between 6-8 lakh).

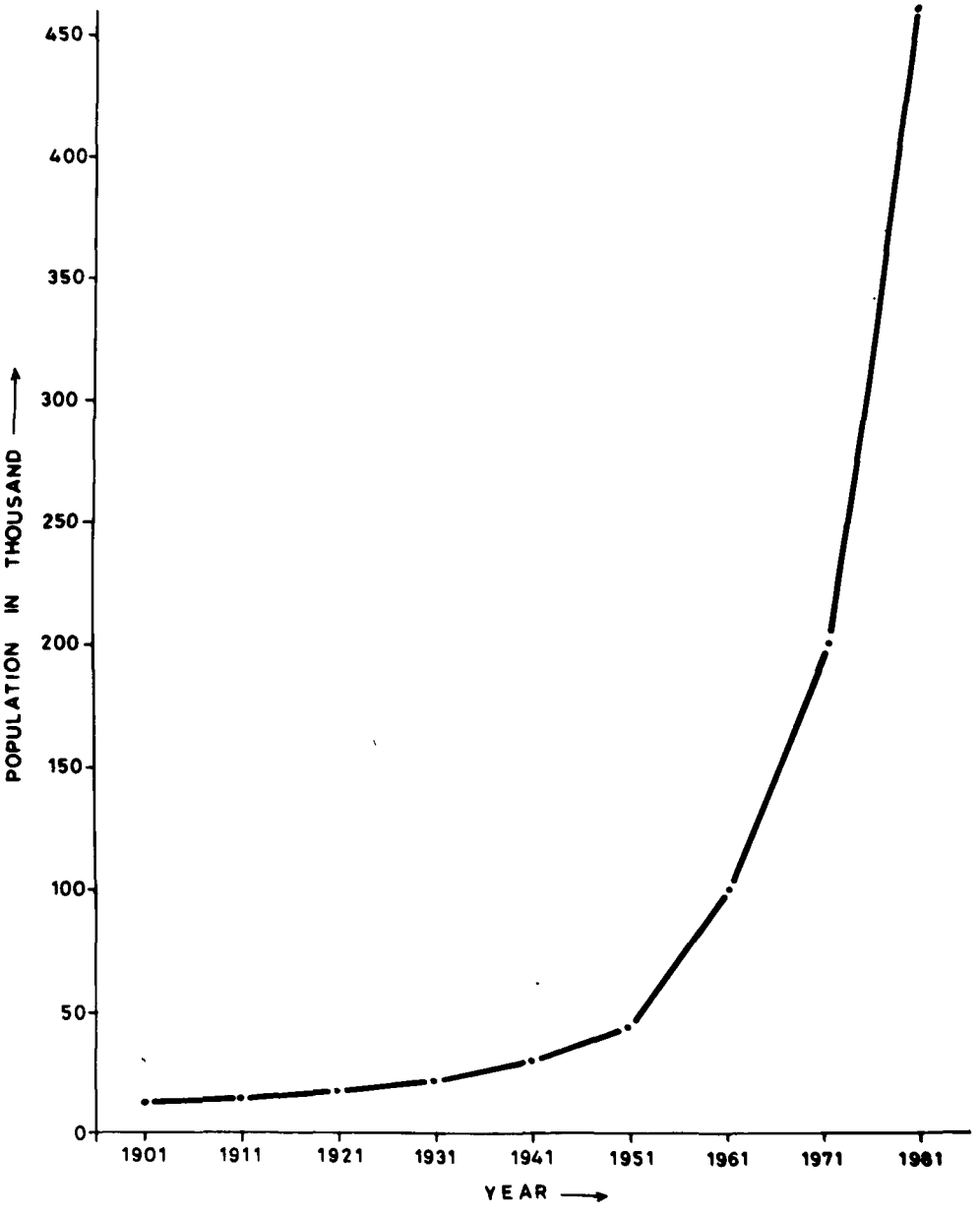

FIG. 9 GROWTH OF POPULATION OF GUWAHATI

The phenomenal growth of the population in the recent three decades may be attributed to the following causes: (i) inclusion of some additional areas into Guwahati complex, (ii) influx of the immigrant both from inside and outside the State into the city, (iii) transfer of capital of Assam from Shillong to Guwahati, (iv) emergence of Guwahati as the chief commercial centre in the eastern region of the country comprising seven States, (v) concentration of industrial and commercial activities within and in the outskirt of the city core.

All these factors of increase of population together with the encroachment of land in several new colonies with little civic amenities had led to worsening of the civic conditions of the city.

(c) Growth Rate of Industries and Commercial Establishment

The growth of industries, and commercial establishment are some of the indicators to measure the growth rate of a city. So far the industrial growth is concerned, it increased from 351 units in 1973-74 to 669 units in 1981. It indicated that the factors for industrial growth such as location, raw materials, labour, capital, marketing facilities are favourable and have encouraged industrial growth in city's environs. There are as many as 16 major industrial establishments (Table VII.2) at Guwahati.

TABLE VII.2

Growth of Industrial Establishment, Guwahati

1973-74 and 1981

Sl. No.	Major establishment	No.of units 1973-74	No. of units 1981	P.C. of 1981
1.	Food products	18	44	6.58
2.	Non-absorbent/surgical cotton	1	3	0.45
3.	Hosiery and garments	7	19	2.48
4.	Wood products	39	65	9.72
5.	Paper products and printing	53	103	15.40
6.	Leather products	1	7	1.05
7.	Rubber and plastic products	20	28	4.18
8.	Chemical and chemical products	56	116	17.34
9.	Non-metallic mineral products	13	30	4.48
10.	Basic Metal industries	16	17	2.54
11.	Metal products	62	132	19.73
12.	Machinery and parts except electrical	2	4	0.60
13.	Electrical machinery and apparatus	3	6	0.90
14.	Transport equipments and parts	2	5	0.75
15.	Misc. manufacturing industries	4	13	1.94
16.	Repairing and servicings	54	77	11.50
	Total	351	669	100.00

Source: The Modified Final Master Plan and Zoning Regulations for Guwahati.

Out of 16 establishments, 4 establishments e.g. metal product, chemicals and chemical product, paper product and wood product alone, claim 50 per cent of the total which are basically engaged in manufacturing consumers goods. Metal products (19.73 per cent) leads among all the manufacturing units while chemicals and chemical products (17.34 per cent) is the second highest followed by paper products and printing (15.40 per cent). Though the other units are less in number, it require special attention for their growth.

On the other hand, the growth of commercial establishments in the city has nearly trebled from 1961 to 1985. The existing shopping areas to be highly congested with little scope for its horizontal expansion. There is also a significant rise in trade and commerce in the informal sector. A recent survey[4] revealed that the percentage share of grocery (32.66 percent) was the highest in the city followed by service (19.59 per cent), small clothing stores (18.09 per cent), stationery (11.35 per cent), Pan (Beetle leaf) shop (7.40 per cent) small hotel and tea stall (7.05 per cent) and medicine store (3.94

4. P. Deka, "A Look into the Informal Sector Activities in Guwahati", Seminar paper on Save Gauhati, 13.6.87.

per cent). It may be mentioned that in the informal sector various kinds of activities are being run without having any formal connections or licences.

(d) **Growth Rate of Traffic**

With the limited road length of about 204.91 Km inside Corporation area make extremely difficult to maintain the ratio between roads (length and width), traffic. During the decade 1977-1987, the growth rate* of four wheelers and two wheelers have been increasing year after year. Besides the registered slow moving vehicles, a significant number of unregistered slow moving vehicles are also plying in the city which created more complex situation (Table VII.3). The registered rickshaws alone became double inside Guwahati during the year 1977 to 1987. Other slow moving vehicles like Bi-cycle and Bullock carts, Hand carts etc. increasing more than 200 per cent in the last decade (Table VII.4).

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* Growth rate has been calculated with the following formulae:

$$\frac{TYt - BYt}{BYt} \times 100$$

where, TYt = Terminal year of traffic numbers

BYt = Base year of traffic numbers.

TABLE VII. 3

Total Numbers of Registered and Unregistered Slow Moving Vehicles in Guwahati (upto March, 1987)

Types of Vehicles	Registered	Unregistered
Rickshaw	9,200	6,000
Bicycle	36,000	2,000
Bullock Carts, Hand Carts etc.	6,605	2,600
Others	400	700

Source: Guwahati Municipal Corporation

TABLE VII.4

Decadal Growth of Registered Slow Moving Vehicles (Guwahati 1977 to 1987)

	Passenger		Goods Vehicles	
	Rickshaw	Bicycle	Bullock Carts, Hand Carts etc.	Others
1977	4,605	10,910	1,821	149
1987	9,200	36,000	6,605	400
Decadal Growth in p.c.	99.78	229.97	262.71	168.45

Source: Guwahati Municipal Corporation.

On the other hand, the fast moving vehicles have also increased. The percentage of Motor Cycles and Scooters have shown highest growth rate (544.74 per cent) in last decade, and was followed by Auto Rickshaws (177.43 per cent), Government vehicles (174.85 per cent) and Trucks (109.27 per cent) respectively (Table VII.5).

VII.2.c. **Slums in Guwahati**

Slums are those areas whose spatio-social arrangements and processes are completely different from those of the city. Initially, they develop to later to the needs the city. Later, however, they become permanent features often assuming parasitic proportions. The city of Guwahati has experienced unprecedented growth in its size, increasing without any perceptible thought to planning. This has made the formation of slums in various pockets of the city inevitable. Moreover, the slums in the city have also indicated a high degree of informal sector activities that has totally disregarded not only municipality laws but also the licencing policies. Thus giving way to many activities that have determined the city structure.

It has been estimated that the slum population constitutes 10 to 60 per cent of the total population in large urban centres of India; and about 20 per cent

TABLE VII. 5

Decadal Growth of Fast Moving Vehicles, Guwahati 1977 to 1987

	Motor Cycle/ Scooter	Light vehicle, cars, etc.	Auto Rickshaws etc.	Truck	Buses	Government vehicles	Others	Total
1977	5,019	7,030	811	9,941	1,443	2,657	2,161	29,062
1987	32,360	12,602	2,250	20,804	2,407	7,303	3,127	80,853
Decadal Growth in p.c.	544.74	79.26	177.43	109.27	66.80	174.85	44.70	178.20

Source: District Transport Office, Guwahati.

of the total population of Guwahati live in the slums.[5] These slums are scattered all over the city. Slums have grown rapidly with least interference from any agency. This way, cremation ground, graveyards, industrial areas, multistoreyed building and so on provided adequate impetus for the growth and location of the slums in the city.

There are seven main slum areas in Guwahati. They are categorised as slum areas on (A) the municipal land, and (B) the private land.

(A) On Municipal Land

i) Sarania Sweeper Basti

ii) Marisali Sweeper Basti

iii) Fatasil Dumping Ground

iv) Fancy Bazar River Side

(B) On Private Land

i) Kachari Basti

ii) Athgaon Pukhuripar

iii) North Guwahati Scheduled Caste Area

Besides, there are several other smaller pockets of slums (Map 13) located in Greater Guwahati. They are

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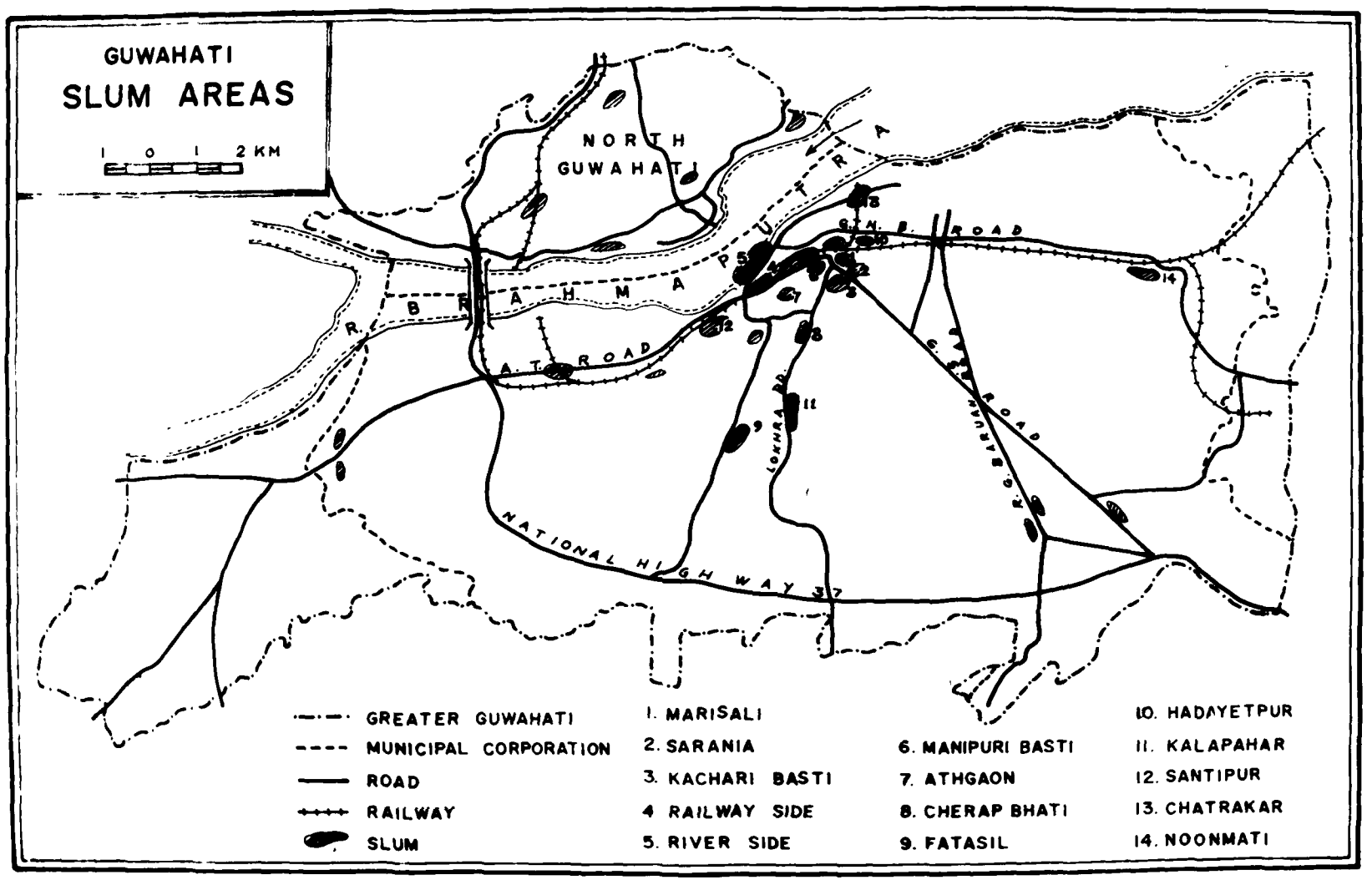
5. N.N. Bhattacharyya, 1981. "Morphology of the Towns of Assam with Special Reference to the City of Gauhati" M. Bhattacharyya, Gauhati -14, p. 53.


GUWAHATI
SLUM AREAS
1 0 1 2 KM
NORTH GUWAHATI
B R A H M A P U T R A
G.S.B. ROAD
A.T. ROAD
LOKHRA RD.
G.S.B. ROAD
NATIONAL HIGH WAY 37
GREATER GUWAHATI
MUNICIPAL CORPORATION
ROAD
RAILWAY
SLUM
1. MARISALI
2. SARANIA
3. KACHARI BASTI
4 RAILWAY SIDE
5. RIVER SIDE
6. MANIPURI BASTI
7. ATHGAON
8. CHERAP BHATI
9. FATASIL
10. HADAYETPUR
11. KALAPAHAR
12. SANTIPUR
13. CHATRAKAR
14. NOONMATI

MAP 13.

in Machkhowa, Chatrakar, Hedayetpur, Cherapbhati, Kalapahar, Fatasil-Ambari, Santipur, Manipuri Busti, Railway Station both sides of the railway line, Brahmaputra river side and one each below the three overbridges (excluding new fly over). In addition few Bastis near the mills and industrial units of Dispur and Noonmati area are now exhibiting slum characteristics.

The growth and origin of the slum (Plate 16) generally seems to be almost same everywhere. They sprang up close to commercial areas, public parks, railway stations or near the big buildings. This was primarily to reduce the transport cost and time. Interestingly, the slum of Panbazar overbridge area have their own prayer house and also a market.

The population structure of slum area is peculiar in character. Most of them are immigrants who cluster in groups according to the places of origin. The rate of growth of population among the slum dweller is the highest for the city and a major percentage of the inhabitants are children.[6] Literacy rate is very bad. Slum dwellers normally, belong to the lower income group of the

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6. P. Deka, "A Look into the Informal Sector Activities in Guwahati", Seminar paper on Save Guwahati, 13.6.87.

Plate 16: A slum pocket near Panbazar Over Bridge, Guwahati.

society. All members of a family above the age of ten years are engaged in a variety of occupations ranging from shopkeepers, daily labourers, rickshaw pullers, hand cart pullers, chowkidars to beggars.

A survey of 12 localities of Guwahati was carried out by Census of India in 1971. Out of the 12 localities surveyed it was observed that the Horizon Colony occupied single room house of about 75 per cent while another slum area occupied single room house of about 95.45 per cent (Table VII.6).

With ever growing slums, all the accompanying vices - gambling, prostitution and thefts - have risen in the city. The petty crimes have increased with the emergence of the floating population in the city[7] that normally finds sanctuary in the slums. Besides additing to the crime rate of the city, the slums are also a constant source of disease carriers. As most of them live in unhygienic conditions, the slum-dwellers are more prone to contagious diseases. As there are no adequate and proper medical facilities the outbreak of a disease non-epidemic is often taken not so sensitively.

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7. Nitin A. Gokhale, "Quo Vadis Guwahati?" The Sentinel, Vol. V, No. 10, 21st June, 1987.

TABLE VII. 6

Percentage of Households by Occupied Room in 12 Different Localities of Guwahati

Name of the localities	Occupied 1 room	Occupied 2 rooms	Occupied 3 rooms	Occupied 4 rooms	Occupied 5 & more rooms
1. Ujanbazar S.C. Locality	-	33.33	26.27	26.27	13.33
2. Ujanbazar	-	8.57	22.86	20.00	48.57
3. Hadayetpur	5.88	35.30	23.53	29.41	5.88
4. Chandmari Colony	-	38.89	22.22	16.67	22.22
5. Harijan Colony	75.00	25.00	-	-	-
6. Slum Area	95.45	-	4.55	-	-
7. Railway Colony	15.00	45.00	15.00	20.00	5.00
8. Fancy Bazar	12.00	28.00	40.00	4.00	16.00
9. Manipuri Basti	25.00	18.75	25.00	12.50	18.75
10. Milanpur	13.04	30.43	17.39	13.04	26.08
11. Lachit Nagar	17.39	17.39	26.09	8.70	30.43
12. Kachari Basti	-	36.36	27.28	36.36	-
Averages (All Localities)	22.04	24.49	20.82	14.28	18.37

Source: Census of India.

There are many pockets of slum areas here and there in city. The Athgaon which is situated in front of the Chaudhury Cinema Hall, most of the people are originated from Bihar and East Uttar Pradesh whose main occupations are wage earner, vendor, cart and rickshaw puller etc. Over and above many prostitutes are also found in this area.[8] Some of the people earn their bread by selling illicit liquors to the working class people. The houses are constructed in most unplanned manner, thereby leaving no space in between the adjoining houses. The houses are very low having no ventilation. Rooms of these houses are dark even in the day time. This is more or less red light area where men of crimes and dubious character predominate others.[9]

Slums occuply a long strip of both side of the N.F. Railway starting from Ambari to the Fancy Bazar areas. Most of the people living in this area belong to Bihari and U.P. The lands where they settled, are owned by the railway authority. The houses are made of bamboos and thatches sometimes made only by ordinary bamboo mattress. The railway tracks are used as latrine. The filth and

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8. Census of India, 1971, Assam, Series 3, Part VI-B, Special Survey Reports on Selected Towns - Gauhati, p.114.
9. Ibid.

garbage dumped outside their houses which release offensive smell throughout the day. Neither water supply nor electric supply are available here. Some shaded room used for cooking and dwelling purposes. The inhabitants of this area are beggars, daily wage labourers, street vendor etc. Selling liquor and prostitution are parallel business of this slum area. The police authority have raided many times followed by breaking house by the district administration. As the slum dweller found this area suitable the mushroom growth of huts again up within no time.

A small pocket in between the Fancybazar and railway track is also under the category of slum. The peoples are Biharis of low income group. There is no approach road to this place from the main streets. The slum dwellers are encircled by multistoreyed buildings. They also use the railway track as latrine, no water or electricity provided in this locality. They do not send their children to the school due to measurable financial condition when they grow up, earn their bread either by daily wage or by selling cinema ticket in black and sometimes becomes pickpocketers and gamblers. It influence often the young job seeker youth which has a serious impact to the society.

Almost all the slums, which were not described specifically area wise, all of them either are wage earner, rickshaw puller, hand cart puller, pony cart puller and

other lower income group of people like sweeper, cobbler etc. A Census of India's survey revealed that a substantial number of such dwellers are vagrant and some of them either from Andhra Pradesh, Bihar, Punjab and Bangladesh refugees.

Significantly few pockets of old slum areas of Greater Guwahati are slightly improved in course of time. These are Kachari Basti of Ulubari, the sweeper colony and the area in between Paltanbazar and the B. Barooah Road.

VII.2.d. **Peripherial Growth**

Like other cities of the country the trend and tendency of growth of Guwahati city is being spread toward periphery. The main factor of decentralisation is the cheaper rate of land in the peripherial area. Most of the residential areas of Guwahati have developed towards periphery in the last two decades. These areas are Narengi, Chandrapur, Khanapara, Beltola, Hatigaon, Sijubari, Dakhingaon, Ahom Boragaon, Tetelia, Gotanagar, Azara etc.

Commerce, on the other hand, follows this trend. The warehouses and retail functions moved to outlying locations sub-urban shopping centres with their base in the central business district also expanded towards the periphery. This type of peripherial growth generally hampered in city planning for future. Because shopping centre

always consider threshold population rather than city planning.

Similarly industry is seizing the opportunity of larger peripherial sites at lower cost, lower taxes and fewer restriction for maximum utility also developed. Some medium and light industries were being established in Amingaon to Jorabat on the National Highway 37. Likewise along the National Highway 37 from the end point of Gauhati University to Borjhar airport a sizeable number of industries are coming up in unplanned manner.

Outward migration cannot deny the peripherial growth. Though lands are less expensive outside the city but still it become expensive to redevelop for settlement. Lands lying vacant towards periphery are generally government lands with very little amount patta land. These government lands are being used by the encroachers and erect low costing house for few years observing government reaction and finally built permanent house if there is no injunction from the government authority. These types of area can be cited from Boragaon, Kalapahar, Kahilipara, Basistha, Beltola and many other places in the periphery of the city.

VII.3. **Scope of Future Growth and Development**

There are still some scope for future growth and development of the city. In view of this, a modified master

plan has been prepared by Town and Country Planning Department, Government of Assam on the basis of earlier master plan prepared by Calcutta Metropolitan Planning Organisation. The plan period is upto 2001 A.D. But it is true that the city has to function with efficiency even beyond the plan period.

The existing major functions and the rate of growth has been discussed earlier (Chapter VII.1.b and VII.2.b). The impact on the future growth of a city is a desirable and obvious fact. Based on the previous studies, city of Guwahati can be inferred to hold the following major functions to decide its future growth.

1. As a premier city.
2. As an Administrative Centre in heirarchies viz. State, Regional, Divisional, District and Local level.
3. As a Centre of Trade and Commerce in the region.
4. As an Industrial Centre.
5. As an Educational and Health Centre.
6. As a Transportation Node.
7. As a Recreational Centre.
8. As an Emerging Nodal Metropolitan Centre of the country.

Population study for future development one of the major aspects to be taken into account for studying

the growth and development of a city. To estimate future growth of population, the past growth of population of few decade are taken into consideration. This estimated figure may not be exact or accurate for target year, still this is the only device for planner for future planning.

A projected figure (Table VII.7) on population of Guwahati upto the plan period is made by the Department of Town and Country Planning, Government of Assam. The major snag in estimating the growth rate of city population is the mobility of people from the rural areas to the city. Guwahati, happens to be the only attraction centre or pole.

TABLE VII.7
Population Projection for Guwahati

Year	Census Figure	Projected Population
1951	97,384	-
1961	1,94,428	-
1971	2,93,219	-
1981	-	4,51,200
1991	-	6,93,660
2001	-	10,67,400

As the area of the city would remain same upto plan period and even after this century there is less scope of expanding city by space. The pressure of population year after year over the same area would result in

the shifting of capital from Dispur. To avoid conjestion in the city there is enough scope of establishment of capital of Assam in North Guwahati provided there is a road-cum-footpath bridge over the Brahmaputra joining Sukreswar ghat to North Guwahati. Along with the capital, all the Secretariate and Additional Secretariate and Directorate Office can also be shifted to North Guwahati.

In context of administrative function, the city is still in the formative stage and most of the offices are being accommodated in temporary hired residential buildings. Surprisingly many of the offices are in rented house in interior residential area which sometimes people find difficult to locate. Such office complexes can be set up in Hatigaon, Basistha area of south bank of the city. The proposed link bridge over Brahmaputra will help to solve the problem of transportation of the thousands of commuters to and from the city.

There is no doubt that a regional centre like Guwahati requires adequate spaces for trade and commerce. Guwahati being a premier regional city of North Eastern region will obviously require spaces for this purposes. Land utilization rate at present is 0.58 hectare per 1000 in trade and commerce. And most of the commercial activities are concentrated in the C.B.D. (Central Business District) at Fancy Bazar. Both wholesale and retail activi-

ties are functioning here which leads to extreme congestion and chaos. Moreover, various sub-centres and market places developed throughout the city and even in the major roads.

It may be suggested that the godowns of the Fancy bazar should be shifted to the outskirt and along the National Highway 37. The retail shopping centre may be remained in the Fancybazar. The District Jail at junction point of Fancy bazar and Machkhowa may be shifted to western part of the city and the present site can be transformed into commercial area, hence whole Panbazar, Fancybazar, Lakhtokia, Kedar road and Machkhowa will be a homogeneous commercial area in future. The city has many potential advantages for industrial growth. The present rate of utilization of land for industries is 0.82 hectare per 1000. As the city is the nerve centre of North East India and have enough scope for establishment of medium and small industries. However, medium industries can be started at Basistha and Dipar bil along the new proposed alignment of National Highway bypass and for small industries Amingaon and Azara can be chosen.

So far the land availability inside greater Guwahati, the city is unable to accommodate new educational centre on it. However, the proposed I.I.T. can be established centering Lakhra Chariali as the area is located towards the southern periphery of the city.

As regards the health centre, the Medical College Hospital at Bhangagarh is sufficient. Its equipments and devices should be upgraded (similar to these available in some of best hospitals in the country). Because Mahendra Mohan Choudhury Hospital of Panbazar will cater the city. Moreover there are many private type of nursing homes scattered inside the city, which are expected to fulfil partially the medical needs of the people. Besides T.B. Hospital, B. Baruah Cancer Hospital and Cholera Hospital already established in Gopinathnagar at Kalapahar area. So far dispensaries and health centres are concerned, all municipal wards do not have such facilities which should be provided urgently.

There is a relation between the road network and the transportation node inside the city. Planning on road network, traffic movement and land utilization for transport sector seems to be lagging behind. This causes the loss of many valuable human lives. During 1987 in Guwahati city alone 136 road accident[10] took place. In these accidents 64 lives were lost and 118 received injuries. Most of the injured persons were crippled for life. This happened due to lack of proper planning on functional activities

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10. The Sentinel, 30th March 1988. Published by Assam Police.

of different categories or perhaps due to the licensing procedures. Had there been bus terminal, truck terminal facilities outside the congested city and Broad Gauge railway line diverted parallel to the National Highway 37, the congestion situation would have been far more eased than the present worst condition. A step is being taken by Guwahati Municipal Corporation that the regional bus terminal is constructed at Garpandu. In this way if Guwahati Municipal Corporation takes measure for truck terminal at Jalukbari and Jorabat the fatal accidents would have been minimised which were generally caused by truck alone. In addition, the present National Highway 37 links of Guwahati should be realigned from via Tetelia along the Dipar bil and to connect it to Azara. Then only the regional function and status of these roads will maintain in future.

The Broad Gauge Railway line may be realigned from Saraighat Bridge to Khanapara along the National Highway 37 and then join with the Digaru station after taking into consideration those factors that are vital for construction of B.G. line. To avoid the crowding in the present railway station in the heart of the city, it may be shifted from Paltanbazar to Basistha Chariali. On a more optimistic note an underground railway line may be proposed from Jalukbari to Narengi for long drawn plan

to avoid the congestion of traffic over the surface of the Greater Guwahati and also it would render the transport efficient.

The demand in cities with recreational functions increases day by day. In the poetic sense, the city is adequately endowed with interesting natural landscapes in the bank of mighty Brahmaputra which could enhance the aesthetic value. Though the citizens of Guwahati are not much more materialistic like the other city dwellers of the rest of the country, still recreation centre is necessary for all. Hence it is high time to plan over the recreational facilities inside the city for future generation. It may be suggested that each municipal ward should have space for cultural activities covering auditorium cum community halls, clubs and libraries. The proposal for recreational centre in the Guwahati Master Plan is acceptable. These are:

1. Botanical Garden cum city forest in and around Dipar bil will be developed for regional park and picnic spots. There will be facilities for boating and fishing.
2. Zoological Garden Cum Acquarium would be developed behind the present zoo site in the Japorigog Hill tract of Hengrabari - Satgaon area.

3. Aswakranta, Basistha, Silsako bil and river bank near Chandrapur can also be developed for picnic and sports.
4. City park along Mahatma Gandhi road will have to develop. Barsola bil can also be converted into recreational centre for boating and fishing.
5. A central stadium for international and national sports may be constructed in Hatigaon - Basistha area. A swimming pool is to be constructed with the same complex.
6. In addition to the present Judges field at least three exhibition cum open lecture ground in three different localities of Satgaon, Azara and Amingaon are to be reserved.

Over and above these functional activities mentioned above, there are many essential services and their functional activities which are not adequate with the existing facilities. These are Post and Telegraph facilities, Police Station or Outpost, Fire Station, Water Supply, Electric Supply, Milk Supply etc. Each one of the service facilities should be available in all Municipal wards.

The facilities of all categories of functions in the city and other ancillary activities should be made available in such a way that there will be no problem

if the city emerged out as nodal metropolitan centre of the country in future.

CHAPTER - VIII

REGIONAL IMPACT

The impact of urban influence on the surrounding areas (both rural and urban) has multifacet effects on their social and economic structure. 'Von Thunen'[1] was the pioneer of model builder of city's influence on the immediate agricultural landuse pattern. Further Ratzel[2] developed the concept of hinterland and recognised the interconnection of areal integration of hinterlands with certain kinds of foci and spatial organisation of society around such foci. However, the 'city-region relationship' gained more importance after Dickinson,[3] Smailes,[4] Harris,[5] Bogue[6] and Ullman[7] etc. extended this relevance. Other

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1. Reference from the Richard S. Thoman and Peter B. Corbin, 1974. The Geography of Economic Activity, McGraw Hill Book Company, New York, pp. 183-86.
2. Reference from R.E. Dickinson, 1969. The Makers of Modern Geography, Routledge and Kegan Paul Ltd., London, pp. 70-71.
3. R.E. Dickinson, op.cit., pp. 234-36.
4. A.E. Smailes, 1947. The Analysis and Delimitation of Urban Field: The Geography of Towns, William Brendon and Son Ltd., London, pp. 151-67.
5. C.D. Harris, 1940. Salt Lake City: A Regional Capital, University of Chicago Press, Chicago.
6. D.J. Bogue, 1945. The Structure of the Metropolitan Community: A Study of Dominance and Subdominance, The University of Michigan, Michigan.
7. Edward L. Ullman, 1976. Geography as Spatial Interaction, ed. R.R. Boyce, University of Washington Press, London, pp. 13-27.

relevant studies have been carried out to develop more theoretical models of city-region and were demarcated on the basis of spatial interactions of population of urban centres and their retail trade and other economic activities. Such a model based on 'Newton's Law of Gravitational Force' borrowed from physical science was used by Stewart,[8] Zipf,[9] Reilly,[10] Taaffe.[11] Hartshorn and Alexander[12] used the same model with modifications (without applying constant).

The study of urban influence done by the Indian geographers is worth mentioning. The problem of delimitation of the rural-urban fringe, and characteristics of such areas has been studied in Indian context by Singh,[13]

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8. J.Q. Stewart, 1942. "A Measure of the Influence of Population at Distance", Sociometry, Vol. 5, pp. 63-71.
9. G.K. Zipf, 1949, Human Behaviour and the Principle of Least Effort, Cambridge, Mass. Addison-Wesley.
10. W.J. Reilly, 1929. "Methods for the Study of Retail Relationship", University of Texas Bulletin, No. 2944, pp. 1-50.
11. E.J. Taaffe, 1962. "The Urban Hierarchy: An Air Passenger Definition", Economic Geography, Vol. 38, pp. 1-10.
12. T.A. Hartshorn and J.W. Alexander, 1988. Economic Geography, Prentice-Hall of India Private Limited, New Delhi, pp. 283-85.
13. R.L. Singh, 1955. Banaras: A Study of Urban Geography, Nand Kishor and Bros, Banaras.

Sarma,[14] Kar[15] and so on. Arunachalam[16] studied the fact that accessibility is a key factor in spreading effects of urbanisation in the hinterland of a Maharashtra city.

A city's impact on its surrounding areas depend on the needs including employment, retail goods and services, information (newspaper), marketing facilities, education and banking service. Some of the human geographers used telephone services and banking services as indicators of city's influence which may not be applicalbe in Indian context and North Eastern region in particular. This is because these facilities have not fully developed. However, the influence of the Guwahati city on its neighbouring area is examined in terms of geo-social and geo-economic activities as well as strategic location. Analysis the city's influence in terms of distance, Nangia[17] delimited the metropolitan area of Delhi by daily commutation to work, immediate shopping and social trips upto 25 miles.

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14. H.N. Sharma, 1975. "Elements of Urban Impact on Rural Society in India: A Spatial Analysis", Ph.D. Dissertation Unpublished, Syracuse University, New York.

15. N.R. Kar, 1963. "Economic Character of Metropolitan Sphere of Influence of Calcutta", Geographical Review of India, June, pp. 108-137.

16. B. Arunachalam, 1975. "Urban Dominance in Developing Communities: A Case Study of Maharashtra", The Second Indo-British Geographical Seminar.

17. S. Nangia, 1976. "Delhi Metropolitan Region: A Study in Settlement Geography", K.B. Publications, New Delhi, p. 2.

To study the gradient patterns, Borah[18] included a distance of 20 kilometres from the city periphery as the urban influence does not extent beyond this. Moreover, Deshpande, Arunachalam and Bhat[19] agreed that beyond the zone of daily commuting to the city, lay an outer fringe, somewhat broader than the sub-urban zone (about 50-60 Km. wide) which may not have a direct impact, but all the same indicates a considerable urban influence permeating into it along the route-way, and creating urban pockets in a predominantly rural landscape.

Here in this study the zone of the influence of Guwahati will be found after evaluating the theoretical and empirical framework of analysis. For the analysis, secondary data collected from various sources, were considered and examined. For this the "Gravity Potential Model"*

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18. J. Borah, 1985. Spatial Structure of Urban Influence in the Neighbouring Areas of Gauhati City, Inter-India Publications, New Delhi, pp. 7-8.

19. C.D. Deshpande, B. Arunachalam and L.S. Bhat, 1980. Impact of A Metropolitan City on the Surrounding Region, Concept Publishing Company, New Delhi, p. 10.

* The gravity model has its roots in the "least effort" principles of Zipf (1949) and the social physics concept of Stewart (1942). Stewart developed a set of models for use in demography which are analogous to laws of Newtonian Physics. Further Carrothers (1956), Taaffe (1962) and Alexander (1988) used this model with slight modification.

has been applied. The model is used to estimate the potentiality between the main city centre with all other neighbouring places. This has been expressed as

$$P_p = K \frac{P_i}{d_{ij}} \quad \text{.....(I)}$$

Where P_p = Population potential at a centre

P_i = Population of the town

d_{ij} = Distance between the main city and j-th town.

Applying this model (see Table VIII.1 wherein 16 urban centres surrounding the Guwahati urban agglomeration have been considered) all the resultant potential values have been plotted and isopotential lines have been drawn in the Map 14. It is observed that the isopotential lines are decreasing with the increasing distance from the centre of business district of Guwahati. It has also been observed that the Barpeta town formed another nodel centre (140 Km away from the Guwahati city). On the other hand in the south the limit was very sharp due to hilly areas of Meghalaya plateau and absence of other urban centres.

To be more precise regarding the attraction of main city Guwahati and surrounding urban centres, the

TABLE - VIII.1

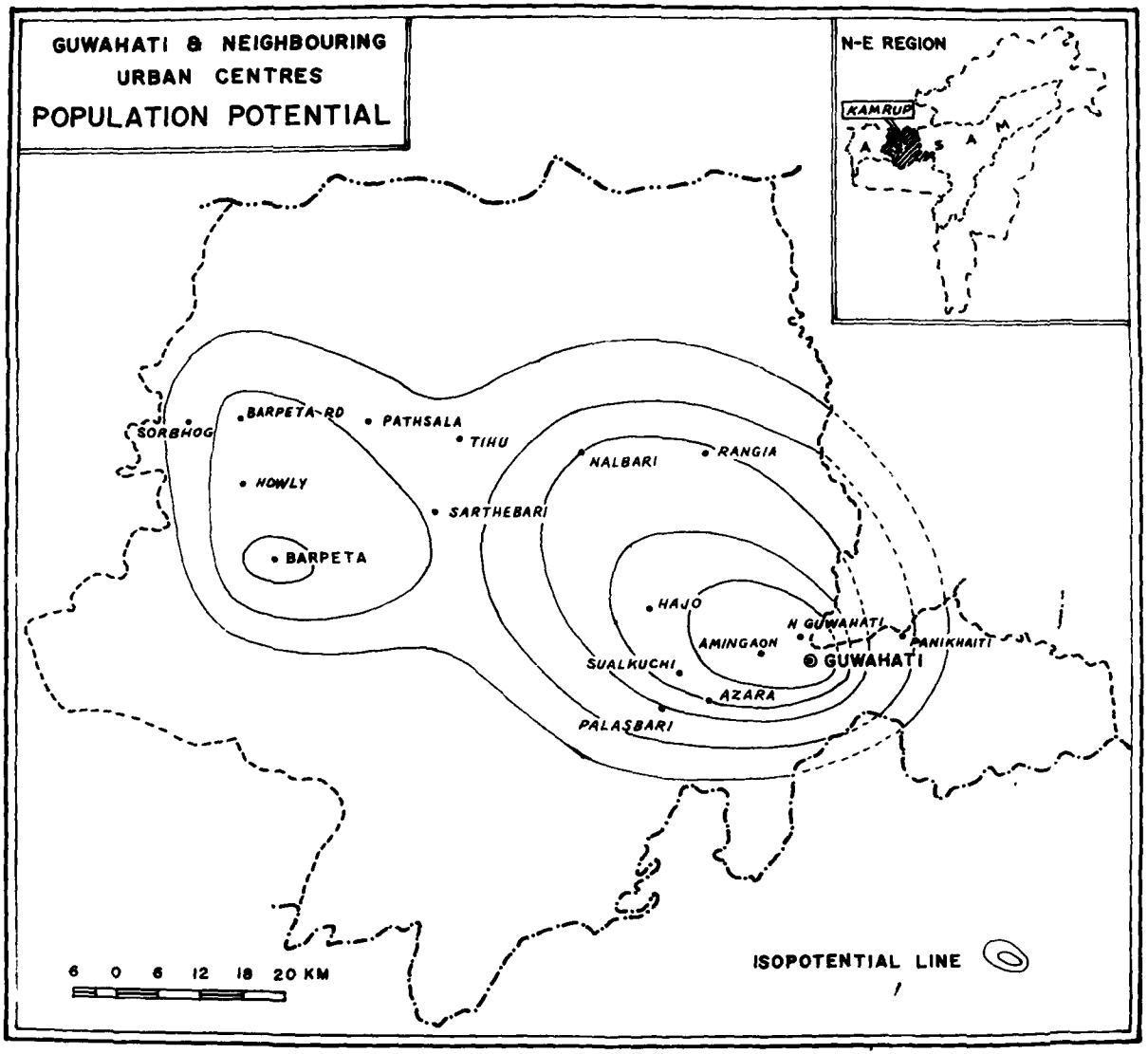
Population Potential Values Between Guwahati and the Neighbouring Urban Centres

		Population potential value
1.	Guwahati - Barpeta	328
2.	Guwahati - Barpeta Road	249
3.	Guwahati - Sualkuchi	499
4.	Guwahati - Nalbari	303
5.	Guwahati - Hajo	481
6.	Guwahati - Rangia	316
7.	Guwahati - Howli	185
8.	Guwahati - North Guwahati	613
9.	Guwahati - Sarthebari	204
10.	Guwahati - Sarbhog	168
11.	Guwahati - Pathsala	175
12.	Guwahati - Azara	382
13.	Guwahati - Amingaon	442
14.	Guwahati - Palasbari	293
15.	Guwahati - Tihu	159
16.	Guwahati - Panikhaiti	242

Computed by the author

"Breaking Point Concept" of converse[20] which is a modification of Reilly's Retail Gravitational law can be applied. The formula is as follows:

20. P.D. Converse, 1949. "New Laws of Retail Gravitation" Journal of Marketing, Vol. 14.


GUWAHATI & NEIGHBOURING
URBAN CENTRES
POPULATION POTENTIAL
N-E REGION
KAMRUP
SORBHOG
BARPETA-RD
PATHSALA
TIHU
HOWLY
SARTHEBARI
BARPETA
NALBARI
RANGIA
HAJO
N GUWAHATI
AMINGAON
GUWAHATI
PANIKHAITI
SUALKUCHI
AZARA
PALASBARI
6 0 6 12 18 20 KM
ISOPOTENTIAL LINE

MAP 14

$$BP = \frac{d}{1 + \sqrt{\frac{PZ}{PY}}} \quad \ldots\ldots\ldots\ldots \text{(II)}$$

Where BP = Breaking point
d = Distance between the two trade centres
PZ = Population of larger city
PY = Population of smaller city

It has provided a way to predict the location of the boundary line separating urban centres around the city unequal in size as envisaged by the estimation using equation II (Table VIII. 2).

TABLE - VIII.2

Breaking Point Distance of the Important Towns Around Guwahati

Sl. No.	Towns	Population	Distance from Guwahati (in Km)	Breaking point (in Km)
1.	Barpeta	26,439	140	44.3
2.	Tezpur	39,870	181	65.57
3.	Nowgong	56,537	123	49.79
4.	Goalpara	16,703	150	40.32
5.	Bongaigaon	13,907	190	47.73

Computed by the author

From this analysis, it is evident that the city's or urban influence is inversely proportionate to the distance from the city centre which proved the earlier hypothesis (Chapter I.2).

Regional impact can also be analysed by applying empirical approach. As far as the spatial dimension is concerned, following two categories have been taken into account, namely (i) geo-social, and (ii) geo-economic.

VIII.1. **Geo-Social Empirical Approach**

The social change due to influence of city centre is rather a common phenomenon over its surroundings. A recent survey[21] revealed that the way of living standard, dress pattern, food habit, traditional practices and other social system of the villages in different localities are transferred due to the urban influence. For example, old belief, custom and religion have been gradually reducing. The caste rigidity is breaking down and restriction of drinking and eating is being gradually eased with the close contact of other caste people. This social change is more significant in the localities where accessibilities are better with the city. The younger generation in these areas use the ready made garment and fashionable dress materials instead of traditional handloom products. They eat a sort of breakfast of bread and biscuits instead of traditional rice flake corn (chira), rice cake (pitha) and drinking tea etc.

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21. J. Borah, 1985. Spatial Structure of Urban Influence in the Neighbouring Areas of Gauhati City, Inter-India Publications, New Delhi, pp. 129-133.

Newspaper is one of the indicator to identify the social status and so also the influence zone of a city. Park[22] used Reilly's law of gravitation in 1929-30 to define service areas of cities taking newspaper circulation as the criterion. Similarly, Singh[23] has also taken newspaper as one of the criterion to delimit the umland boundary of Banaras though he was criticised by Sharma.[24] As Newspaper is a good media for dissiminating information in the society an empirical study can be made by this parameter. The Assam Tribune Group of paper of Guwahati is the leading publishers and highest circulated in North Eastern Region.

It publishes two dailies, one each in English and Assamese and another one Assamese weekly. The English daily is widely circulated inside the city, while other two are circulated almost all rural areas of the Assam, because later two are published in Assamese language. Observing the Table VIII.3 it is clear that the circulation of Assamese daily (Dainik Assam) was more in the rural area as compared

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22. R.E. Park, 1929-30, "Urbanization as Measured by Newspaper Circulation", American Journal of Sociology, Vol. 35, pp. 60-79.

23. R.L. Singh, 1955. Banaras: A Study of Urban Geography, Nand Kishore and Bros, Banaras.

24. H.N. Sharma, 1982. "The Theme of City-Region Relationships: Review of its Development", The North Eastern Geographer, Vol. 14, No. 1 & 2, p. 12.

TABLE - VIII.3

Newspaper Circulation Pattern in Guwahati's Neighbouring Areas

Important Centres		Direction	Distance from the city (in Km)	Dainik Assam (Assamese daily)	Assam Tribune (English daily)	Assam Bani (Assamese Weekly)
1.	Nalbari	North	71	1,430	465	1,550
2.	Rangia	North	52	205	100	300
3.	Baihata Chariali	"	33	320	70	250
4.	Sualkuchi	"	37	400	56	175
5.	Hajo	"	29	210	45	75
6.	North Guwahati	"	16	314	148	300
7.	Boko	West	63	171	75	-
8.	Chayagaon	"	45	225	45	200
9.	Borihat	"	39	248	36	120
10.	Rampur	"	36	120	18	125
11.	Bijoynagar	"	33	273	-	-
12.	Palasbari	"	25	1,042	178	115
13.	Jagiroad	East	55	330	140	250
14.	Sonapur	"	31	143	25	124
15.	Chandrapur	"	26	151	46	-
16.	Burnihat	South	20	23	15	-

Source: Data collected from the Assam Tribune Group of Paper, Guwahati, on June 1988.

to the English daily. This was due to less subscribers to the English daily (or perhaps less English learners). The circulation area includes Nalbari in the northern part, Palasbari in the west and Jagiroad in the east. The limited number of copies are circulated in Burnihat in the southern part (because it is thinly populated township). The pattern of newspaper circulation is such that it is difficult to demarcate the influence zone, as it has wide circulation in all district of Assam in varying degrees.

Both the education and the medical services are the important social functions of a city which extend facilities to the city dweller as well as to other people of this region. A large number of students from its neighbouring areas have been coming every year for their education (despite a number of such institutions being set up in the rural areas). This has been largely due to the perceived abundance of opportunities in the urban located institutions. In addition, the technical institution like Engineering College, Medical College, Veterinary Collge, Ayurvedic College and other colleges of Law and University attracted the student not only from Guwahati's surrounding areas, but also from the entire North-Eastern Region.

Therefore only general educational institutions (Colleges etc.) can be used as indicators of city's influence

in the neighbouring areas. A recent survey[25] proves that the about 50 per cent of the students admitted in the city's colleges are from the distance of 25 kilometre to 35 kilometre of its surrounding areas. The influence of Medical services, behaviour has more or less similar radii of attraction.

From this brief discussion on geo-social aspect, it can be concluded that it is difficult to demarcate a definite boundary of city's impact. Because geo-social is a broad term under which city's influence extends the services upto its optimum limit. This is reinforced by developing communication links. For example, all district and subdivision headquarters of Assam are well linked by transport services. However, such relationship of different degree are found in all the three parameters (newspaper, educational, medical service) etc.

VIII.2. **Geo-Economic Empirical Approach**

Every urban centre has its defined services area consisting of groups of villages and towns. An urban centre, in other sense, define the scope, content and service that serve the groups of villages and towns around it. These relationships may either be social or economic and have reversable relation with each other.

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25. J. Borah, 1985. Spatial Structure of Urban Influence in the Neighbouring Areas of Gauhati City, Inter-India Publication, New Delhi, pp. 55-56.

The social relationship between the city and neighbouring areas has been discussed earlier (see Chapter VIII.1). Here we will discuss about economic relationship between the city centre and the region.

The number of person, in general, engaged in secondary and tertiary activities, in and around Guwahati has progressively increased during the last few decades. Persons engaged in primary activities has proportionally decreased. This is of great significance as it indicated the degree of urban influence over the area. The percentage of workers in secondary and tertiary sectors in Guwahati sub-division has increased from 3 and 18 in 1961 to 10 and 32 in 1971* respectively. On the other hand, the percentage of workers in primary sector inversely decreasing from 71 in 1961 to 58 in 1971.[26] There are many industries growing up in and around Guwahati which has attracted non-agricultural worker from the neighbouring areas of Guwahati. This is due to lack of scope for employment opportunities in the surrounding rural areas, and growing pressure on agricultural land, mostly the landless labourers have turned towards unskilled

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* Census Operation in Assam during 1981 could not be done due to prolong movement on foreign national issue.

26. Census of India, Series 3, Part A-B, Assam, District Census Hand Book, Kamrup District, 1971.

job opportunities of low grade in the secondary and tertiary sectors. It is seen that the traditional agricultural pattern in and around Guwahati has gradually changed.

Dickinson[27] opined that the city is a human phenomenon, and its complex relation with surroundings are as much cultural and administrative in nature as they are economic. On the other hand, Duncan's concept is not free from bias towards an economic city-region relationships.[28] Thus, bus service has been found to be a very useful criterion for city-region delimitation.[29] On this basis, Guwahati city is linked with road ways in all direction while the railway line is absent in west and south from city centre. Hence, role of bus service is highly significant in linking Guwahati and its surrounding areas. The area like Baihata and Chariali in the North, Burnihat in the South, Sonapur in the East, and Palasbari in the West, come closer to the city due to its frequent bus services. Table VIII.4 shows the limit of the bus service zone and the intensity of services to

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27. R.E. Dickinson, 1964. City and Region: A Geographical Interpretation, Routledge and Kegan Paul Ltd., London.
28. C.D. Duncan et al. 1960. Metropolis and Region, The John Hopkins Press, Baltimore, pp. 36-37.
29. F.H.W. Green, 1950. "Urban Hinterlands in England and Wales", Geographical Journal, Vol. 116, pp. 66-88.

TABLE - VIII.4

Number of Buses Plying Between Guwahati and its Surrounding

		Direc-tion	Distance from Guwahati (in Km)	ASTC Bus	Private bus	Total Number of Buses
1.	Nalbari	North	71	2	42	44
2.	Rangia	"	52	6	40	46
3.	Baihata Chariali	"	33	-	50	50
4.	Burnihat	South	20	4	-	4
5.	Jagiroad	East	55	6	-	6
6.	Sonapur	"	31	2	40	42
7.	Rajapara	West	75	2	4	6
8.	Boko	"	63	-	35	35
9.	Chayagaon	"	45	-	42	42
10.	Rampur	"	36	-	42	42
11.	Palasbari	"	25	-	-	50

Source: District Transport Office, Guwahati.

different places. Interestingly, the northern and the western direction from which people move to the city cover a maximum distance as it includes extensive plain area. On the other hand, southern and eastern parts are covered by hilly terrain with a few important market centres.

In the former two direction (north and west) the frequency of bus services are higher than later two direction.

The private buses are run with an interval of 15 minutes* in north and west direction from morning till evening.

One of the significant aspects of the economic activities and its impact over the city's neighbouring area is retail trade services. The retail trade of different goods generally is carried at different levels by the centres upto the specific distances. As Guwahati is the nerve centre of trade of North Eastern Region it has an impact over the region of varying degree. It supplied varieties of goods to the region.

For retail trade services, here we will discuss about Guwahati and its immediate environs which cover the area as indicated by newspaper circulation, bus service etc. Guwahati is the premier city on which the people from neighbouring areas depend on machinery, stationery, jewellery and cloth etc. Over and above the daily needs grocery items, rice, wheat, pulses, oil, sugar etc. are also supplied to the surrounding areas. It has been observed that the retailers from the city sell their goods in some of the market centres directly. Some its kinds of market centres are given in the Table VIII.5.

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*Source: Personal investigation by author.

TABLE - VIII.5

Important Retail Market Centres in the Neighbouring Areas of Guwahati

Retail Centres	Direction	Distance from the city (in Km)	Nature of market
1. Nalbari	North	71	Bi-weekly
2. Rangia	"	52	Daily
3. Baihata Chariali	"	33	Weekly
4. Sualkuchi	"	37	Daily
5. Hajo	"	29	Daily
6. Khetri	East	42	Weekly
7. Sonapur	"	31	Weekly
8. Panikhati	"	15	Weekly
9. Rampur	West	36	Bi-weekly
10. Bijoynagar	"	33	Bi-weekly
11. Palasbari	"	25	Daily

A recent trend and tendency of these retail trade centre are observed and found interesting. A particular business community of Rajasthan have their wholesale trade centre Guwahati and open their retail trade at its surrounding market centres. Even from the retail trade centres they extend their business services to the weekly or bi-weekly interior markets locally known as 'haat'. The items selling in these markets are cloth, leather shoes and sandal (Chappal), steel utensils etc.

However the extreme limit of retail trade service zone is delimited by Nalbari and Rangia in the north, Chayagaon in the west, Jagiroad in the east, and Burnihat in the south. Now it can be concluded that the Guwahati's impact on its surrounding area in terms of services is varying with distance and accessibility from the city. Moreover retail trade service zone is more or less like the bus service, and newspaper circulation zone.

However this study has projected some of the important characteristics (social and economic) of city's impact on its surroundings to a great extent. Much of these aspects and approaches are yet to be investigated into the type of the spatial patterns of relationship between the city and the regions. It is further suggests that repeated use of physical science models in geography should be descriptive rather than prescriptive especially in the developing countries (Indian spatial context) where geo-social and geo-economic characters are completely different than that of developed western countries.

CHAPTER - IX

SUMMARY AND CONCLUSION

The Guwahati city grows like an organic entity. Each aspect of growth is related to other. Only a comprehensive, balanced growth plan can ensure a future for this city. Therefore, a high-powered, apex body with the required degree of autonomy and adequate powers vested on it should be immediately constituted to address the multifacted problems of the city in a comprehensive manner. Otherwise, the city is going to die an uncontrolled cancerous death - and that too at its very adolescence stage. Alternatively, if steps are not taken soon enough towards this end, the inhabitants of the city may have to reconcile with the prospect of having a properly planned new city (like New Delhi from Old Delhi) growing somewhere as an adjacent to this old, uninhabitable city.

The analysis of the theme, then suggests the following important attributes. After the introductory chapter, the nature and purpose of the study, continues with an examination of the prevailing notions on the theme of the growth problems and its impact on neighbouring areas. The review of relevant literature has been found useful to the study and has been discussed with a view to evaluate the lapses and inadequacies of the plans. This was considered essential for formulating new approaches for a proper appraisal of the problem.

The size and the structure of the city and its historic evolution has been discussed in the Chapter III. The geographical boundary, population size of the city and the situations during historic times, have led to change in the city landscape. The ancient scriptures, inscriptions and literature, accounts of early foreign travellers and historians gives some ideas about the Pragjyotishpura (present Guwahati). The garh (fortified embankments) along with Chowky (Camp) encircling the capital city of pre-Ahom period, adjoining both north and south bank, exemplify superior technology adopted by the ancient architects for building the fortified city of Guwahati.

The British administrative established their administrative functions on south bank of the Brahmaputra, centering on the Deputy Commissioner Court. Educational and cultural functions of the town was also geared up at that time on the same line. So also was the municipal board which was established around 1878. The face of Guwahati has changed abruptly in the post-independence period.

With the re-organisation of Assam, the capital of Assam was relocated at Dispur, Guwahati in 1972. This resulted in coming up of more administrative offices (Secretariate, Directorate etc.) in Guwahati. This led to the extension of town's jurisdiction that now included. The trend and

tendencies of its past evolution profusely indicated that Guwahati city in the near future will assume metropolis character.

In the Chapter IV, the geographical factors were analysed in the context of growth problem of Guwahati. Relief, drainage, geology and soil, climate and vegetation, basin structures, population and landuse pattern were treated in greater detail. The factors dealt in the prvious chapters are very important and in depth studies have been indicated the cause and effects of the situation. The hillocks of this study area are the outliers of the Meghalaya plateau, predominantly, residual in character. The plains along with swamps and depressed parts are situated in between the hillocks. The low-lying areas are inundated often during heavy rainfall. Geology and soil structure are relevant in the context of drainage of water. The oldest precambrian rocks and the infilled alluvium precisely indicating low permeability of the area which is responsible for water overflows in certain places.

Tremendous increase of population during last two decades posed serious problems to the Guwahati city. Influx of the immigrants both from inside and outside the state into the city was the prime factor of population explosion and growing problems. Transfer of capital, establishment

of new industries and rampant growth of commercial activities further added salt to the problem. Encroachment over vulnerable lands, growth of several new colonies, filling up of low-lying areas of residential establishments led to abrupt and abnormal horizontal expansion of the city. All legislative checks and control on landuse pattern for planned development of the city failed. Unplanned growth of city functions resulted into the present chaotic civic situations in the city.

In the Chapter V, emphasis has been laid on the slope analysis and distributional pattern of rainfall (in short and long duration). As such discharge capacity of river Brahmaputra, gradient of the Bharalu and Mora Bharalu have been exhaus-tively treated.

Most parts of the Bharalu bank have been encroached. This had hindered the discharge of the river water. The Foreshore basin being adjacent to the bank of the Brahmaputra, hardly faces water logging in monsoon season. The diversion canal in the Dipar basin partially relieved the urban agglomeration from the flash flood caused by the river Bharalu. The Khanajan river is linked with the Brahmaputra and it discharges water from Dipar bil. The Bondajan is the outlet of Silsako bil.

The river Brahmaputra discharges maximum water specially during the monsoon period. During the peak period of discharge the Brahmaputra water level rises up and frequently crosses the danger level. At the time of high water, the sluice of Bharalu, Bondajan and Khanajan are closed to stop the back-flow from the Brahmaputra. Eventually constand closure of the sluices results in inundation of the low-lying areas, as the accumulated water cannot flow out the catchment area.

Gradient of Bharalu and Mora Bharalu river shows peculiar character. The river bed of Bharalu from Zoo gate bridge to Lakhra road bridge point is found to be of higher elevation than the upper course. This is perhaps due to meandering course and deposition of enormous silts. Hence from Zoo gate bridge to Lakhra road bridge should be redesigned properly and regraded immediately. So also the shallow gradient of Mora Bharalu fails to drain off the water with speed and consequently submerge the low-lying areas of the basin in heavy rains.

The analysis in various aspects of the city environ, boils down to the following formidable issues: These are - a) the natural drainage problem, b) the silting problem, c) the artificial drainage problem, and d) undesirable construction.

a) The Natural Drainage Problem: The main natural drainage of the city is the Bharalu river. Due to prolonged silting, aggradation and encroachment upon its banks have reduced the load discharge capacity of the drain, especially in the lower part from R.G. Baruah road bridge to Lakhra road bridge point.

Bed of the middle part of Mora Bharalu is at a higher elevation which fails to carry off the normal discharge.

At the time of high water level of the Brahmaputra, the water back-flows into the city through the existing channel and open culverts.

Dipar bil needs to be excavated to enable it to absorb the city runoff through the existing drain.

Barchala bil connected through open drains cannot accommodate all the water received at the time of peak discharge. There is also no practical use of Chalabil (Chatribari swamp) due to its shallowness and encroachment from all sides. Hence, both the bils needs to be excavated to enable them to reserve the excess storm water.

b) Silting Problem: The problem of silting is very serious, specially in high rainfall intensity areas, as it is related with the hill cutting and earth filling. Even,

well designed drainage systems may not cope up with the huge volume of silt load carried along with the runoff, unless some remedial measures are taken.

A deep drain may be constructed along the foothill of Navagraha to catch the additional silt load. Some additional "silt traps"* may be constructed at important site, along the existing drain. This may ease the problem temporarily. These silt traps need to be cleared after each storm.

c) The Artificial Drainage Problems: Existing drainage facilities of Guwahati, are not adequate to carry all storm waters from each of the locality. Hence, some more new drains could be constructed along the natural slope of the area. Moreover, existing drain can be renovated for easy flow of rainwater with provision of annual clearance.

As most of the roads, inside the city are very narrow, underground drainage networks are desirable. These roads should not be utilised for drain-cum-footpath indiscriminately.

Existing manholes of drain-cum-footpaths are not adequate. More manholes and inlet-holes are required for the quick disposal of silt and stagnated water. The size of the inlet holes and their position needed to be reoriented.

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* "Silt traps" is a design which maintain settling velocity for selected particle size.

d) Undesirable Construction Problem: There are many areas where construction of building has been made at free will without considering hygienic and drainage problems of the city. In Rehabari area, the main drain has been blocked by an unauthorised R.C.C. building.

In Athgaon (Fakirtola), the inner drain which carries a major part of water from the entire Fancy Bazar area has been obstructed by a building in mid way. Likewise many unauthorised structures have reduced its size to a narrow strip.

The planning and the execution of such a project may be enormously costly but directly and remote benefits taken together with a long term perspective will definitely be much higher than the cost of implemation.

The present drainage network are not constructed in consonance with the natural slope of the land and are not adequately interconnected for temporal transfer of locally accumulated water. Silting due to low velocity of the flow is ubiquitous which indicates that the different government agencies responsible for maintenance of the urban situation work discordantly. New residential areas are almost devoid of proper drains which help rapid water accumulation and frequent floods.

A canal parallel to Brahmaputra in its southern part from Dipar bil to Dora bil has been proposed and design by the Flood Control Department. This proposed canal should be executed as early as possible. This long drawn project will relieve the city (even if Guwahati attain its metropolitan character) from the flood.

Rainfall analysis had been made by taking average hourly variation of rainfall for seven years (1980-1986). Further standard deviation and coefficient of variations of mean hourly data have been calculated. From the analysis it was observed that Guwahati experiences about 8 peaks of high intensity rainfall in one monsoon season. As monsoon begins in the month of May, the rainfall of peak hours could not results the flood as rainfall absorbed by the soil into the saturated point. The other peaks of primary and even secondary maxima from June to September are effective to the flood in the city through runoff water. The intensity of mean hourly rainfall is maximum in the June. Significantly coefficient of variation is also very high in June. Hence, this month is always alarming as it exposed the inherent drawbacks of the Guwahati's drainage system.

In the Chapter VI, it is seen that the natural environment is progressively destroyed by unplanned construction and haphazard landuse. Removal of plants, cuttings of hill sides, unplanned construction of buildings and roads, release

of industrial wastes to the drainage channels, stagnation of filthy water in the intermittently unfilled depressions, which become the breeding place of mosquitoes, etc. have created serious problem of environmental pollution, endangering the health of civic life of Guwahati.

The contamination of rivers water (Brahmaputra and Bharalu) due to 'Foul water' of built up areas of Guwahati harboured more number of coliform bacteria which may cause water borne infectious diseases. Some other diseases (tuberculosis, lung cancer, asthma and eye disease) may be caused by micro-mini particles of smoke released from the industries. Proper treatment of drinking water and neutralisation of industrial smoke and affluent are essential.

The degree of growth of Guwahati city is heading significantly towards unplan system than plan system (Chapter VII). Unsystematic occupation for residences and official establishments in the city indicates haphazard growth and equally ruin the scenic beauty of Guwahati. Inadequate length and undersize road and increasing number of vehicles resulted heavy traffic jam which reflect the lack of planning in land-use and transportation. Encroachment upon the land and ineffective urban land ceiling act further compounded the problems of the city. Slum areas of the city are found unhygienic and are more prone to contagious diseases (Chapter VII.2.c.).

To relieve the congestion of the city and to maintain the homogeneity of the functions, reallocation/allocation or shifting of some functions (wherever necessary) are urgently needed. These are: (i) godown of C.B.D. area should be shifted to the outskirt and nearby national highway 37, (ii) district jail which occupied a vast area of heart of the city should be reallocated in western part of the city, (iii) medium size industries should be allotted at Basistha and Dipar bil area (along the proposed alignment of national highway by-pass), (iv) proposed I.I.T. (offshoot of 'Assam Accord 1985') in southern part of the city, (v) diversion of broad-gauge line parallel to national highway 37, (vi) an underground railway line can be constructed from Jalukbari to Narengi (provided watertable and geological structure of the ground permitted), (vii) shifting of capital from Dispur (as it was constructed as temporary capital) to North Guwahati with provision of a new road bridge from Sukreswarghat to North Guwahati, (viii) there are many other scope to develop Guwahati for recreational purposes such as Barchala bil for boating and fishing, Bonda for picnic spot and Dipar bil for botanical garden, picnic spot, boating and fishing.

The city's impact over the surrounding regions is analysed in the Chapter VIII. For this both theoretical and empirical approaches have been applied and analysed. The 'gravity potential model' and the 'break-point concept' are used to have a general understanding of the spatial

extent of the city's influence zone. From the results it may conclude that the intensity of influence gradually decreasing as the distance increase from the city. But the newspaper study reveals that the radiation of urban influence does not always reduced regularly with increasing distance. Hence this study disapproved the earlier hypothesis (see Chapter I.2) that the degree of urban influence does fall regularly from the city centre.

The author is of the opinion that the growth of Guwahati has just begun, the commercial headquarters of the North-East India has every prospect of being an important commercial centre for the regions as the progress of South to South cooperation and the cooperation among the South Asian Regions is in the process of materialization with the progress of time. Hence, the author feels that at least what the government at best can do immediately, is to survey the entire ajdoining areas including some of the regions of north bank of the river and prepare aerial photographs for detail analysis.

However this work cannot claim to be all pervading and complete in all respects. There are ample scope for further investigation in this field by geographers. Nevertheless, the contribution made through this humble work might be helpful in tackling this genuine problem, with better understanding and clearity.

BIBLIOGRAPHY

Advani, H.C. 1974. "The Alarming Problem of Traffic Growth in Bombay", Mobile, October.

Agrawal, M. 1972. "A Morphometric Analysis of Some Drainage Basins of Jabalpur Plateau", National Geographical Journal of India, 18, Parts 3 & 4, B.H.U., Varanasi.

Alam, S.M. and V.V. Pokshishevsky, (eds.) 1976. "Urbanization in Developing Countries", Indo-Soviet Collaborative Volume, Osmania University, Hyderabad.

Amos, F.J.C. 1972. "The Development of the Planning Process", Journal of the Royal Town Planning Institute, Vol.58.

Appleyard, D. 1970. "Styles and Methods of Structuring a City", Environment and Behaviour, Vol. 2.

Barthakur, M. 1979. "Growth and Development of Service Centres in the Brahmaputra Valley and their Influence on the Rural Development," The North-Eastern Geographer, Vol. XI, No. 1 & 2.

Barthakur, M. 1986. "Weather and Climate of North-East India", The North-Eastern Geographer, Vol. 18, No. 1 & 2.

Beavon, Keith S. 1977. Central Place Theory: A Reinterpretation, Longman, London.

Berry, Brian J.L. and John Kasarda, 1977. Contemporary Urban Ecology, Macmillan, New York.

Bez, K. and S. Sarma. "Spatial Models for Shopping and Residences: A Brief Survey", Seminar Paper, Gauhati University (Also under print in the NEHU Journal of Soc. Sc. and Humanities, Shillong).

Bhat, L.S. 1961. "Delineation of Metropolitan Region - A Method", Journal of the Institute of Planners, India, New Delhi, No. 25 & 26.

Bhatt, S. 1986. Environmental Laws and Water Resources Management, Redient Publishers, New Delhi.

Bhattacharyya, N.N. 1978. "Population Density Gradient of Gauhati City", The North-Eastern Geographer, Vol. X: No. 1 & 2.

Bhuyan, M.C. 1977. "Immigrant Population of Assam", An unpublished Ph.D. Thesis, Gauhati University, Guwahati.

Bhuyan, S.K. 1957. Atan Buragohain and His Times. Lawyer's Book Stall, Guwhati.

Borah, J. 1985. Spatial Structure of Urban Influence in the Neighbouring Areas of Gauhati City, Inter-India Publications, New Delhi.

Bose, A. 1970. "Urban Development with Social Justice", Economic and Political Weekly, Vol. V, Nos.29-31.

Bose, A. 1978. India's Urbanisation (1901-2001), Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

Bulsara, J.F. 1970. "Patterns of Social Life in Metropolitan Areas (With Particular Reference to Greater Bombay), Research Project under the Auspices of the Research Programmes Committee of the Planning Commission, Government of India.

Burton, J. et al. 1978. The Environment as Hazard, Oxford University Press, New York.

Census of India, 1971. Assam Series - 3, Part V-B, Special Survey Reports on Selected Town - Gauhati, 1978.

Chakravarty, S.C. 1983. "Perspectives on Managing Man-Environment Relationship", Annals of the National Association of Geographers, India, Vol. III, No. 1.

Chorley, R.J. and P. Hagget, (ed.) 1967. Socio-Economic Models in Geography, Methuen and Co., London.

Chow, V.T. 1962. "Hydrologic Determination of Waterway Areas for the Design of Drainage Structures in Small Drainage Basin", University of Illinois, Eng. Expt. Sta. Bull.

Clapham, W.B. 1981. Human Ecosystems, Macmillan, Inc. New York.

Cliff, A.D. and K. Ord, 1975. "Model Building and the Analysis of Spatial Pattern in Human Geography", Journal of the Royal Statistical Society, Series B, 37.

Coppock, J.T. and H.C. Prince, 1964. The Geography of Greater London, Feber, London.

Cox, K.R. 1972. Man, Location and Behavior - An Introduction to Human Geography, John Wiley and Sons, New York.

Das, Manamohan, 1984. Peasant Agriculture in Assam: A Structural Analysis. Inter-India Publications, New Delhi.

Das, H.P. 1970. Geography of Assam (India - the Land and People), National Book Trust, New Delhi.

Dayal, P. 1959. "Population and Rural-Urban Migration in India", The National Geographical Journal of India, Vol. 5, Part 4.

Department of Traffic and Transportation Planning, "A Study on Planning of Inter-State Passenger Terminal Locations in Delhi Urban Area", School of Planning and Architecture, New Delhi, 1974-75.

Deshpande, C.D.; B. Arunachalam and L.S. Bhat, 1980. Impact of a Metropolitan City on the Surrounding Region, Concept Publishing Company, New Delhi.

Developmental Problems of the City of Guwahati, Seminar Proceeding of the Institution of Engineers (India), Assam State Centre, Sept. 14-16, 1982.

Dhar, O.M. 1962. "Rainfall and Floods in Yamuna Catchment", Indian Journal of Meteorology and Geophysics.

Dickinson, R.E. 1964. City and Region: A Geographical Interpretation, Routledge and Kegan Paul Ltd., London.

Ehrlich, Paul R. et al. 1977. Ecoscience: Population, Resources, Environment, W.H. Freeman and Company, San Francisco.

English, J. et al. 1976. Slum Clearance, Croom Helm, London.

Freeman, T.W. 1967. Geography and Planning, Hutchinson University Library, London.

Friedmann, J. and R. Wulff, 1975. The Urban Transition, Arnold, London.

Furon, R. 1967. The Problem of Water: A World Study, American Elsevier Publishing Co., Inc. New York.

Gerasimov, I.P. 1981. Geography and Ecology, Progress Publishers, Moscow.

Gibbs, J.P. 1966. Urban Research Methods, Von Nostrand East-West Press, New Delhi.

Golley, F.B. 1977. "Ecosystem Futures - Predictions and Prognostications", American Biology Teacher, Vol.39.

Gopalakrishnan, R. 1984. "Some Theoretical Considerations in the Analysis of Immigration into the Brahmaputra Valley", The North-Eastern Hill University Journal of Social Sciences and Humanities, Vol. II, No. 4.

Gopalakrishnan, R. 1986. "Geographical Aspects of a Crisis in Brahmaputra Valley (Assam)", The Indian Journal of Political Science, Vol. XLVII, No. 3.

Goswami, D.C. 1985. "Pattern of Sediment Yield from the River Basins of the Brahmaputra System, North-East India", The North-Eastern Geographer, Vol. XVII, No. 1 & 2.

"Greater Guwahati, Better Guwahati" Seminar Proceedings of the Assam Engineering Service Association, January 5-6, 1987.

Gupta, K. 1983. "Gradient of Urban Influence in the Vicinity of a City - A Case Study of Agra and its Adjoining Areas", Annals of the National Association of Geographers, India, Vol. III, No.1.

Harris, B. 1965. "Urban Development Models: A New Tool for Planners", Journal of the American Institute of Planners, Vol. 32.

Hartshorn, Truman A. 1988. Interpreting the City: An Urban Geography, John Wiley and Sons, New York.

Hartshorn, Truman A. and John W. Alexander, 1988. "Economic Geography", Prentice-Hall of India Privated Ltd., New Delhi.

Herbet, D.T. and R.J. Johnston, ed. 1979. Geography and the Urban Environment: Progress in Research and Application, Vol. II, John Wiley and Sons, New York.

Hodges, L. 1977. Environmental Pollution, Rinehart & Winston, New York.

Hunter, W.W. 1879. A Statistical Account of Assam, Trubner and Co., London.

Hutchinson, B.G. 1975-76. Principles of Urban Transportation Planning, University of Waterloo, McGraw-Hill Books, Ontario.

Jafri, S.S.A. 1979. "Intra-City Variations in Public Utility Service/Facilities in Metropolitan Delhi", Unpublished Ph.D. Thesis, JNU, New Delhi.

Johnson, J. (Ed.) 1974. Suburban Growth, Wiley, London.

Kalita, S. and S.K. Sarmah, 1982. "Diurnal Variation of Monsoon Rainfall at an Inland Station in the Brahmaputra Valley", Current Science, Vol. 51, No. 18.

Kelly, R.A. and Spofford, W.O. 1977. "Application of an Ecosystem Model to Water Quality Management: The Delaware Estuary", In C.A.S. Hall and J.W. Day (Eds.) Ecosystem Modelling in Theory and Practice, Wiley, New York.

King, L.J. 1984. Central Place Theory, Sage Publications, Beverly Hills.

Knox, Paul, 1982. Urban Social Geography: An Introduction, Longman, London.

Kormondy, E.J. 1986. Concepts of Ecology, Prentice-Hall of India Private Ltd., New Delhi.

Krueckeberg, D.A. and A.L. Silvers, 1974. Urban Planning Analysis: Methods and Models, John Wiley & Sons, Inc.

Larkin, R.P. et al. 1980. People, Environment and Place, A Bell & Howell Company, London.

Lichfield, N. 1970. "Evaluation Methodology of Urban Regional Plans: A Review", Regional Studies, Vol. 4.

Mandal, R.B. 1982. Statistics for Geographers and Social Scientists, Concept Publishing Company, New Delhi.

Mahto, K. 1985. Population, Mobility and Economic Development in Eastern India, Inter-India Publications, New Delhi.

Merril, R.L. and M.B. Kelly, 1970. "The Simulation of Hospital Use and the Estimation of Location Efficiency", Geogr. Anals, Vol. 2.

Miller, J.T. Jr. 1981. Living in the Environment, Concepts, Problems and Alternatives, Wadsworth Publishing Co. Belmont.

Misra, T.K. 1982. "Studies on Some Water Pollutants", Unpublished Ph.D. Thesis, Visva Bharati, Santiniketan.

Mooley, D.A. and B. Parthasarathy, 1985. "A Probability Model for Areal Extent of Drought/Flood Over India During Summer Monsoon Season", Anals of the National Association of Geographers, India, Vol. V, No.1.

Nangia, S. 1976. Delhi Metropolitan Region - A Study in Settlement Geography, K.B. Publications, New Delhi.

National Academy of Sciences (NAS), 1975. "Air Quality and Stationary - Source Emission Control", Washington.

Neogi, Sisir, 1970. "Traffic Problems of Indian Cities - Its Solution", Civic Affairs, March issue.

Newling, Bruce E., 1966. "Urban Growth and Spatial Structure; Mathematical Models and Empirical Evidence", Geographical Review, Vol. 39, No. 3.

Paura Bichitra, (Guwahati Municipal Corporation Journal), 1978, Guwahati.

Pinch, Steven, 1985. Cities and Services, Routledge and Kegan Paul Inc., London.

Rao, D.P. 1985. Problems of Urban Transport in India, Inter-India Publications, New Delhi.

Ravenstein, E.G. 1885. "The Laws of Migration", Journal of Royal Statistical Society, Vol. 48.

Ravenstein, E.G. 1889. "The Laws of Migration", Journal of Royal Statistical Society, Vol. 52.

Sarma, S. 1985. "Drainage and Urban Development: Case Study of the Greater Guwahati Regions", Hill Geographer, Vol. IV, No.2.

Sarma, S. 1986. "Cartographic Representation of Waterlogged areas in the Guwahati City and its Development Planning", Seminar Proceedings, NATMO, Calcutta.

Sarma, S. 1986. "Cartography in Environmental Planning: A Case Study of Greater Guwahati", Souvenir of Indian National Cartographic Association, Trivandrum.

Sarma, S. 1987. "Pragjyotishpura - An Ancient Capital of Assam: Revisited", Proceedings of North East India History Association, Eighth Session, Kohima.

Sarma, S. and R. Gopalakrishnan, 1987. "Impact of Hourly Rainfall on Guwahati City (Assam)", 12th Annual Conference of N.E.I.G.S., Jorhat, Dec. 28-29.

"Save Guwahati", Seminar, organised by Ashinam, 13th June, 1987.

Sharma, H.N. 1979. "Urban Growth and Spatial Pattern of Urban Development in the Brahmaputra Valley, Assam", The North-Eastern Geographer, Vol. XI, No. 1 & 2.

Sharma, H.N. 1981. "Socio-Economic Profile of a Urban Community Near Gauhati: A Geographical Analysis", The North-Eastern Geographer, Vol. XIII, No. 1 & 2.

Sharma, K.K. 1985. Urban Development in the Metropolitan Shadow: A Case Study from Haryana, Inter-India Publications, New Delhi.

Sharma, M.M. 1978. Inscriptions of Ancient Assam, Gauhati University, Guwahati.

Sharma, R.C. 1972. Settlement Geography of the Indian Desert, Kumar Brothers, New Delhi.

Sinclair, R. 1967. "Von Thunen and Urban Sprawl", Annals of the Association of American-Geographers, Vol. 57.

Singh, R.L. 1955. Banaras: A Study in Urban Geography, Nand Kishor and Bros, Banaras.

Sinha, S. 1985. Slum Eradication and Urban Renewal: Patna, Inter-India Publications, New Delhi.

Srinivasan, N.S. 1970. "Long Term Measures to Solve Urban Mass Transportation Problems", Transport, October issue.

Stearns, F.w. and Montag, J. (Eds.) 1975. The Urban Ecosystem, Halstead Press, New York.

Stewart, J.Q. and W. Warntz, 1958. "Microgeography and Social Science", Geographical Review, Vol. 48.

Taher, M. 1986. "Physiographic Framework of North-East India", The North-Eastern Geographer, Vol. 18, No. 1 & 2.

Tardiff, R. and M. Deinzer, 1973. "Toxicity of Organic Compounds in Drinking Water", E.P.A. Water Supply Research Laboratory, Cincinnati.

The Assam Gazette, Extraordinary Issue No. 129, Dispur, 24th December, 1986, Government of Assam.

The Air (Prevention and Control of Pollution) Act, 1981, Gazette of India Extraordinary Part II of Section I, dated 30th March 1981.

Vander Velde, Edward, J. 1979. "The Role of Ecology in the Development Geography of North-Eastern India", The North-Eastern Geographers, Vol. XI: No. 1 & 2.

Ward, R.C. 1973. Principles of Hydrology, McGraw-Hill, London.

Williams, K. (ed.) 1975. Statistics and Urban Planning, Charles Knight & Company Limited, London & Tonbridge.

Wilson, A.G. 1981. Geography and the Environment, Systems Analytical Methods, John Wiley & Sons, New York.

Wilson, A.G. and Pownall, C. 1976. "A New Representation of the Urban System for Modelling and for the Study of Micro-level Interdependence", Area, Vol. 5.

Yadav, C.S. 1979. Land Use in Big Cities: A Study of Delhi, Inter-India Publications, New Delhi.

Yeates, M. 1974. An Introduction to Quantitative Analysis in Human Geography, McGraw-Hill Book Company, New York.

Zakaria, T. 1975. "Analysis of Urban Transportation Criteria" Transportation Engineering, August issue.

Zipf, G.K. 1949. Human Behavior and Principle of Least Effort, Addison-Wesley, Cambridge.

APPENDIX - IV.1

Areas of Greater Guwahati

Municipality	Town Committee	Rural Areas	Other Areas
1	2	3	4
1. Guwahati	2. Kamakshya	4. Abhayapur	
	3. North Guwahati	5. Ajragaon	
		6. Amingaon	
		7. Bagharbari N.C.	
		8. Bamunimaidan	
		9. Barmataria	
		10. Barasaji	
		11. Barsapara	
		12. Betkuchi	
		13. Bhogargaon	
		14. Birkuchi	
		15. Birkuchi N.C.	
		16. Bonda	
		17. Bonda N.C.	
		18. Chapaidong	
		19. Charmaujalipam	
		20. Chunsali T.G.	
		21. Clarence Garden	
		22. Dakshingaon	
		23. Dakshin Jhalukbari	
		24. Dehangarigaon	
		25. Dhalbama	
		26. Dharapur	
		27. Dispur	
		28. Dispur N.C.	
		29. Duaranhda	

Municipality	Town Committee	Rural Areas	Other Areas
1	2	3	4
		30. Durgasarobar N.C.	
		31. Fatasil N.C.	
		32. Fatasilgaon	
		33. Garalgaon	
		34. Gauripur	
		35. Ghorajan	
		36. Gorpandu Kumarpara	
		37. Greenwood Grant	
		38. Hatigaon	
		39. Hengarabari	
		40. Hengarabari N.C.	
		41. Independence Garden	
		42. Jansimalu N.C.	
		43. Japarigog	
		44. Jatia	
		45. Jatikuchi	
		46. Jugipara	
		47. Kacharigarigaon	
		48. Kahikuchi	
		49. Kahilipara	
		50. Kahilipara N.C.	
		51. Kalitakuchi	
		52. Khanapara	
		53. Khanapara N.C.	
		54. Kharghuligaon	
		55. Kharghuli N.C.	
		56. Madgharia I	
		57. Madgharia II (P)*	
		58. Madgharia N.C.	

*(P) stands for part.

Municipality	Town Committee	Rural Areas	Other Areas
1	2	3	4
		59. Maidam	
		60. Mikirparachakarda	
		61. Mirjapur	
		62. Natabama	
		63. Namalijalah	
		64. Noonmati (P)	
		65. Noonmati Garden (P)	
		66. Odalbakra Grant	
		67. Pashim Bargaon	
		68. Pashim Baragaon N.C.	
		69. Pashim Jhalukbari	
		70. Pub Baragaon	
		71. Pub Baragaon N.C.	
		72. Rajabari	
		73. Rudreswar	
		74. Rukani	
		75. Sarusajai	
		76. Sarumataria	
		77. Saukuchi	
		78. Sadilapur	
		79. Silagrant	
		80. silmahekhaiti	
		81. Tetelia	
		82. Tetelia N.C.	
		83. Tilinggaon	
		84. Ulubarigaon	
		85. Uttarjhalukbari (P)	

Municipality	Town Committee	Rural Areas	Other Areas
1	2	3	4
			Military Colony
			86. Bagharbari
			87. Barjhar
			88. Basisthagrant
			89. Jansimalu
			90. Kalitakuchi N.C.
			91. Satgaon
			Refinery Colony
			92. Chunsali T.G.
			93. Madgharia II (P)
			94. Noonmati (P)
			95. Noonmati Garden
			Railway Colony
			96. Gorpandu Kumarpara
			97. Gotanagar
			98. Maligaon
			University Colony
			99. Maj Jhalukbari
			100. Uttar Jhalukbari (P)

APPENDIX - IV. 2

Landuse Variation of Guwahati, 1956-1980

Sl. No.	Landuse Classification	1956		1974		1980	
		Area in hectares	Percent	Area in hectares	Percent	Area in hectares	Percent
1.	Residential	882	5.5	2754.47	40.56	2908.09	45.11
2.	Commercial	139	8.6	226.33	3.33	291.92	4.52
3.	Industrial	10	0.6	185.00	2.73	406.21	6.30
4.	Public and Semipublic	258	16.3	640.82	9.43	913.64	14.17
5.	Park and Playground	33	2.0	70.34	1.03	26.79	0.43
6.	Transportation	279	9.9	781.09	25.50	1071.74	16.62
7.	Special Use	-	-	1182.57	17.42	828.67	12.85
	Total	1601	100.00	6790.62	100.00	6447.00	100.00

Source: Town and Country Planning Department, Government of Assam.

APPENDIX - V. 3

Three Point Moving Average of Rainfall Per Hour for the Monsoon Season 1980-1986

Rainfall in mm

Three Point average of the hours	May	June	July	August	September	Seasonal (Monsoon)
1, 2, 3	4.0	3.1	4.4	3.1	3.7	3.7
2, 3, 4	3.8	2.6	3.7	2.5	3.5	3.2
3, 4, 5	3.1	2.2	2.1	2.9	3.4	2.7
4, 5, 6	2.6	1.8	1.6	3.2	1.9	2.2
5, 6, 7	2.5	1.5	1.9	3.9	1.3	2.2
6, 7, 8	2.0	1.2	2.0	3.6	1.6	2.1
7, 8, 9	2.2	1.4	2.4	3.2	1.8	2.2
8, 9, 10	1.7	1.9	2.5	3.1	1.9	2.2
9, 10, 11	1.9	2.6	2.8	2.9	1.7	2.4
10, 11, 12	1.6	3.3	2.5	2.6	1.9	2.3
11, 12, 13	1.7	3.6	2.0	2.5	1.9	2.5
12, 13, 14	1.5	5.9	1.4	2.2	1.6	2.3
13, 14, 15	1.9	5.0	1.3	1.9	1.5	2.5
14, 15, 16	1.7	5.8	1.4	1.9	1.6	2.6
15, 16, 17	1.7	4.1	2.5	2.2	2.3	2.6
16, 17, 18	1.1	4.0	2.5	2.9	2.1	2.4
17, 18, 19	2.0	2.5	2.8	2.7	2.3	2.2
18, 19, 20	2.5	1.5	2.0	2.6	2.6	2.7
19, 20, 21	2.3	1.7	3.3	2.7	3.6	3.1
20, 21, 22	2.4	3.0	3.3	3.1	3.9	3.6
21, 22, 23	4.4	2.9	3.6	3.2	3.8	3.4
22, 23, 24	5.5	3.0	2.8	2.6	3.0	3.4

Computed by the author.