WATER LOGGING IN JORHAT TOWN

A GEOGRAPHICAL ANALYSIS

ABSTRACT

SUBHALAKSHMI RAJKUMARI

THESIS SUBMITTED FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY (Ph. D.) IN GEOGRAPHY

DEPARTMENT OF GEOGRAPHY

SCHOOL OF ENVIRONMENTAL SCIENCES

NORTH – EASTERN HILL UNIVERSITY

SHILLONG-793022

2009

Geography

ABSTRACT

ABSTRACT

Introduction

Water logging, being a menace to the dwellers in an urban area imparts deep penetrated impact on the society. Jorhat town, mainly the Jorhat municipal area has been suffering from water logging problem since long back. The existing drains are not sufficient to drain out storm waters of the town. This water logging problem is Gradually increasing as the town grows. The present work aims at cognition of the interaction of both natural and human factors, responsible for the water logging problem and consequent interconnected catastrophe effects on society.

1. **Statement of the Problems**

Jorhat town is served by many natural streams, which are locally known as *"Jans"*. The important point to consider is that the bed level of the main river of this town Bhogdoi is much higher than the bed level of the other natural cum man-made streams. It is difficult to drain out storm water directly to the river Bhogdoi. So it is proposed to drain out the storm water to the *jans* where appropriate gradient is available. The storm water of the areas outside the municipal boundary is drained out mainly by overland flow through the fields to rivulets .Strom water and sewage are carried through the surface drains and the natural streams. Rapid industrialization and increase in urban settlements, indiscriminate dumping of garbage and misuse of these natural channels are positioned serious threats to their existence of the natural streams, making some areas waterlogged in rainy season. Due to human interference most areas of the town are facing water logging during rainy season. This problem has become more complex during last few years, since this garbage dumping is creating huge siltation at Bhogdoi river.

In Jorhat, river Bhogdoi experiences more flood waves than any other rivers on the south bank of Brahmaputra. The flood lift of the river is quite small when compared to the other rivers of the south bank in upper Assam. The bed of the river is very shallow and as a result during flood season the river crosses danger mark within 12 hours of precipitation. Due to shallowness of the river section and low lying adjoining areas, the river has a great tendency to change its courses during high flood period. Due to the unprecedented and concentrated rainfall, Jorhat and its suburbs were submerged in May 1977. The situation was further aggravated due to inadequate drainage section of Tocklai and Tarajan channel. Since the bed of the river Bhogdoi being higher than the level of the town , it has created flood congestion due to backwater flow of the river through the Tocklai channel that caused inundation and water logging in most areas of Jorhat . Thus, it has been seen that man's interference on natural drainage and its consequences is perhaps nowhere more clearly visible than in Jorhat town. The embankment along the Bhogodi river has proved to be boon as well as a curse for the town. They are boon in the sense that they protect the urban area from devastating floods but are a curse because they do not permit rapid run-off to drain out water and thus create water-logging in areas of the town. Moreover the growth of settlement of the ill drained low-lying areas of the town where no scientific drainage scheme were taken up has made the situation worse. Water-logging in the low-lying areas has become a regular feature during the rainy seasons after a heavy rainfall.

The storm water that is generated in the town is collected partly by Tocklai river and five numbers of natural streams, viz. Jawkhariajan, Tarajan, Anthubhangajan, Rowriahjan and Mahuajan . Duborijan and Khoragorajan are two

other *jans* which also carry the surface of some part of the region. They are presently acting as the major trunk drains. Storm water generated in the town area generally collected by the road side drains and then finally discharged into one of these streams. With rapid urbanizations and indiscriminate dumping of garbage and encroachment in certain areas along both Tocklai river and Tarajan has paused serious threat to some areas of the town. The main problem areas are the Jorhat town and the adjoining areas so far executed and their performance areas which are developing at quite a fast rate.

2.Objectives

There are three bases of water logging which has been attempted here:

a) Water logging on the basis of topography and slope characteristics in relation to river bed changes.

b) Water logging on the basis of drainage system with urban planning.

c) Water logging on the basis of the urban growth pattern as a causative factor.

3.Hypotheses

The hypotheses can be outlined in the following manner:

a) That unplanned growth of urban area or the topography is the major cause of water logging and flooding in Jorhat town.

b) That growth of settlements alongside the Bhogdoi river and a land use change intensifies the problem of the town.

c) That disposal of garbage on the *Jans* which cause clogging creates water logging of the town and surrounds.

4. Database and Methodology

The study intends following thee aspects as outlined in the conceptual framework:

1) The analysis of the urban growth data using both theoretical and empirical framework. For evaluating the influence of the town Gravity Potential model, Population Interaction and Breaking Point Distance have been applied. Regional impacts of the town on its neighboring areas are analyzed by applying theoretical and empirical approach.

2) The analysis of water logging and flood study area based on past and present data. The assessment of impact of water logging is analyzed by primary and secondary data collection. Analysis has been done on the basis of showing the table of maximum and minimum discharge and water levels of the river Bhogdoi of the study area ; Flood waves of the river Bhogdoi ; Intensity of rainfall; Average variation of rainfall per hour for the monsoon season; Mean, Standard deviation and Co-efficient of variation of rainfall per rainy day for the months of May to September and preparing maps of sequential increase of water logged area by using the method of GPS (Global Positioning System) of the study area.

3) The analysis of socio economic data collected through the schedule questionnaires.

Four types of information and data have been required for the present study. These are -

1) Secondary information on general characteristics of population, land use and settlement pattern, urban growth , socio economic variables etc. for the town of Jorhat have been collected from

    a) Various census publications, particularly District Census Hand Book, 2001 and 1991 .

b) District Administration , Jorhat

c) Master Plan and Zoning Regulation Book of Town and Country Planning Organization.

d) Jorhat Municipality Board

e) Town and Country Planning Department, Jorhat .

f) Jorhat Development Authority .

g) District Urban Development Agency ,Jorhat .

h) Upper Assam Commissioner Office ,Cinnamara .

i) District Transport Office , Jorhat .

2) Map based information (including air photos and satellite imageries) on relief, vegetation, drainage slope and geology for the study area have been collected from the following sources

a) Topographical sheets of 1:50000 scales of Survey of India.

b)Satellite imageries pertaining to Jorhat District.

3) The data on drainage and flood have been collected from Brahmaputra Flood Control Department ,Jorhat ; Embankment and Drainage Department , Rajabari ; Jorhat Municipal Board ; Meteorological Department, Guwahati ; Survey Of India Toposheets ; Rajabari Raingauge Station, Jorhat etc.

4) Primary data that is collection of field data of socio economic and water logging of various selected areas have been used. The study carried out from 19 localities using stratified sampling method .

5. Findings

From the analysis of the various data collected for understanding the past and the present water logging scenario the following facts have been found out :

- The bed level of the river Bhogdoi which passes through the town is higher than the bed level of the other streams and drains making it difficult to drain out the storm water directly to the river Bhogdoi. During high flood there is reverse flow from Bhogdoi through other drains and inundates the town making most part of the town water logged.
- The average slope of the town varies from 0^0 to 8^0 . The maximum slope is 8^0 and is noticed in Tocklai area (6^0 to 8^0), Rajamaidam , Kabarsthan road (2^0 to 4^0) and Malow Ali bears a slope of 0^0 to 4^0. In the same way the central part of Jorhat is of 4^0 and all the adjacent areas bear the same slope making this part even. Borbheta area in southwestern part of the town shows low land and has a slope of 2^0 to 4^0. It is seen that average slope of the town gradually falls southeast to northwest. It is observed that the flood and water logging in Jorhat is absolutely a temporary feature and there is no any natural blockade.
- The present drainage networks are not constructed in consonance with the natural slope of the land and 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 are responsible for maintenance of urban siltation work discordantly. New residential areas are almost devoid of proper drains which creates rapid water accumulation and frequent floods.

- Concentration of rainfall in 2 / 3 months in a year and that too accounts very heavy is another cause of water logging. The average annual rainfall is 2420.91 mm. About 60 percent of this rainfall occurs only in 80 to 100 days almost in every year which cause inundation in many places.

- The maximum value for mean monthly discharge was recorded in July 1983 as 190.05 m^3sec^{-1} and the minimum in March 1982 as 0.2 m^3sec^{-1}. It indicates that the month of November to March are not subjected to flood and maximum fluctuations of discharge occurred in July and the minimum in February. Discharge data of 21 hydrological years have been studied (1977 to 1997). From the hydrographs prepared for these years, it is seen that during this peak period of discharge the Bhogdoi water level rises up and even crosses the danger level (89 meter). When water level crosses the danger mark, the river water backflows through other streams. The water received from the catchments area of the Tocklai and Tarajan automatically accumulates and, if the water level of the Bhogdoi remains constant for few days flood begins as a result of which low lying areas of the town is submerged during these periods.

- River gauge records were maintained at Assam Trunk Road Crossing Site at Jorhat and its records available here are from 1987 to 1997. The danger level of the site is 89.00 meter while the maximum water level observed is 90.27 meters on 15/7/96. During the period 1987 to 1996, the high flood level varied from 89.24 meter to 90.27 meter.

- One oil pipeline of Oil India Limited crosses the Tarajan channel perpendicularly. It was put at such a height that it is standing like a barrier to the discharges of the channel. Garbage come through the channel struck at this

point and become dome shaped. All the water comes through this channel becomes stagnant at this point and in rainy days the channel overflows, and inundates northwestern side of the town.

- Beyond the by pass, across Malow Ali, there is a box culvert, which was placed three meters above the normal height of the town. The culvert was constructed for discharging the waters of the diversified Tocklai, but practically water comes on this spot, rushes back and overflows creating water logging in the adjacent areas.
- Construction of Jorhat Medical College at Jail road site has created some new water logged areas in Senchowa gaon, Cheuni gaon and Sonari gaon by obstructing the main channel of Duborijan which carries the waters from Na-Ali, Bongalpukhuri and Lichubari area. Before the construction of the college the channel was within the college campus.The *Jan* is now filled up with earth due to which the neighboring areas has been suffering from water logging after heavy rainfall. Besides, all the water of the channel accumulates at the south side of the college campus creating havoc in the Jail road - Sonari gaon path.
- Jorhat experiences about eight peaks of high intensity rainfall in one monsoon season. As monsoon begins in the months of May, the rainfall of peak hours could not result flood as rainfall is absorbed by the soil into the saturated point. The other peaks of primary and even secondary maxima from June to September is a sensitive period with full of potential of flooding in the town through runoff water. The intensity of mean hourly rainfall is maximum in

June. Co-efficient of variation shows very high in June (77.61percent). Hence this month is always alarming as it exposed the inherent drawbacks of Jorhat's drainage system. The rainfall intensity graph shows high and low intensity at different time. The maximum intensity of rainfall per hour occurs in 27th June while the second maximum occurs in 23rd August. Intensity of rainfall of 5 mm column exceeds twice in May, once in the months of June and July, thrice each in August and September. It means intensity of rainfall of 5 mm per hour is experienced on ten occasions during the year 2001.

- Out of the 5 slum areas, Sweeper Colony occupies single roomed house of about 72 percent while Dhakkai Patty occupies single roomed house of about 85.94 percent.
- In view of the diversion of Tocklai in the upper reaches which will further increase the high flood level of Bhogdoi, raising and strengthening of the embankment system is therefore very essential. The outgrowth of the water hyacinth plant on the Tarajan channel near Sarucharai and Tocklai at Immersionghat hinders the natural flow of water.
- After constant personal observation in the last few consecutive rainy seasons (2003 – 2007), five permanent water logged areas have been identified. These areas are Malow Ali, Rajamaidam, Bongalpukhuri, Choladhara and Pujadubi . Maximum duration of water logging has been found in Malow Ali area in June 2006 as 72 hours. In some water logged areas the depth of the water rises up to 3.9 feet. Within the observation period it is seen that the volume of water in respective areas have been increased sequentially. No significant changes are found in between 2003 and 2004.

Choladhara and Rajamaidam got an extension of 0.08 sq. kms. In 2005 the magnitude of expansion of Bongalpukhuri was the highest (0.27 sq. Kms.) among all the areas. The year 2006 experienced heavy rainfall. Few newly created water logged areas were formed in this year. Malow Ali got an expansion of 0.55 sq. kms in 2006. In the year 2007, both Pujadubi and Choladhara areas became enlarged by 0.43 sq. km. Little development was experienced in Malow Ali after the constructions of some new road side drains.

- With the increase of dwelling houses, offices, business establishments etc. the existing roadside drains become inadequate to discharge the rain and waste water of the town. Moreover many small drains have been connected with the main drains right angled for which natural flow is greatly hampered. In addition, due to silt accumulation in roadside drains, carrying capacity of storm water is lost for which little rain may cause havoc in the town.
- The existing drainage facilities of Jorhat are not adequate to carry all the storm water from each locality. Roads inside the town are very narrow and manholes of drain cum footpath are inadequate.
- Defective drainage network and adopting some adhoc measures for controlling water logging, certain new areas inundated.
- Drains are very narrow and they are not capable of carrying the huge bulk of water that pours over the different parts of the town during heavy rains. The drains constructed in the town do not all end at the ultimate discharge points which is capable of holding this huge quantity of water.

- The erosion problems on the banks of river Bhogdoi is very serious due to very close spacing of embankment system. Canalization of the river at some of the very vulnerable reaches was taken up with a view to develop the banks and deepening of the channel so as to reduce the increased flood levels and also to tackle the dangerous erosion problem threatening the town. These works in the form of bank bars and dampeners have been successful in developing the banks of the river. In many reaches the direct erosive attack of the river could stopped, but the bed is not deepening and the flood levels do not show any sign of relief.
- Removal of forest cover from the newly constructed building region aggravated the soil erosion. On the exposed areas the erosion rate is very high compared to the areas covered by green plants. This erosion and tremendous speed of down flowing rain water during the monsoon months increase silt accumulation as well as water logging.
- The channel banks are being encroaching illegally by the people mainly in the town area where constructions of permanent nature are being done. Large quantities of debris and waste material are being collected at the bottoms and slopes since people tend to through all kinds of litters including polyethylene and household garbage in the channel blocking the water way . A numbers of outlets of sewers and service latrines are made into the channels that pose health hazard in the locality.

- The Central Business District areas of Jorhat like Chowk bazar , Assam Trunk road and Gar Ali are extremely congested and there is hardly any space for future expansion. Industrial land use occupies about 38.20 hectares of the total developed area. Other small establishments are scattered all over the Jorhat Master Plan area in a haphazard manner.

6. Suggestions and Recommendations

The following suggestions and recommendations seem to be useful for future planning for its growth and development .

- The drains should be cleaned at regular intervals .For cleaning to be effective and water flow easier, the beds of the drains must be of concrete cast.
- Streams like Rowriajan, Mohuajan , Anthubhangajan and Tocklai river need to be cleaned from time to time and their misuse and encroachment be strictly dealt with. It would be necessary to connect the major drains to these streams.
- Mahuajan, Tarajan and Rowriahjan connected through open drains cannot accommodate all the water received during the peak discharge. There is no practical use of Tocklai river due to its shallowness and narrowness. Encroachment on the river adds more to the problem. Hence, all these *jans* need to be excavated to enable them to reserve the excess storm water.
- To absorb the city runoff which come through the existing drains, the low lying areas of Tarajan that is, the northwestern part of the town needs to

be excavated. The outgrowth of water hyacinth plant on Tarajan and Tocklai channel should be cleaned.

- Deepening of Anthubhangajan, Rowriahjan, Jawkhoriajan, Tocklai and Tarajan linking them with Bhogdoi river and connecting the water logged areas of the town with these natural streams will decrease the problem.
- It is necessary to borrow the services of technical experts from different departments and institutions to suggest the actual size and lay out of drains based on the volume of water it has to carry during smart showers. Appropriate lay out of the entire drainage network is highly essential to discharge the entire town water to natural wet lands.
- The existing oil pipeline on the Tarajan should be replaced in a systematic way. If this is done, Tarajan will be free from all obstructions at this reach and get a direct slope.
- On Malow Ali, along the bypass, the bed of the box culvert should be lowered down at least by two meters from the existing level to get a straight slope, so as to get a maximum discharge in minimum time.
- Drain should be kept free from all obstructions by regularly removing the excessive accumulation of silt. A deep drain may be constructed along the bypass to catch the additional silt loads from the Tocklai and the Bhogdoi river. Excess silt can be removed by manually also, after a definite interval of time. Some additional silt traps (silt trap is a design which maintains silting velocity

for selected particle size) may be constructed at important sites along the existing natural drains. These silt traps need to be cleaned after each storm.

- Efforts should be made to convert the existing drains free from garbage. This will increase the water carrying capacity of the drains and water logging will be reduced. Service path on both sides of the drain should be kept for maintenance purpose.
- Non degradable solid waste like plastics, polythene, rubber items and metallic products should not be thrown into drain water which acts as the hindrance of free flow of drain water. Coverage on the channels with nettings would prevent dumping of garbage.
- In case of refuse disposal, modern method of incineration can be adopted. The first of its kind may be located in the present site of garbage disposal near Tocklai river.
- Garbages should never be kept bare making some compromise with people's standards, wheeled metal boxes of moderate size with back side covered three fourths at convenient points can be placed and the filled boxes can be carried by tractors during night hours replacing with another empty box . The garbage thus carried, instead of discharging at open places or low lying areas or the wetlands, must be scientifically treated to produce manure or electricity.

- Rain water harvesting, particularly roof top harvesting should be encouraged, so that some amount of water could be kept there to reduce the intensity of water logging.
- The deposited silt on the bed of the river Bhogdoi during immersion of idols can be minimized by removing the debris immediately after the immersion.
- To prevent water logging on the Jail road - Sonari Gaon Road, construction of alternative outlets needed to drain out the accumulated water of Duborijan on the south side of the college campus.
- Some new drains in the residential areas of Bansbari, Bongalpukhuri, Jail road, Choladhara etc. should be constructed along the natural slope of the area connecting them to the nearest natural streams to carry the surface water for each of the locality. Due consideration has been given to adapt the drainage system to match with the prevailing climate in Assam.
- As most of the roads inside the town are narrow, underground drainage network are desirable. These roads should not be utilized drain-cum-footpath indiscriminately. Due consideration has been given to provide covered drainage on both side of the wider road. In case of a narrow road a single side can be used to construct covered drainage.
- More manholes and inlet holes are required for the quick disposal of silt and stagnant water. The size of the inlet holes and their positions needed to be re-oriented.
- Degradation of forest both on the bank of the natural *jans* and rivers are to be stopped and works on afforestation are to be encouraged in the region.

Retaining walls on both the sides should be constructed to increase the capacity of the channels.

- The existing drain should be expanded so that water flow is increased. In this context a well integrated master plan for the management of Bhogdoi river and other *Jans* will ensure the stability of progress of life in the region in future.
- In order to protect the area from the backflow of the river Bhogdoi, marginal bund on both banks from Immersionghat to upstream can be provided.
- Unauthorised encroaches are to be evicted from vulnerable points for which strict legislative control will necessary .
- Strict vigilance is necessary for restricting the unauthorized construction.
- Proper legislation for avoiding environmental pollution and disposal of industrial waste is urgently necessary.
- Aerial photographs of greater Jorhat should be taken for proper land use planning.
- Appropriate academic and practical steps as regard water logged areas are to be taken urgently. All these steps need proper investigation, assessment and monitoring on the situation. To lessen the drainage congestion it can be recommended to include a clause in the building bylaws to compulsorily keep of a unit of land for construction of household drainage.

This work can not be claimed to be all pervading and complete in all respects. There is ample scope for future investigation in this field by geographers. However the contribution made through this humble work within a short period might be helped in tackling this age old problem.

.....

WATERLOGGING IN JORHAT TOWN: A GEOGRAPHICAL ANALYSIS

THESIS SUBMITTED IN FULFILLMENT OF THE REQUIRMENT
OF THE DEGREE OF
DOCTOR OF PHILOSOPHY IN GEOGRAPHY

Submitted by
SUBHALAKSHMI RAJKUMARI

Supervisor
PROF. B.S. MIPUN

DEPARTMENT OF GEOGRAPHY
SCHOOL OF HUMAN AND ENVIRONMENTAL SCIENCES
NORTH-EASTERN HILL UNIVERSITY
SHILLONG -793022
DECEMBER, 2009

Geography

NORTH-EASTERN HILL UNIVERSITY

DECEMBER, 2009

I, Smti. Subhalakshmi Rajkumari, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form basis of the award of my previous degree to me or to the best of my knowledge to anybody else, and the thesis has not been submitted by me for any research degree in any other University/Institute.

This is being submitted to North-Eastern Hill University for the degree of Doctor of Philosophy in Geography.

Subhalakshmi Rajkumari

(Subhalakshmi Rajkumari)

(Candidate)

(Prof. A.C. Mohapatra)

(Head)

HEAD
Department of Geography
North-Eastern Hill University
Shillong-793022

(Prof. B.S. Mipun)

(Supervisor)

ACKNOWLEDGEMENT

I take the opportunity to record my deep sense of gratitude to my Supervisor Prof. B.S. Mipun Department of Geography, and Dean, School of Human and Environmental Sciences, NEHU, Shillong for guiding me this research work towards the successful completion of work and manuscript.

I would like to place on records my sincere thanks to Prof. Debendra Kr. Nayak Department of Geography, NEHU for their constant encouragement and support given during the progress of my work.

My acknowledgements are also due to the Librarians of NEHU; Mr Mukul Chetia (Asst. Er, T&CP.Dept.) for extending help in perfecting my work; Dr. Kamala Kanta Gogoi, (HOD, Department of Geography, J.B.College, Jorhat); Dr. Biswajit Sharma, Lecturer, J E C, Jorhat; Dr. Kalyan Borthakur (Dy. Manager, L.S.H.E.P., Geruka Mukh, Lakhimpur) for their cooperation and ungrudging help in completion of the thesis; Alokesh Goswami (Scientific Officer, GIS, Guwahati) for helping me in preparing the maps and diagrams; Arunjyoti and Minku for extending help during data collection in the field.

I extend my tanks to Prof. A.C. Mohapatra, HOD, Department of Geography, NEHU and Dr. S. Sarma, Sr. Cartographer for their valuable support and suggestions during the preparation this manuscript.

During this long and tedious journey to the conclusion of the present study, I have received constant encouragement and affectionate guidance from my mother and by relieving me from my household responsibilities during the progress of my work. She not only accepted the burden but also proved to be an excellent friend and

guidance in my academic pursuit. My father, who silently wished me all success, was a great source of emotional support. Last but not the least I am grateful to my husband for his constant encouragement and help in preparation of this research work.

Dated:

Subhalakshmi Rajkumari

Department of Geography

North Eastern Hill University , Shillong-793022

Subhalakshmi Rajkumari

CONTENTS

List of Tables

13. Growth of Industrial Establishments ,2005
14. Total Numbers of Registered and Non-registered Slow Moving Vehicles in Jorhat (upto March 2007)
15. Decadal Growth of Registered Slow Moving Vehicles, Jorhat
16. Decadal Growth of Fast Moving Newly Registered Vehicles, Jorhat,1997-2007
17. Percentage of Household by Occupied Rooms in Different Slum Locations of Jorhat, 2004
18. Population Projection of Jorhat Master Plan Area, 2004
19. Population Interaction Values Between Jorhat and Its Environs, 2001
20. Population Potential Values Between Jorhat and Its Environs, 2001
21. Breaking Point of the Important Towns Around Jorhat, 2001
22. Newspaper Circulation Pattern in Jorhat and Its Neighbouring Areas, 2005
23. Frequency of Bus Service Between Jorhat and Its Surroundings, 2001
24. Important Retail Centres of Jorhat And Its Surroundings, 2001
25. Area - Altitude Data of Bhogdoi River Basin.
26. Maximum and Minimum Discharge of Bhogdoi River at Assam Trunk Road Crossing Site (1990 – 2005)
27. Water Discharge and Water Level of The Bhogdoi River at Malow ali Site,(1990-2000) .
28. Mean Annual Discharge of the River Bhogdoi, 1977 – 1988
29. Water Level of Bhogdoi at Assam Trunk Road Crossing Site (1985 – 2005)
30. Water Level of River Bhogdoi at Malow ali Site (1985 – 2005)

List of Maps

List of figures

List of Plates Page

CHAPTER I

INTRODUCTION

Urban infrastructure is the basic requirement of urban life and plays a major role in the city structure and its development. Its adequacy and accessibility are also the two important parameters and main contributors in up gradation of quality of urban life, which is the primary objective of the planned development efforts. The associated problems cropped up due to rapid urbanization have generated stresses and strains on the urban infrastructure.

In most of the cities and towns in India, infrastructural planning and maintenance is still a low-key affair and urban sewerage and drainage are the most neglected components. Assam ranks 13th among the states in India in consideration of the size of population and constitutes 2.65 percent of the total population of India. The density of population in Assam is 340 persons per sq. kms (Census of India, 2001). As per 2001 census, the level of urbanization in Assam is 11.1 percent as compared to the all India figure of 25.7 percent. It is a noticeable fact that most of the cities and towns in Assam, urban life extends much beyond the statutory limit of the town which have not been extended or reorganized for more than three decades. In that case considering the standard urban area the percentage of urban population in Assam will be more than the double compared to the present census figure.

The level of urban infrastructure in Assam is extremely poor and is far below the minimum requirement. It is observed that urban services and urban infrastructures are practically non-existent outside the core areas of the towns in Assam. The facilities of efficient drainage system for storm water disposal to improve the water logged areas is one of the most essential services to protect the urban

environment and improving the quality of life in urban areas. Improper management practices and direct disposal of residential, commercial and industrial waters into drain leads to many environmental problems and health hazards to the people living in its adjoining localities. In this research work, issues related to water logging of Jorhat town is taken into consideration.

1.1. **Nature and purpose of the study**

Jorhat is a historically famed ancient town of the North East India. It is situated predominantly on the south bank of the mighty river Brahmaputra. The general topography of the town is mostly flat. River Bhogdoi originates in the Naga Hills on the south, which drains the water of the town.

During the rainy season, both the Brahmaputra and the Bhogdoi swells and flooding the most low-lying areas of the basin land. This creates unprecedented problems for the town. Since long, attempts have been made in a piecemeal to overcome this situation, but with very little success. On the contrary, with the rapid growth of population and settlements resulted expansion of the town area and in turn the problem of accommodating them in the town area has increased.

The urban planners, Jorhat municipality board and other connected organizations were faced with problems of measuring the spatial dimension of this issue and their attempts to realize the problems have not been successful. Therefore it is believed that a geographer might relieve this burden by suggesting an alternative measures to solve this problem. A geographical approach of investigation to this problem is needs of the hour. It is necessary to explore the problems from the points of view of its relief, drainage, soil composition, underground water level, climate and vegetation cover etc. in relation to the urban hydrology and socio-cultural

phenomenon. This will add towards explaining the relationship between ecosystem and human geography to understand the balance in the habitability. It is right on the part of geographers to accept the challenges of solving the colossal drainage problems of Jorhat town. Jorhat is a regional urban centre and is well connected by roads with all the important towns in Assam and with neighbouring states. The Jorhat town also caters like a gateway to Nagaland for all its requirements. In recent years, the town is experiencing a rapid population growth and consequent mushrooming of settlements. Thus, it has overtaken the existing municipal facilities as well the minimum civic amenities that was available.

Like other classical towns in India Jorhat has also negative effects of urban growth like defective road structure, drainage and sewage facilities, lack of open spaces, public utilities etc. The cumulative actions of this unplanned growth of different wings of the city life have jeopardized the habitability of the town. To have a clear idea of the dimension of the problem and the dilemma of the town, it can be stated, "Artificial floods and water loggings have revisited the sprawling city even as the monsoon is receding. Incessant downpours since the last couple of days have inundated all major thoroughfares and localities here, throwing normal life out of gear. The breakdown of the existing drainage system has reflected on the planning process to dispose off storm water by the agencies concerned. The District Administration, Jorhat Development Authority and Jorhat Municipality Board have drawn flak for their abject failure to rein the twin problems despite putting lot of efforts, albeit misdirected." *

The piecemeal remedies to the problem might have eased the problem temporarily, but it created greater problems to other areas. Thus, the inhabitability of

Jorhat, particularly in certain localities has gone to the lowest ebb of city life. The empirical observations and patchwork of the various organizations for improvement did not bear any definite result in the past. The problem then is evidently explicit, that is, drainage and its associate aspects as relevant in Jorhat. A news report of 19th July, 2006 revealed that "after witnessing rain induced flash floods that inundated several localities of the city, Chief Minister Mr. Tarun Gogoi on Monday asked the top officials of the PWD here to prepare a master plan for ameliorating the situation and submit it to the state government and to be approved by August 17. It goes without saying that water logging on following Sunday night's downpour caused great inconveniences to day to day activities of local citizen. **

Another news report of 31st September, 2007 revealed that "Bejijan, a stream of Alengmara, Jorhat was a boon for the villagers. It flows from Patiachala, Jorhat to river Bhogdoi. The stream now is a nuisance to the people and affected more than 10,000 people by this artificial floodwater from the stream. The people have been affected by this artificial flood for the last four months". ***

Above all this study reveals following important facts:

a) The region under study has remained unnoticed in the field of water logging and their impact on human.

b) The region is facing increasing water logging and drainage problems affecting human habitation and economy. The study therefore reveals the nature of such a burning problem and forward suggestions to planners, economists, administrators and other field scientists.

c) Drainage and water logging have been acting as geomorphological as well as geographical problems in this region. Therefore, the study tries to bring out the nature

of water logging, drainage and their relationship with men. The study also brought light to at least some aspects of the process and pattern of drainage development in the town.

d) Human responses to water logging and drainage problem in terms of people's perceptions, behavior and adjustments are also attempted to evaluate.

I.2. Statement of the Problem

Human interference with the natural drainage system, for settlements, laying down roads, railways and canals often cause havoc to the region resulting into water-logging, deterioration of environment and several other problems. The deterioration of town habitat has reached an alarming situation in recent years, given in polarization of metropolitan centres. The converging forces of population, urbanization, technology and environment have come into serious conflict. This is particularly relevant in a crowded environment. It is not necessary to elaborate here about the water logging problem in urban areas of Assam. Right from a layman to a highly educated man living in the urban areas in Assam, especially in Jorhat town has seen the magnitude of the problem.

Jorhat town has been suffering from water logging problem since long back. The existing drains are not sufficient to drain out storm water of the town. Therefore, water logging problem is becoming more and more complex day by day as the town is growing rapidly. Storage capacity of the low-lying areas is decreasing as new constructions are going on by filling up of these low-lying areas. Man may build express high ways into the city and use physical and environmental criteria, such as topography and bearing strength of the surface material into the road planning. By clearing, excavating, filling and paving man creates a new environmental surface, but

natural process continues to operate across this new interface and unexpected repercussion may occur. Local flooding and erosion due to surface water are typical consequences that may require new engineering adjustments, such as placement of new culverts and storm drains. This in turn may trigger additional environmental problems to man, such as sedimentation or change in the water table (Marcus and Detwyler) .****

Jorhat town is served by many natural streams, which are locally known as '*Jans*'. The important point to consider is that the bed level of the main river Bhogdoi of this town is much higher than the bed level of the other natural cum man-made streams. It is difficult to drain out storm water directly to the river Bhogdoi. So it is proposed to drain out the storm water through the *jans* where appropriate gradient is available. The storm water of the area to the outside municipal boundary is drained out mainly through overland flow from the fields to rivulets. Strom water and sewage are normally carried through the surface drains and the natural streams. Rapid industrialization and increase in urban settlements, indiscriminate dumping of garbage and misuse of these natural channels are posed serious threats to their existence of the natural streams, making some areas waterlogged during rainy season. Due to human interference, most areas of the town are facing water logging during rainy season. This problem has become more complex during the last few years, since this garbage dumping is creating huge siltation at Bhogdoi river.

In Jorhat, the river Bhogdoi experiences more flood waves than any other rivers on the south bank of Brahmaputra river. The flood lift of the river is quite small when compared to the other rivers of the south bank in Upper Assam. Since the bed of the river Bhogdoi is very shallow and as a result during rainy season the river crosses

its danger mark within 12 hours of precipitation. Due to shallowness of the river section and low lying adjoining areas, the river has a great tendency to change its course during high flood period. Due to the unprecedented and concentrated rainfall, Jorhat and its suburbs were submerged in May 1977. The situation was further aggravated due to inadequate drainage section of Tocklai and Tarajan channel, which could not drain away the accumulated water. It is also due to the shallowness of the bed of the river Bhogdoi which is becoming higher than the level of the town (map-7). It has also created flood congestion due to backwater flow of the river through the Tocklai channel that caused inundation and water logging in most areas of Jorhat town. Moreover, due to lack of proper drainage system in the Garmur area (near Jorhat Engineering College) causes stagnation and accumulation of water.

Thus, man's interference on natural drainage and its consequences is perhaps nowhere more clearly visible than in Jorhat town. The embankment along the Bhogdoi river has proved to be boon as well as a curse for the town. It is boon in the sense that they protect the urban area from devastating floods but a curse because they do not permit rapid run-off to drain out water, which in turn create water logging in the town. Water logging in the low-lying areas has become a regular feature during the rainy season. To look into the problem of water logging in the town and its real causes are the main aim of this study and then to suggest some corrective measures to tackle this situation.

I.3. Objectives

The following objectives have been formulated to study this problem:

i) To study the topography and slope characteristics in relation to river bed changes;

ii) To study the water logging and drainage system of the town along with urban planning;

iii) To understand the pattern of urban growth as causative factor of water logging.

I.4. Research questions

In order to achieve the above objectives, the following research questions are put:

a) Is unplanned growth of urban area or the topography is the major cause of water logging and flooding in the town of Jorhat?

b) Is disposal of garbage on the *jans* which create clogging and water logging in the township and surrounds?

c) Is growth of settlements along side of the river Bhogdoi and land use change intensifies the problem of the town?

I.5. Data base and Methodology

To have detail information on the effects of water logging and flood etc. extensive field works have been carried out in the study area. The assessment on the impact of water logging has been analyzed from the primary as well as secondary data. The study has been carried out on 19 locations of the town. Altogether 250 households were surveyed. For this purpose, the selection of the area has been made considering their distance from the river, accessibility to drainage, population size etc. The concentration of the different wards and general level of development in drainage network have been taken into account for the selection of data. It is observed that, the central part of the town, which shows more areas of water logging. In each selection, the sample sizes have been taken using the proportional allocation method. Here care has also been taken to include the households of different levels of economic

conditions. For this purpose, a scheduled questionnaire has been prepared covering various aspects relating to demographic, economic and social characteristics of the people. The scheduled questionnaire was first tested in few wards and then recasted to suit the conditions prevailing in the area. While completing the schedule, informal discussions were also held to understand the character of response of the people on the urban induced effects. Further maximum and minimum discharge and gradient level of the river Bhogdoi, cumulative growth studies of waterlogged areas of the town have been prepared. Flood waves of the river Bhogdoi; intensity of rainfall; average variation of rainfall per hour for the monsoon season; mean, standard deviation and co-efficient of variation of rainfall per rainy day for the months of May to September and sequential increase of water-logged area in per square km by using GPS (Global Positioning System) have been taken into consideration.

In this study, the zone of influence of Jorhat twon has been found out after evaluating the theoretical and empirical framework analysis. For the analysis, secondary data collected from various sources have been considered and examined. For this purpose gravity potential model is applied. Besides, population potential values between Jorhat and neighboring urban centers, population projection of Jorhat town, breaking point distance of important towns around Jorhat have been found out. Regional impact on the town has been analyzed by applying empirical approach.

The present study has been carried out on the basis of the following methods: first, relevant literatures pertaining to the subject has been gathered from the books, journals etc. available in various libraries. Second, field investigation have been conducted to get first hand information regarding various features of landforms, characteristics of drains, settlement pattern, transport network etc. The study makes

use of large number of incidental photographs to exhibit some of the significant aspects considered relevant. Third, secondary data regarding the problems have been collected from various sources. The data collected are from records of Brahmaputra Flood Control Department, Jorhat; Town and Country Planning Department; Jorhat Development Authority; Indian Meteorological Department, Guwahati; Jorhat Municipal Board and Census of India. Simple statistical methods are applied to evolve the results wherever necessary. Among the statistical methods mean, standard deviation, co-efficient of variation have been applied to analyse the data.

To find out the average slope, the well-known C.K. Wentworth's method has been applied. In case of rainfall analysis hourly data of seven years (2000-2006) have been collected from the Meteorological Department, Guwahati.

Average hourly variation of rainfall during monsoon period has been calculated by the following formula:

$$R = {}^{r}/n$$

Where, R = Average rainfall per hour

r = of total rainfall of the hour of the month

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

In order to adopt a pragmatic approach, standard deviation and co-efficient of variations of hourly data have been calculated on the basis of the following formula:

1. $$\sigma = \frac{(x - x)^2}{n}$$

Where, σ = Standard Deviation

X = Hourly Rainfall

x = Mean hourly Rainfall.

n = Number of Observation.

2. Cov = σ

Where, Cov = Co-efficient of Variation of mean hourly rainfall

= Standard Deviation

= Mean hourly rainfall.

Besides, to make the study more comprehensive, mapping and cartographic techniques have been applied to analysis data collected both from primary and secondary data.

1.6. 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 link the expertise of geographers, sociologists, economists, traffic engineers, hydrologists, engineers, planners and a host of other experts ask variants of the same question. What is city? How does it function? What are its sustaining mechanisms? What are its implication for human behavior and economic development? Although a long way from resolving such questions, different scholars have tried to provide answers within the framework of logistic, historical and economic, sociological and psychological concepts.[1]

A plenty of works have been done in theoretical as well as applied aspects relating to the present types of works in different parts of the world. The countries like USA, UK, the erstwhile USSR, Japan and China are the advanced countries in this field. They not only prepare theoretical frameworks for studies on the above line but also apply them through practical works in order to enjoy the outcomes. In fluvial

geomorphology, some aspects of hydrology, engineering hydrology, wasteland and watershed management etc. have their general means and ends. At the same time flood proliferation, flood hazards, flood protection, watershed and flood plain management, impacts of floods on human occupancy and human responses to flood etc. are investigated for delineating specific relationship of fluvial geomorphology with men.

In developed countries, these aspects have attained due attention and achievements. The researchers of these countries have their serious enterprises to find out the ways for mitigation or management or natural as well as artificial hazards through bringing the man and nature relationship to light. Studies on impact of flood on human occupancy have now become a field of attraction because such evaluation may help the sustainability of life in the society. Flood events as well as their studies and controls have observed and records in the history of many countries like Egypt, China and Turkey etc. Modern studies on this line based on data are of very recent origin. In the United States of America, such a study had begun only in 1928 with the adoption of a proposal by a congress to expand the flood control measures of the river, Mississippi. In the United Kingdom, the year 1933 opened the door of modern studies on floods after the formulation of a proposal for the study on reservoirs practices by the institution of civil engineers. Today a large number of studies in various fields exist to bring out the dimension and utilization of the natural and man-made hazards oozing out from floods. Along with the physical studies, for the control of floods by engineers, hydrologists and other physical scientists have also tried to investigate the characteristics of floods and their interaction with human society. They also want to examine the environmental impact of flood control and measures adopted

by engineers and hydrologists. The topic on drainage and water logging on a town in particular needs systematic multivariate analysis on its geographical setting; the land slope that control the run-off; the nature of the stream flow and drainage system of the area. There are many physiographic and physical variables that affect the hydrologic and hydraulic aspects of urban storm water run off.[2]

Until recently, little attention was paid to urban drainage research. There exist a serious need for much more extensive investigation, consistent with the huge public expenditure in this field in India in general and North East India in particular. Among many theoretical as well as applied researches are available, the notable works go to the publications of geographical monographs by the University of Chicago under the initiation of White and his fellow students from 1945 onwards. These monographs discuss and analyse at their best levels of all the physical characteristics of floods and with them deep-rooted destructive effects on society. White (1945, 1961, 1964)[3], Murphy (1958), [4] Sheaffer (1960), [5] Kates (1962, 1965)[6], Sewell (1965)[7] etc. are noted researchers in this field. The work of IASH/ UNESCO/ WMO (1969)[8] entitled floods and their computation is also a leading one in the evaluation of physical characteristics of floods. Hydrologist, geomorphologist and environmental scientist like Jervis, (1926)[9], Leopold and Maddock (1954) [10], Hoyt and Longbein (1955) [11,] Dury (1961)[12], Chow (1964)[13], Leopold et. al (1964) [14], Burton et al (1969)[15], Coates (1971)[16], Penning Rousell et.al.(1972),[17] Strahler (1971),[18] Ward (1978)[19] etc. have all contributed valuable works to the chapter of and associated problems in addition to others.

The institute of civil engineers of the United Kingdom (1966) has also contributed a good quality of works to this field. Some of the present day studies are

not only done on the existing state of facts, but they are extended beyond this to embrace the historical perspectives of flood problems. In this case mention may be made of number of path finding works done by Willey (1953)[20], Forbes (1965)[21], Bowen (1966) [22] Lambert and Millard (1969)[23], Biswas (1970)[24] and Smith (1970)[25] etc. Flood analysis through application of a large number of empirical methods on basins characterized by different physical and climatic processes has already been done in plenty by hydrologist and engineers. In this case, applications of unit hydrograph principle and statistical techniques include important methodologies are content analysis for flood estimation, flood routing, and forecasting. Different techniques for the dams and reservoirs are also included here. The leading works in this fields are due to Jarvis (1926)[26], Chow (1956)[27], Walman et al (1957)[28], Schumn and Litchi (1963)[29], Miller (1966)[30], Simons (1969)[31] Dury (1969)[32], Mcpherson (1969)[33] etc.

In India also, contributions have been made in the field of flood hydrology. The contributions of Versney and Lahr, (1974)[34] Raghunath (1982)[35], Ghose (1986)[36], Mutreja (1988)[37] to mention only a few are noteworthy. Many government organizations and institutions are engaging in the investigations and researches about the problems of flood in India. Many educational institutions and universities are also investigating the patterns, processes and problems of floods from hydrological, geographical, geomorphological and ecological point of view.

The topic on drainage and water logging on a town in particular needs systematic multivariate analysis on its geographical setting, the land slope that control the runoff, nature of the stream flow and drainage of the area. Many physiographic and physical variables affect the hydrologic and hydraulic aspects of urban storm

water runoff[38]. 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 and northeast India in particular. In 1851, Mulvaney made some observations of the relations of rainfall and flood discharges in a given catchments by using self registering rain and flood gauges[39].To measure the drainage problems and impending flood, resulting from rainfall in the surrounding catchment area, and peak runoff, there are many empirical and 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, for example, i) It is simple and popular and ii) It is easier to compute.

Das[40] applied this model in his paper. "Storm Drainage and Sewerage Designs in High Rainfall Intensity Urban Areas." and obtained fruitful results. In the meantime, a number of formulations have been evolved to evaluate the drainage problem on the basis of slope of a terrain. There are several methods of average slope determination. Among them, Wentworth's method is a 'general and random' method and is easier to follow. 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 region, this technique does not hold good. Raisz and Henry had tried to apply other methods to eliminate the defects of Smith's method. In 1948, Robbinson devised another method which quantitatively accurate relief map could make showing slope variation. In the recent past Dhurandher[41] had made a more rational approach to this method of determining slope of land surfaces and attempted modifications by replacing one of the most powerful components (average of the contour crossing per mile).

Drainage system has a direct bearing on the urban land use pattern. While evaluating the drainage structure quantitatively, it is imperative to keep a close eye on the existing and potential land use in the urban centres. Dey perhaps was a pioneer in evolving a methodology for land use planning and engineering alternatives for flood plain management. But his attempt was introduced for specific purpose, viz , land use planning and development activities for optimum allocation of land for residential, commercial and open spaces. A methodology on land use zoning was presented by Rivera (1973). The applicability of this proposed methodology appears to be restricted to upland watershed with predominant agricultural activity. Similarly, 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 cognizance of the presence of complex systems of detention and storage, reservoirs, water and sewage distribution systems, channels, modifications, levees, land use controls, flood proofing and pumping facilities.

Jens and McPherson, co-author of a paper on "Quantitative Determination of Urban Storm Runoff" discussed empirical models critically. According to them, the engineers of late 19^{th} century developed empirical formula to determine design discharge for storm drains through a general model. It was $Q= CAI (S/A),^{x}$ where Q is the peak discharge in cfs, C is the runoff of co-efficient 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, example, in the famous Burkli – Ziegler Model, X= 0.25, in the Mc. Math formula, X= 0.5. The 'C' value of both the model varies from 0.20 in pervious

rural areas to 0.75 in highly impervious build up areas. About 100 empirical models have been collected by Chow[42], in order to find out a workable model for determining the runoff. On the other hand, the critical review on the rational method, currently used by many design engineers[43], usually expressed (* cfs-cubic feet per second) in terms of the following equations:

Q=CIA, Where Q is the peak discharge in cfs. 'C' is the runoff co-efficient depending on the flow characteristics of the drainage area, I is the uniform rate of 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[44] in 1932 and developed a general rational formula. They took into account some factors like watershed, shape and slope, the pattern of the streams system and the elements of channel flow. Bernard[45] further modified the runoff co-efficient 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 formula of Kuichling[46] has been in use till the present day. Now a day the society become urbanized and city's impact on its surrounding areas are undoubtedly of great significance. The socio-economic relationship in terms of space (physiography, location etc) between towns and their surrounding areas are vital aspects of the spatial organization 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. Huson[47] also dealt with the pattern of the Chicago Metropolitan city and two problems were found out. The first problem that the city faces is that it has no adequate drainage as the city expanded across the

bed of the old Chicago Lake in 19th century. Another problem is the lack of a river outlet to the west.

Most cities in developing countries use to discharge 80 to 90 percent of their untreated sewage directly into river and stream, which are used for drinking, bathing and washing. In recent years lack of sewage treatment has allowed dangerous microorganisms to spread as in South America, where the cholera, bacterium threatens drinking water and food supplies. Today impoverished people in developing countries still face catastrophic losses of life due to dirty water[48]. Growth problems of the cities were dealt with by many geographers along with human settlement and geography, these were limited mainly to the study of urban settlement as isolated units with little concern for physiographic region. Richthofen and Hettner extended their works in the field of settlement geography[49]. Schluter developed the methods of studying the internal pattern and layout of cities in 1899[50]. Following the works of Hassert[51] subsequent works did much to define the scope and methodology of urban geography in Germany. Subsequently many studies of European cities have been coming up. Contribution of Geddes whose formulations of principles of urban growth and structures were popularized in Britain, were brought to the attention of the students of urbanism in the United States by Mumford[52]. They emphasized on the problem of cities, growing out of rapid urbanization, but given less emphasize on city's impact on surroundings. Later, Blanchard recognized the "city region" study as one of the basic themes of urban settlement through his work on Annecy, Quibec and Montreal[53].

Further, Sorre has given some attention to the study of urban functions, morphology, and physical structure of population and studied the impact of the urban

centre on its surroundings[54]. Dickinson elaborates (his paper "The scope and states of Urban Geography – an assessment") on the geographic approach to the study of a specific urban settlement. He stated that the task of geographers 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 to a better understanding of the location, spacing and size of the cities and their layout and builds. Prior to this work he published, "City region and regionalism"[55] and "City and Region"[56], which can be summarized as - every urban centre has close relations with the group of villages and cities which surrounds it. The entire area therefore represents a geographical association of human space relationships and by virtue of his centralized activity acquires a short of homogeneous character. The natural area which has a certain amount of homogeneity in socio economic activities, cultural intercourse and human development and space relationships may be called a "region". An urban centre with the group of cities 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. Ricardo (1817)[57] was developing Thunnen's formula which he formulated in a 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 also all spatial economic systems. "Central Place Theory" developed by the German geographer Christeller[58]

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. However, this theory is not applicable to manufacturing other specialized activity[59]. The Gravity and Potential Models based on Newtonian law of physics was borrowed by Revenstein (1885, 1889)[60], Stewart (1942)[61] and Zipf (1949)[62] etc. They worked out mathematical rules pertaining the distribution and support of population with a slight modification of 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.[63].Though the model had been used primarily, for descriptive purposes, it could be used also for perspective purposes[64] as this sometimes, appeared as a disturbing factors to the geographers.[65]

A series of studies were carried by the Indian Geographers on different towns and cities. They were Singh R.L. (on Banaras), Alam S.M. (on Hyderabad and Secunderabad), Janaki V.A. and Sayed Z.A. (on Padra town). Kar N.R. (on Kolkata), Agarwala A.N. (on Kanpur), Dikshit K.R. (on Poona), Nangia S. (on Delhi), Deshpande C.D, Arunachalam B and Bhat L.S. (on South Kolaba, Maharastra), Banu Zubeida (on Chennai), Tripathi Rajmohan (on Allahabad), Singh R.C. and Srivastava Ajay (on Bhillai), Mohan (Arawalli Region), Sangwan (on Rohtak); Singh S.B, Gupta, Lamichhane (on Gorakhpur), Mahesh (on Mysore).

The problem of delimitation of the rural urban fringe and characteristics of such area has been studied in the Indian context (Banaras) [66]. Alam[67] seems to be correctly differentiating two sets of indices for delineating the hinterland. (1) Which reflect the impact? and (2) Which represent the central function?

In defining the boundary, Janaki and Sayed[68] have taken into account the flow of exact amounts 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[69] also dealt with the economic relationship of Kolkata with its neighboring areas based on business activities such as collection of raw materials and supply of finished products. Apart from the identification of interflows of goods (consumer goods, capital goods etc) Agarwala[70] gave little idea about the spatial pattern of interflow between Kanpur and its hinterland. Dikshit and Sawant[71] studied city hinterland relationship of Poona. The unit of observation used by them was so small that they seemed to give some erroneous results.

Nangia[72] studied a single city region, Delhi. In her study, the distance was the main factor of growth and included density of population, percentage of workers engaged in tertiary activities that shows inverse relationship with distance. Deshpande and others[73] studied the impact of a metropolitan city on its surrounding region, which enlightened and encouraged the Indian geographer to study the virgin cities of India with the same methodology. The findings of the study serve to sieve out the strategy for development appreciate to the local conditions. Further, the methodology adopted for the study could be used to geographers, social scientists, planners and administrators.

Environmental degradation in urban context occurs when there is an imbalance in the urban ecosystem in the process they disrupt, obliterate and foul them. Keeping this on backdrop, Banu[74] in her paper attempted to bring out the different factors responsible for environmental degradation in turn having an impact on human health, particularly, lack of sufficient drinking water supply, inadequate

drainage and sewage, improper solid waste management etc. According to her, almost four million people in Chennai did not have any sanitary facilities and about 15 percent of the people of Chennai were not connected to the sewage system. Tripathi[75] collected primary data from ten localities and randomly selected four hundred households for delineating the allied urbanized problems in Allahabad city. He used computer-based techniques to analyse and process the problems. In his paper, efforts had been made to study the existing drainage pattern in Allahabad city. Embankments protecting the city and railway line have obstructed natural drainage resulting into perennial problem of water logging in the eastern part of the city, especially in the low-lying areas of Allahabad city like Allahpur, Tagore town etc. Singh and Srivastava[76] studied city drainage relationships in the industrial complex of Bhillai and proved that the city is free from the complexity of drainage due to the influence of two rivers, namely Sheonah and Kharun, which flows from west to east. Mohan[77] tried to find out the reasons for frequent water logging in the northern flank of Arawallies, and came into conclusion that the quarrying activities have a major impact on drainage of this region for which water stagnation and hydrological imbalances of the ground water and rain water take place resulting into the whole area water logged. In 1995, the devastating flood experienced by the populous city Rohtak was also of riverine type. The causal factors responsible for such an unprecedented flood were enquired by Sangwan[78]. The reasons of the flood were the lack of proper drainage system as well as defective and poor drainage system including inadequate sewage system. In Gorakhpur city, the urban environmental problems like drainage etc. were studied by Singh and others[79]. The bowl like surface shape of the city is the

main reason for the city's serious problems of drainage and sewage disposal. Another main feature that can be seen here and there is the waterlogged surfaces.

In his article, "Air and water pollution in Mysore City", Mohan[80] studied the relationship between the inhabitants and various industries in the city. In conclusion he found that the drainage of electro-plating waste of an automobile factory near Mysore city was responsible for severe metal pollution. Taking Remote Sensing and Geographical Information System techniques are powerful tools for watershed management programme Biswas and others[81] studied different watersheds. Drainage was analyzed quantitatively, they revealed that low value of bifurcation ratio, and very low values of drainage density indicate that the drainage has not been affected by structural disturbances.

Besides, contributions have been made in the field of flood hydrology. The contribution of Versney and Lahr (1974)[82], Raghunath (1982)[83], Ghose (1986)[84] and Mutreja (1988)[85] to mention only a few are noteworthy. Many government organizations and institutions are engaging in the investigations and researches about the problems of floods in India. Many educational institutions and universities are also investigating the pattern, processes and problems of floods from hydrological, geographical, geomorphological and ecological point of view.

Works on floods in India by hydrologist are many in comparison to the works on the human interaction with flood by geographers and other field scientists. Works on the human adjustment to floods, human perception and responses to floods, impact of floods on land use and agriculture, damages of crops and properties, etc. are found within a limited number. Studies on floods with historical perspectives are also done in some quarters. Reputed works on this field are of Biswas and some others[86].

Studies on flood control, watershed management and drainage engineering are developing in India. Uses of aerial photographs and satellite imagery, computer software's towards assessments, monitoring and mitigation have now attracted various researchers of Indian Universities and investigation. Iyer,[87] in his study revealed that in India making embankments for controlling floods in turn may lead to drainage and water logging problem or man made flood by blocking drainage from the adjoining areas into the river, while rebuilding and fail in the event of major flood. The situation relating to Kerala's rivers are attended by a multiple problems in discharges of industrial effluents, tendency to dump garbage from slaughter houses and to discharge sewage etc. deteriorate the condition of drainage. Besides, the siltation at the mouth of the river causes navigation bottlenecks, flooding and damage to the environment. Next to it, canalization is virtually killing the rivers of Kerala and affects its water flow. These works on the rivers of Kerala was completed by Ramakrishnan.[88] In Raipur, the year 1994 was the worst year of flood. The cause of the flood was studied by Gupta[89] and he found that excess and high intensity of rainfall was the main cause of the flood. Yet, other reasons of the floods were deforestation, human settlements and low-lying areas. According to him, civic bodies and administration should check the development of slums in low-lying areas in Raipur. Munsi[90] studied the flood management in India. His opinion was that the most agreed indigenous management of flood control is non-interference in the normal drainage behavior of a stream and regulations of flood through the use of natural reservoirs.

In Assam, only a very few works have been done so far in respect of floods and their associated problems. In this context works of Borthakur, (1968)[91] Goswami

(1972)[92], Borthakur (1988)[93], Bora (1990)[94], Kar (1995)[95], may be mentioned. The studies related to impact of floods on man and human perspectives and responses to floods are getting to take a turn in this part of India. Fluviogeomorphological and other studies were however conducted by Sharma and Basumallik, (1984)[96], Taher (1988)[97], Goswami (1990) [98] etc.

It is high time we realized that the western path of industrialization, urbanization and modernization is not the best path of Indian situation. At the same time, we must clearly recognize the essential role of urbanization in the process of urban growth and social change. Bose[99] warned that ever since the partition of India and tremendous influx of refugees to all the border states of India, squatting on government land 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 areas, which pollute the urban environment. The spatial extent of impact should be studied not only according to size of the urban centers but from variable to variable as studied by Sharma[100] in his doctoral thesis "Elements of Urban Impacts on Rural Society in India". He attempted to explain 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. Borah[101] carried out a study of Guwahati 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, Sharma[102] emphasized in his study, 'Drainage and Urban Environment' taking relief, rainfall and nature of river inside the city as the major parameter. He suggested some remedial measure to

improve the situation in the city. Jorhat municipality board and Development Authority had been trying to tackle and solve the problems of greater Jorhat. Town and Country Planning of Assam have been working in co-ordination 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 re-sectioning, degrading, constructing sluice gates, wherever necessary and diverting the stream flows to relieve the urban areas from flood.

Environmental pollution is not only associated with industrial growth but also with the pressure of population on scarce natural resources. Urbanization 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 Mishra.[103]. With this background work, it is attempted to give a full appraisal, of the water logging problem of this town in Assam. Literature, facts and information lie haphazardly in various departments. The available information is in piecemeal. Through this 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 and instruction is felt to be indispensable and useful.

References

* News report under the caption "Faulty Drainage System Causes Flash Floods in Jorhat" published in the Assam Tribune 7th September, 2007.

** A news report under the caption "Water logging", publish in Assam Tribune, July 19th, 2006.

*** A news report under the caption, "10,000 hit by the Floods at Alengmara," published in Assam Tribune on 21st Sept, 2007.

**** Marcus, M. G. and Detwyler, T. R. "Urbanization and Environment in Perspective Urbanization and Environment", The Physical Geography of the City, p.7 .

1. Robson, B.T. 1969: "*Urban Analysis, A study of City structure with special reference to Sunderland*", Cambridge (University Press). London, p.3-35.
2. Zen, S.W. and Mcpherson: "Quantitative Determination of Urban Storm water runoff" (Eds) (V.T. Chow, - *Hand book of applied Hydrology*) .
3. White, G.F. 1945: "Human Adjustment on Flood Problems", University of Chicago, Deptt. of Geography. Res. Paper 30.
4. Murphy, P.C. 1958: "Regulating Flood plain Development." University of Chicago, Deptt. of Geography, Res. Paper No.56.
5. Shefer, J.R. 1960: "Flood Proofing Element in a Flood Damage Reduction Programme", University of Chicago. Deptt. of Geog. Res. paper – 65 .
6. Kates, 1962: "Hazard and Choice perception in Flood Plain Management" Univ. Chicago, Deptt. Geog. Res. Paper 78.
7. Sewell, W.R.D. 1969: "Human Response to Flood in Chorley" R.J. (ed) *Introduction to Geographical Hydrology*, Methuen and co. Ltd. London.
8. *"IASH/ UNESCO/ WMO (1969) Floods and their computation"*, vols 2, pros of Leningrad de Symposium, August, 1967.
9. Jervis, C .S. 1926: *"Flood Flow Characteristics"*, Trans. Amr. Soc. civ. Engrs. 89. pp. 985 – 103.
10. Leopold, L.B. and Maddock T. 1954: *"The Flood Control Controversy"*, Ronald Press Newyork.
11. Hoyt, W.A. and. Langbein, W.B. 1995: "Floods" Ronald Press, New York.
12. Dury,G.H.1961: *"Bankful Discharges, An Example of Statistical relationships"* Int. Assoc. Sci Hydrol 6th year U.S. Geol, Ser V.3 pp. 48-55.
13. Chow, V.T. 1969: "*Handbook of Applied Hydrology"*, Mc. Grow Hill, New York.
14. Leopold, L.B. et. al 1964: *"Fluvial processes in Geomorphology"*, Eurasia Publishing House (pvt) Ltd. New York.
15. Burton, I. et al 1969: "Flood. Damage Reduction in Canada," in Nelson J.G. and. Chambers M.J (eds), *"Water"* Methuen, Toronto. pp. 77-108.
16. Coats, D.R. 1971: *"Environmental Geomorphology and Landscape Conservation,"*vols, I, II and III. and Ross. Inc. Stroudsburg, Pennsylvania.
17. Pennig, R.F.C. and Underwood, L. 1972: "Flood Hazard and Floodplain Management Survey of Existing Studied", Middlesen. Polytechnic Flood. Hazard. Res. Project. Progress report. 2.
18. Strahler, A.N. 1971: *"Physical Geogrophy"*, Wiley, Eastern Pvt. New Delhi, pp. 415 – 500.
19. Ward, R.C. 1978: "Flood – A Geographical perspective", Mc. Millan, London, Institute of civil engineers, 1966. *"River Flood Hydrdogy"* ICE. London.
20. Willey, G.R. 1953: "Classification and use of Irrigation Waters" U.S. Deptt. *"Agriculture"*, Circular No. 969.
21. Forbes, R.J. 1965: *"Irrigation and power studies in ancient technology"*. vol 2. Laiden.

22. Bowen, A.J and. Inman, D.L. 1966: "Budget of point Argnello", California, CERC. Tech. Memo 19.
23. Lambart, W.G. and Milland, A.R. 1969: "*Atrahasis the Babylonian story of the Flood*", Oxford University Press, London.
24. Biswas, A.K. 1970: "*History of Hydrology*", North Holland, Amstardam, London.
25. Smith, K. 1972: " *Water in Britain*", Mcmillan London.
26. Jarvis, C.S.1926: "*Flood Flow Characteristics*" ,Trans Amr. Soc. Civ. Engrs.89 pp 985-1032.
27. Chow, V.T. 1956: "*Hydrologic Studies of flood*", the U.S. International Assoc of Science. Publications 42. pp. 134-170.
28. Walman, M.G. and Leopold L.B 1955: "*River Floodplain. Some Observations of Their Formations*".
29. Schumn, S.A. and Litchi, R.W 1963: "Channel Widening and Floodplain Construction along Cimmeron River in Kansas." U.S. Geol, Sur prof. paper 352-3 pp – 71-88.
30. Millar, D.H. 1966: "*Cultural Hydrology, A Review Economic Geog.*" pp. 82-89.
31. Simons, D.B. 1969: "Open Channel Flow in Chorley", R.J. (ed). "*Introduction to Fluvial processes*", Methuen, pp 124-127.
32. Dury, G.H. 1969: "Perspective on Geomorphic Processes" ,Assoc. Amer. Geographical Resource paper – 3.
33. Mc. Phersoon, H. J. 1969: "Flow Channel and Flood plain characteristics of the Lower Red Dun River", Alberta Nelson and Chambers (ed). *Geomorphology*. pp. 257-279.
34. Verseney, R.S. and Lahr M. (1974): "*Engineering Hydrology*". New Chand and Bros. Roorkee, U.P. India.
35. Raghunath, H.M 1992: "*Groundwater*", Wiley Eastern Limited, New Delhi.
36. Ghosh, S.N. 1986: "*Flood Control and Drainage Engineering*". Oxford and IBH. Publishing Company Ltd, New Delhi.
37. Mutreja, K.N. 1988: "*Applied Hydrology*", Tata Magrow.Hill publishing Company Ltd. New Delhi.
38. Jen, S.W. and McPherson, M.O: "Quantitative Determination of urban strorm water runoff." eds, (V.T. Chow – *Handbook of Applied Hydrology*) .
39. Chow, V.T. 1962: "*Hydrologic Determination and Water way areas for the design of Drainage Structures in Small Drainage Basin.*" University of Illinois, Eng. Expt Sta. Bull. P-462.
40. Das, B.K 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.
41. Dhurandher, K.P 1981: "A model Rational Approach to the Determination of Slope of Land Surfaces" Abstract, NAGI, second annual conference.
42. 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. p-462 .

43. "Design and Construction of Sanitary and Storm Sewers", American Society of Civil Engineering Practice, No 37 or Water Pollution Control Federation Manual of Practice, No 9, 1960.
44. Greggory, R. L. and Arnold, C.E 1992: "*Runoff – Rational Runoff Formulas*", Trans. Am. Soc. Civil Engineers. vol. 96 pp. 1038 – 1099.
45. Bernard, M. 1938: "Modified Rational Method of Estimating Flood Flows", Appendix A, in law dams, National Resource Committee, Washington.
46. Kuichling, E. 1889: "*The Relation between the Rainfall and Discharge of Sewers in Populous Districts*", Trans. Am. Soc. Civil Eng. vol.20, pp. 1 – 56.
47. Huson, J. C. 2001: "Chicago pattern of the Metropolis", Journal of Geography P.110.
48. Tibbetts, J. 2000: "Water World 2000", Environmental health journal of the National Institute of Environment, P-69.
49. Dickinson, R.E. 1969: "*The Makers of Modern Geography*", Routledge and Kegan Paul Ltd. London. PP. 78-80, 116-118.
50. Mayer, H.M, 1954: "*Urban Geography*", ed, Preston. E. James Clarence F.Jones, American Geography. Inventory and Prospects. Syracuse univ. Press. P.144.
51. Ibid.
52. Idem.
53. Dickinson, R.E, op, cit. pp. 234 – 36 .
54. Ibid, p.238.
55. Dickenson, R.E 1960: "*City Region and Regionalism - A Geographical Contribution to Human Ecology*", Routledge and Kegan Paul Ltd. London.
56. Dickinson, R.E. 1964: "*City and Region, A geographical interpretation*", Routledge and Kegan Paul Ltd, London.
57. Thoman, S. R. and Peter, B.C. 1974: "*The Geography of Economic Activity*", Mc Grow Hill Book Company London, pp. 183-84.
58. Christeller, W. 1966: "*Central Place in Southern Germany,* "(Translated from *Die Zentralen Orte* in Suddentschland, Englewood, Cliffs, Prentice Hall Inc. New Jersy.
59. Truman, A. H. and Alexander, J. W. 1988: "*Economic Geography*", Prentice Hall of India Private Ltd. New Delhi p. 278.
60. Ravenstein, E.G. 1885-1889: "The Laws of Migration". Journal of Royal Statistical Society, vol.48. pp. 167-235 and vol. 52. pp.493 - 96.
61. Strewart, J.Q. 1942: "*A measure of the influence of population at Distance.*" Sociometry, vol 5. pp. 63-71.
62. Zipf, G.K. 1949: "*Human Behaviour and Principle of Least Effort*", Addison Wesley Cambridge.
63. Merril, R.L. and Erickson, R. 1969: "Problems of Modeling Interaction", in K. Cox and R. Gollege (eds), "*Behavioral Problems in Geography*". North western University Press, Eranston.
64. Merril, R.L and Kelley, M.B.1973: "*The Simulation of Hospital use and the Estimation of Location Efficiency*", Geog. Anal. vol.2 pp. 283-300.
65. Yeates, M. 1974: "*An Introduction to Quantitative analysis in Human Geography*", Mc. Grow Hill. Book Company. New York. p. 131.

66. Singh, R.L, 1955: *"Banaras - A Study in Urban Geography"*, Nand Kishore and Bros. Banaras.
67. Alam, S. M.1965: *"Hydrabad – Secunderabad (Twin cities) A study in Urban Geography"*, Asia Publications Private Ltd, Bombay.
68. Janaki, V. A. and Sayed, Z.A, 1962: *"The Geography of Padra City"*, Baroda Univ. Press, Boroda.
69. Kar, N.R. 1963: "Economic Character of Metropolitan Sphere of Influence of Calcutta", Geographical Review of India, June. pp.108-137.
70. Agarwala, A.N. 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.
71. Dikshit, K.R and Sewant,S.B.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.
72. Nangia, S. 1976: *"Delhi Metropolitan Region, A study in settlement Geography"*, K.B. Publications, New Delhi.
73. Deshpande, C.D. et.al. 1980: "Impact of a Metropolitan City on the Surrounding Region - A study of South Kolaba, Maharastra", Concept publishing company, New Delhi.
74. Banu, Z. 1999: "Environmental Degradation and its Impact on Human Health", A study of Chennai, Journal of Dravidic Studies p. 57.
75. Tripathi, R. M. 1999: "Spatial Characteristics of Drainage Pattern in Allahabad City", National Geographer, p. 59.
76. Singh, R.C. and Sriwastava, A. 1995: "Land use Management and Urban Planning in Bhillai, an Industrial complex", Geographical Review of India. pp. – 195-201.
77. Mohan, M. 1998: "Quarrying Activities on the Northern Flank of the Arawallies" the Indian Geographical journal, pp 130-136.
78. Singh, R.S. 1999: "Flood Hazards in Rohtak City", Transactions Institute of Indian Geographers. P. 65.
79. Singh, S.B and others,1998: "Urban Environmental problems and planning", National Geographer, p.28.
80. Mohan, T. M. 1998: "Air and Water Pollution in Myshore City", National Geographer, p.45.
81. Biswas, S and others, 1999: "Morphometric Analysis of Drainage Basin. A Remote Sensing and G.I .S. Approach", Journal of Indian Society of Remote Sensing.
82. Verseny, R.S. and Lahr, M. 1974: *"Engineering Hydrology"*, New Chand and Brothers, Poorke, U.P, India.
83. Raghunath, H.M. 1992: "Groundwater", Wiley Eastern Ltd, New Delhi.
84. Ghosh, S.N. 1986: *"Flood Control and Drainage Engineering"*, Oxford and IBH Publishing Co. Pvt.Ltd, New Delhi.
85. Mutreja, K.N. 1988: *"Applied Hydrodogy"*, Tata Mc.GrowHill publishing, Company Ltd, New Delhi.
86. Biswas, S and others, 1999,op.cit.
87. Ramswamy, R.I. 2001: "Water–Charting a Curse for the Future" Economic and political Weekly, p. 1115.

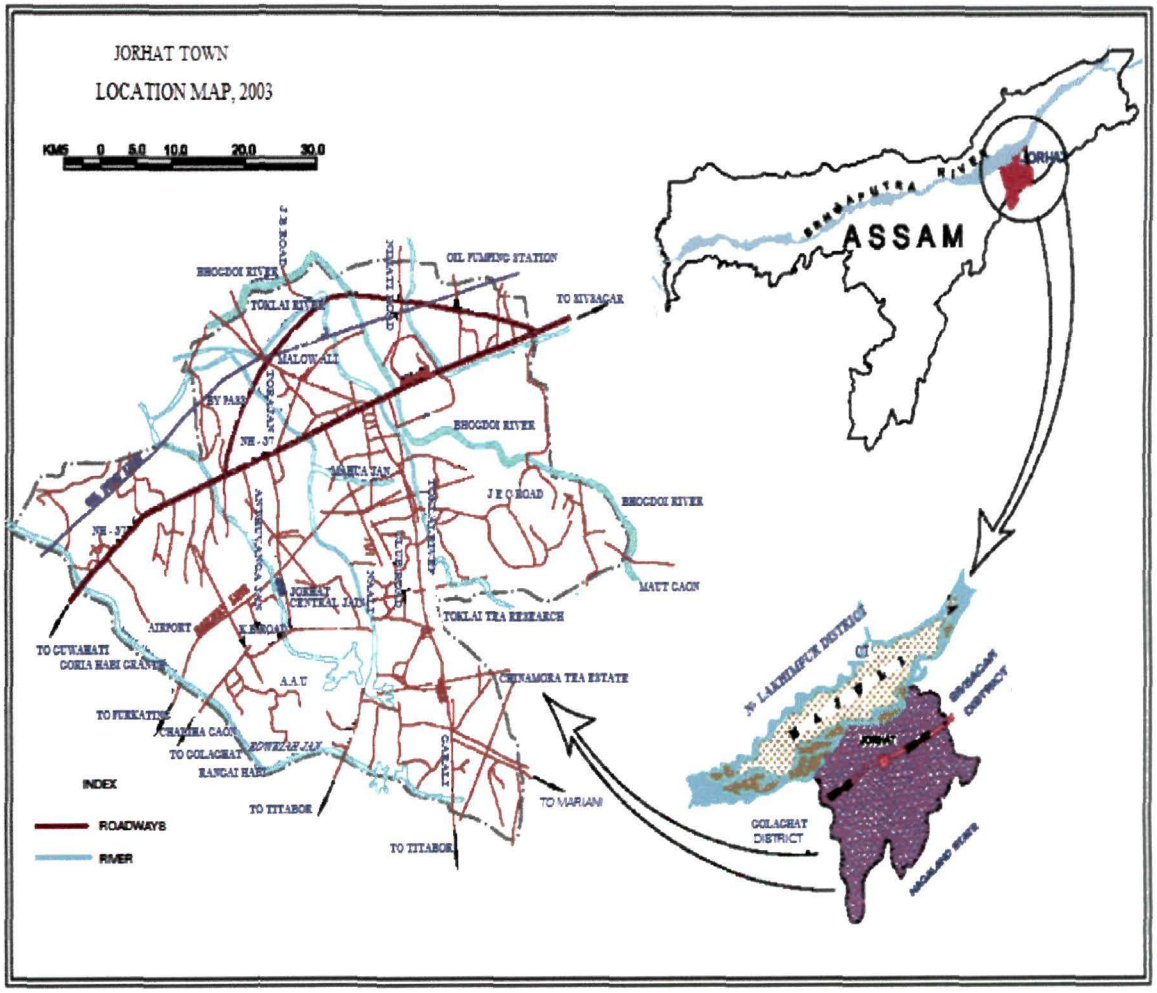
88. Ramakrishnan, K. 2000: "State of the Environment in Kerala." Economic and political Weekly, p. 1801.
89. Gupta, M.P. and Sharma, S. 1998: *"Flood Situation in Raipur District, Madhya Pradesh"*, India, p.1.
90. Munsi, S. K. 1998: "Problems of Flood Management in India, Policies and Programmes", Geographical Review of India. P.239.
91. Borthakur, 1968: "Drainage and flood in Upper Assam", Proc. Precongress Symposium and Field Study, etc. 21st International Geog. Congress, India, held in the deptt. of Geog, G.U.
92. Goswami, A.C. 1972: "Regional Flood Frequency. Analysis of Brahmaputra Basin in N.E. India", Jr. of Institute of Engineers. India. vol. 77.
93. Borthakur, D.N. 1988: "Flood Control and Agricultural production". Key Note Address in the seminar on Flood Protection for Dibrugarh and Sub-urbs organized by Dib. Univ.
94. Bora, A.K. 1990: "Jia Bharali River of Assam. A study in Fluvial Geomorphology", an unpublished Ph.D. Thesis, Gau. Univ.
95. Kar, M. 1995: "Flood Hazard in Nagaon and Marigaon District, of Assam, A Geomorphological perspective" – An unpublished Ph. D thesis G.U.
96. Sarma, J.N. and Basumallik, S. 1984: "Bankline Migration of the Burhi Dihing River, Assam". Ind. Jr. Earth Science vol. II Nos. 3 and 4. pp 199-206.
97. Taher, M. 1988: "The population in Assam", North Eastern Geographer, G.U. vol. 19. Nos. 1 and 2 pp. 1-16.
98. Goswami, D.C. 1990: "Impact of the Pagladia River (Assam) on Human occupancies in its Lower Basin". An unpublished M. Phil Dissertation G.U.
99. Bose, A. 1978: "India's Urbanization (1901-2000)", Tata McGraw Hill publishing Co. Ltd. New Delhi.
100. Sharma, H.N. 1975: "Elements of Urban Impacts on Rural Society in India - A Spatial Analysis".PhD Dissertation, Unpublished.Syracuse University.New York.
101. Borah, J. 1985: "Spatial structure of Urban Influence in the Neighboring Areas of Guwahati City", Inter India Publications, New Delhi.
102. Sharma, H.N. 1985: "Drainage and Urban Development: Case Study of the Greater Gauhati Region", Hill Geographer, Vol.IV.No.2, pp.37-44.
103. Mishra, T.K. 1982: "Studies on some water pollutants'', unpublished PhD. thesis, Visva Bharati, Shanti Niketan.

CHAPTER II

Geographical Setting of the Region

Jorhat town is located at $26^0$46' North latitude and $94^0$12' East longitude and is situated on national highway 37 at a distance of 316 km from Dispur, Guwahati, and the state capital of Assam (map-1). The study area is about 7257.65 hectares out of which the developed area is 2313.16 hectares, forming about 31.9 percent of the total area. Municipal area covers an area of 504.85 hectares which forms about 7 percent of the total area.

Map-1.



Source:Master Plan Zoning Regulation Book,T and CP,Jorhat

The town Jorhat is the district head quarter of Jorhat district. The district comprises of three sub-divisions viz., Jorhat, Titabor and Majuli lying between $93^0$12' east to $94^0$36' east longitude and $25^0$49' 30" north to $27^0$12' north latitude. The district occupies an area of 6,400 sq. kms.

Jorhat town is bordered by south bank of the Bhogdoi river, northern village boundary of Sarbaibandha village, western village boundary of Bohatia gaon, a portion of northern bank of Anthubhangajan, northern village boundary of Bhatemara and Parbotia gaon, Dulia gaon, Chengeli gaon and a part of Bamun gaon no – 1 on the north.

Rowriahjan and southern village boundary of Katoni gaon, a part of Cinnamara grant, southern boundary of Tocklai tea estate and Dulia pam on the south.

Eastern village boundary of Bamungaon no–2 and south bank of the Bhogdoi river on the east and Rowriahjan in the west. Ninety-six kilometers east of Kaziranga national park and south of Majuli island – the biggest river island in the world and denoted a world heritage site, Jorhat has many other places of tourist interest as well in and around its vicinity. Gibbon wildlife sanctuary, south of Jorhat and Nambar forest with its sulphur springs 60 kms away are places of eco-tourism. Sibsagar town with its historical relics and monuments is 53 kms away on the national highway 37 towards east of Jorhat.

Major towns near Jorhat are Nazira (Oil and Natural Gas Commission, eastern head quarters), Moran (Oil India Installation), Titabor (highest rice production) and Dibrugarh. Numaligarh refinery is 53 kms southwest of the town of Jorhat.

II.1. **Physical Settings**

Physiographical framework of a particular place has immense influence on nature and characteristics of drainage. Factors of physical environment like physiography, climate, soil, drainage pattern etc play a vital role, especially on the growth of settlements as well as urban infrastructures. In this context, a back knowledge of physical setting of an area is imperative.

Physiography

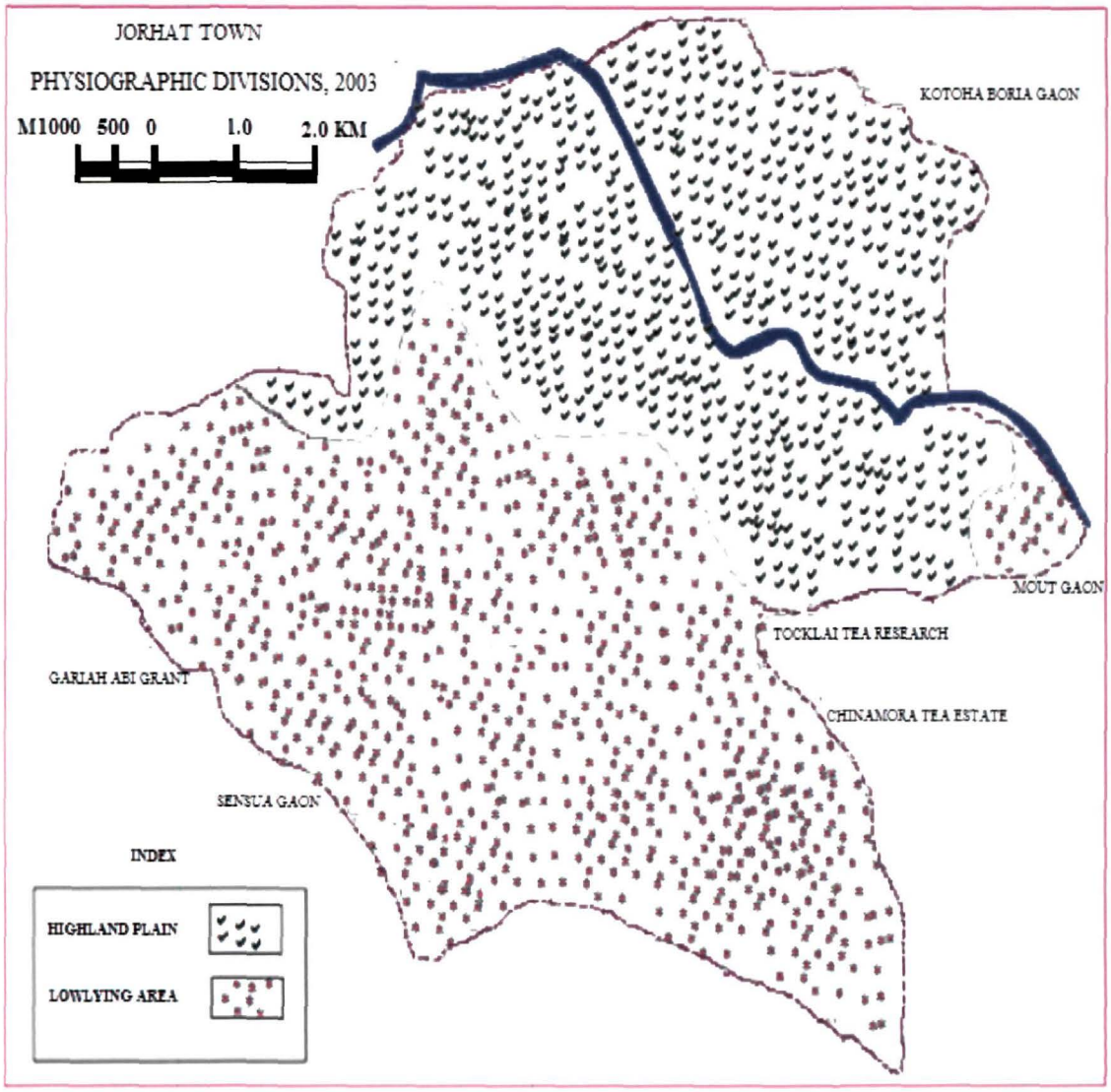
Jorhat is situated on the south bank of the river Brahmaputra that flows east to west about 8 kms north of the town. Except this, there is no physical barrier for expansion of the town. The tea gardens and paddy fields form the present landscape.

The area as a whole is considered as plains representing a part of the upper Brahmaputra valley, the land surface being slopping gradually from southeast to northwest up to the south bank of Brahmaputra. It is situated on a flat plain at 26^0 46 / east and is 234 feet (72 meters) above the mean sea level. The elevation of the southeastern part is about 99 metres above mean sea level on the average and that of the bank of the river Brahmaputra in the northwest is only 82 metres. But, the topographic variation along the southeast northwest direction is almost insignificant. Geomorphologically the area is an aggdational plain, built up by the depositional works of the Brahmaputra and its tributaries. The study area comprises patches of plains and *char* (shoal) lands formed by the braided river Brahmaputra.

Geologically, it is built by the deposition of alluvium upon sag formed during the period of the rise of Himalayas. River Bhogdoi is winding its courses through the plain dissecting from the north to south. Most of the streams and the rivers of the region have had its origin in the Naga hills, the branches of Himalaya and

they have been flowing in almost north south direction. But before finding their ways into the Brahmaputra they run in parallel courses to the main stream and encounter its levees leading to formation of good numbers of *beels* (depressions) and huge marshy tracks as a result of their conspicuous meandering courses. The area comprises of built up active flood plain and *chars* (shoals) lands formed by the raided river Brahmaputra. Physiographically the region may be divided into two distinct physiographic zones running sub parallel to the Brahmaputra river (map -2).

Map-2



Source:Master Plan Zoning Regulation Book, T and C P, Jorhat

(a) Low-lying areas in the north (active flood plain)

(b) High land Plain

(a) Low-lying areas in the north:

Along the course of the Brahmaputra, Jorhat is bounded by a long stretches of depressed areas, ranging in width, roughly 5 kms. in the eastern part to 12 kms in the west covered with several '*Beel*'s and swamps. The adjacent low-lying flood plains are very thinly settled by Mising tribe and Nepali grazier.

(b) High land plain:

On the south of the flood plain and low lying areas lie this plain. This runs parallel to the former track. Its southern border is sealed by the long wall of Naga hills. This is a wide homogeneous plain formed by aggradational work of the river Brahmaputra and its tributaries. Jorhat is situated in the flat plain of the river Brahmaputra which flows east to west about 8 kms north of the Jorhat town. The floodwater of this river inundates the areas lying north of Jorhat and therefore the expansion of the town towards that side is limited. The whole area slopes gradually from southeast to northwest and composed of old alluviums. This is the densely settled area of the Jorhat district, where all the urban concentrations are located. Moreover, this is one of the oldest tea growing areas of Assam.

II.1. (i) Relief and Drainage

Jorhat town is washed by a close network of drainage which originates in the Naga hills on the south and other highlands. There are two rivers including the Bhogdoi and many other streams or *Jans*. Bhogdoi river empties itself in the mighty river Brahmaputra, which crosses the town from east to west.

The Brahmaputra in this part is sufficiently wide and completely braided in character. It's wide channel is occasionally studded with sandy '*Chars*' or 'Shoals', The Brahmaputra is gradually and slowly shifting towards south with its regular flood and erosive activities.

The notable characteristics of the drainage of this area are –

(a) The river has attained the early maturity and run through a matured plain.

(b) It usually follows sharp meandering course and have formed a number of ox-bow lakes.

(c) The river considerably dwindles during the winter season.

The Brahmaputra, the chief architect of the vast plain is of erratic in nature. The present main channel of the Brahmaputra especially in this part was originally the lower channel of river Dihing. It appears from the account of Wilcox[1] that before the great flood of 1780, the rivers of Jorhat region like Jhanji and Desoi (Bhogdoi) were tributaries of the river Dihing. The combined water was discharged to the mighty river Brahmaputra near Mahura. After the great flood, the Brahmaputra shifted southwards and met the above tributaries at different points. Most of the areas bordering the southern Brahmaputra are occupied by a vast tract of low-lying swamps and '*beels*' (depressions). Heavy floods occasionally inundate this tract.

Here flood is a very common feature. But their nature and extent mainly depend upon the amount of rainfall in the catchments area and the level of water in the river Brahmaputra. Except the *beels* and shallow mires (viz. Dighali, Bandarhari, Bor, Geela, Kanphata, Goroimari, Rowmari, etc) there is no other large water bodies or lakes in Jorhat area. However, a few tanks dug by Ahom monarch are still in use as a source of fresh water for its surrounding areas. Most of these old tanks are situated

in and around the Jorhat town. Important old tanks of Jorhat are – Mangalu Khatar Pukhuri[2], Buragohain Pukhuri, Aideo Pukhuri, Rajmao Pukhuri, Balia Gohain Pukhuri, Kunwari Pukhuri, Kotoki Pukhuri and Mitha Pukhuri.

II.1. (ii) Natural Vegetation

Assam is the paradise for naturalist with its exquisite flora and fauna. Jorhat, with its peculiar topography and fertile alluvial soil helps the growth of luxuriant vegetation.

Flora: Botanically vegetations of Jorhat region can be classified as the Tropical Evergreen Forest and the Miscellaneous Forest.[3] The vegetation can be grouped into four broad types. –

(a) Tropical Evergreen and Semi-evergreen Forest

(b) Riverine Forest

(c) Savanna Type Forest[4]

(d) Swampy Forest.

Jorhat conserves a best stockade of evergreen forest especially in its rainiest eastern and south eastern part. Under this category, the valuable species are hollong, nahar, sam, gunsoroi, makai, sopa etc. In the south eastern part of the district especially Disang and Desoi valley reserve forest, hollong (*dipterocarpus-marcocarpus*) species predominates, the makai is also found extensively in the eastern quarter of the region which is sometimes associated with hollong species. The nahar trees abundantly grow on the older alluvium soil belts of Jorhat. The hollong and makai provide raw materials for the plywood industries of upper Assam, while nahar is mostly used as timber. Other notable species are sam, jutuli, gomari, sopa, khokan, dhuna etc. The semi-evergreen species are also extensively found in the region. The

bansum and gomari predominates this forest. Other common semi-evergreen forests are hollock *(terminalia myriocarpa)*, dhup, makarisal, bandardima, bhumura, jamu, hollock, azar, urium etc. The lower canopies of these forests are completely covered with luxuriant undergrowth of evergreen, semi-evergreen shrubs and creepers. The Riverine Forests are found in the northern fringe of the Jorhat, especially in the *char* areas. Simalu, kadam, koroi etc. are some of the important species of the type. Long grasses like son-kher are very common species of elevated riverine tract.

The Savannah type of forest occurs in the highland areas. The forest cover of Kaziranga is of this type which contains various kinds of grasses such as ekora , nal, khagori etc. Over comparatively elevated areas, son grass holds its way. It is sometimes found intermixed with riverine species of vegetation.

The swampy forest are found in the shallow mires bordering the southern bank of the Brahmaputra and in some part of foot-hills region especially, in Dayang reserve the forest area. Tora, cane, ekora, palidoi etc. are common species of this tract. The water hyacinth is a potential raw-material for paper pulp industry. It is widely found in waterlogged areas. Varieties of cane are abundantly found in Majuli and in Dayang region.

In addition to the above-mentioned vegetation, bamboos are widely found all over the region. This region is best known for its several species of beautiful orchids. Common varieties are *kapauful* and *bhatauful.*

Fauna: The fauna of Assam is somewhat peculiar in that it contains animals not to be found at anywhere else in India (Krishnan).[5] The unusual topography and extensive forest area has enabled many species of mammals, birds, reptiles thrive in different forests of Jorhat region. The world famous rhinoceros, a

unicorn for which Assam is well known is found in Kaziranga, 60 kms away from the town. In addition to it, Jorhat is the abode of wild buffalo, swamp deer, hog deer, barking deer, wild boar, sambar, elephant, tiger, leopard, bear, etc. Out of the four famous apes of the world, white-browed gibbon or hylobates hoolock is found only in Assam, in India.[6] Moreover, the Jorhat region provides home for nearly 200 species of rare birds and several hundred species of rare animals under its natural environment.

II.1.*(iii)* *Geological Structure*

From the point of geological history, Jorhat formed the part of long, narrow trough of geosynclinal sea, known as Tethys. However, its southwestern part is the continuation of the foreland of Meghalaya plateau and now under the thick cover of alluvium brought by number of streams from the southern hills. This thick layer of alluvium constitutes the older alluvium of the plain.

As in the other part of the Brahmaputra valley, the older alluvium also conceals the underlain geological structure of Jorhat. The geological survey aided by drilling for oil has revealed that under these thick deposits, there are many thousands of metres of tertiary sediments. These deposits presumably belong to the Dihing group. The southern edge of the region is marked by the Naga thrust. This thrust separates the Brahmaputra valley from the Naga hills. The thrust materials are mostly of shale and they underlie the thick alluvial deposits of Dihing group, the greater part of the plain of the area is overlaid by new alluvium deposited from Pliocene to recent. Along the foot-hills to the south-eastern border of the region, terraces of high level alluvium of Pleistocene age occur. However, the Naga hills in the south of the region is formed of Namsang formation belonging to Miocene era. The alluvium deposit in the plain area is estimated to be about 1500 metre thick.[7] As Bhogdoi basin comprises

a vast area of Jorhat district (920 sq. km.), the geology of the basin influences the whole Jorhat area. Moreover, as the study is based on the different streams and rivulets of Bhogdoi, the geological study of the basin is quite necessary.

General geology of Bhogdoi river basin: The Bhogdoi river basin, the main river basin of the town is situated in the Assam Arakan geological province within an active tectonic zone (Mathur and Evans, 1964)[8]. The Naga-Patkai hill ranges are the result of collision of Indian and the Burmese plates where the entire rocks have been uplifted and segmented by a number of thrusts. The "Belt of Schuppen" (Mathur and Evans,1964), comprising a series of complex thrusts, is located in the heart of the basin. The northernmost thrust of the belt is called the Naga thrust, which demarcates the boundary of hills and plains. The southernmost thrust of the Schuppen belt is the well-known Disang thrust which is passing through the hilly part of the basin.

The river flows over the rocks of Tertiary age in the hills of Nagaland. Main rock groups occurring within the Bhogdoi basin are the Barail, Surma, Tipam and Dupi Tila. Due to complex structural arrangement of repetition and omission of the sequences are observed in this area. In the plains of Assam also, the Bhogdoi river basin is overlain by the Tertiary and Quaternary groups of rocks. The generalized regional geological succession and geological map of the Bhogdoi basin is given in table-1 and fig-1 respectively. In Assam, the Bhogdoi river basin comprises of two units of unconsolidated rocks. The older Pleistocene units, representing high level terraces are found along the river course in the foothill regions. The younger unit is the recent alluvium of the Brahmaputra flood plain.

Fig-1.

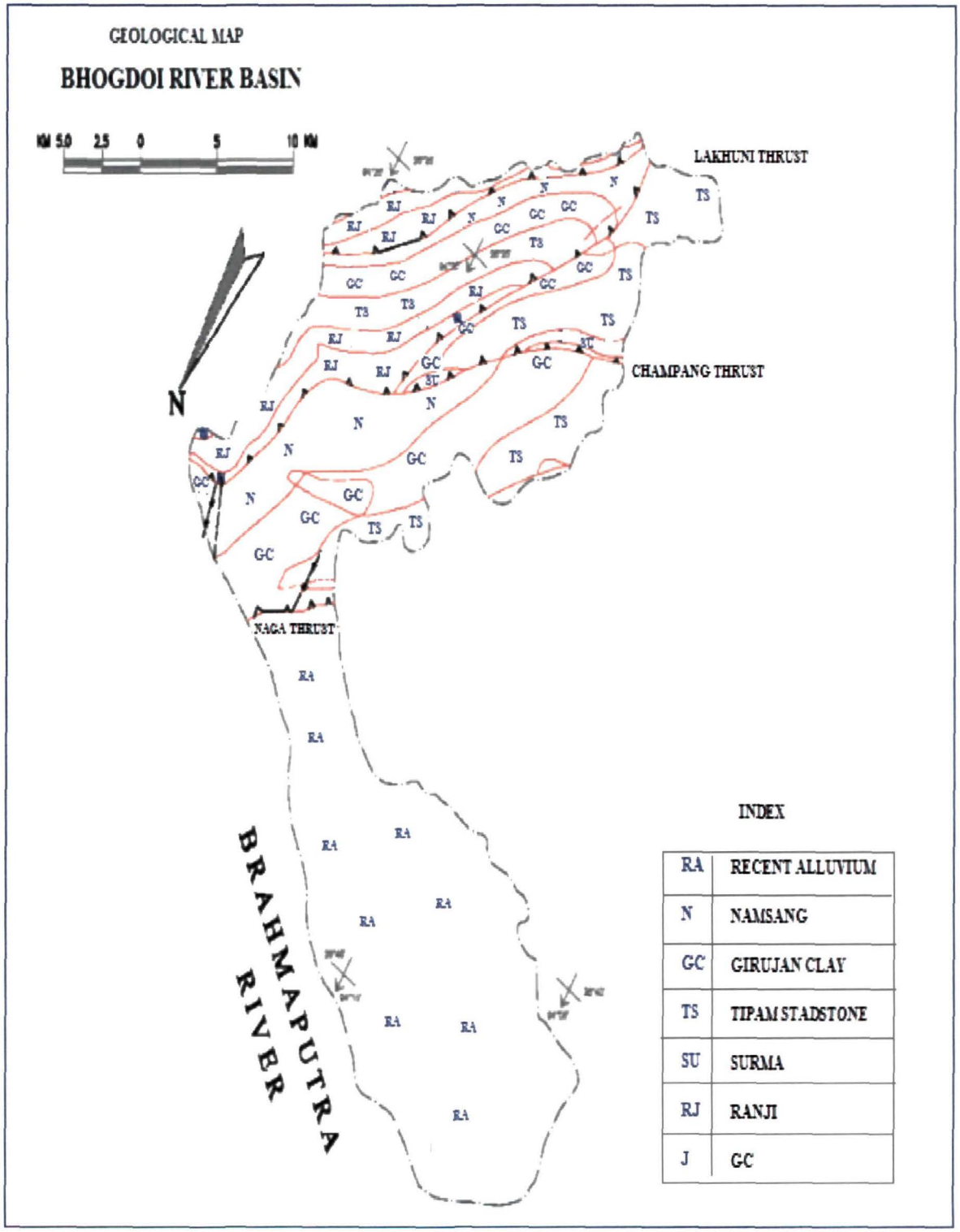

GEOLOGICAL MAP
BHOGDOI RIVER BASIN
KM 5.0 2.5 0 5 10 KM
N
LAKHUNI THRUST
CHAMPANG THRUST
NAGA THRUST
BRAHMAPUTRA RIVER
INDEX
RA RECENT ALLUVIUM
N NAMSANG
GC GIRUJAN CLAY
TS TIPAM STADSTONE
SU SURMA
RJ RANJI
J GC

Table -1: Regional geological succession of the area (after Mathur and Evans, 1964)

Age (approx.)	Group	Formation and local facieses	
Recent and Pleistocene		Geosynclinal's sediment in Upper Assam and Naga Hills	Shelf sediment within Assam valley
Recent and Pleistocene		Alluvium and high level terraces	Alluvium and high level terraces
Pliocene	Dihing	Unconformity Not subdivided (900m)	Dhekiajuli beds (1800m)
Mio-Piocene	Dupi Tila	Namsang Beds (800m)	Namsang Beds (800m)
	Tepam	Girujan Clay (1800m) Tripam Sst. (2300m)	Girujan Clay (600m) Tipam Sst. (900)
Miocene	Surma	Not subdivided	Not subdivided
Oligocene	Barail	Tikak Parbat (600m) Baragolai (3300m) Naogaon (2200m)	Not subdivided (1200m)
Eocene	Disang	Not subdivided (3000m)	Not subdivided (1200m) Jaintia Kopili Alternations (500m) Sylhet Lst (500m) Therria Sst. (100m)

- Figures in parentheses give maximum thickness

The upper Assam valley is covered by thick recent alluvium. The sub surface geology of this region has come to light due to exploration of oil by Oil and Natural Gas Commission. The stratigraphic sequence around Jorhat is shown in table-2.

Table -2 : Subsurface Geology of the Region

Probable Age	Group	Formation	Member	Approximate Thickness (m)
Pleistocene to Recent	Alluvium		Present day alluvium Older Alluvium	1000
Plio-Pleistocene	Namsang			166
Mio-phocene	Tipam	Teok Sandstone Nazira Sandstone Lakwa Clay		500 250 190
Oligocene	Barail		Sandstone-Coal Shale	375

Modified after Ray. 1981[9] and Murty, 1983[10]

II. 1. (iv) Soils

As in the other parts of Assam, soils of Jorhat region are mainly acidic in character. The hilly region has more acidic soil, while the less acidic soil is found in the riparian tract of the region. Added with balanced proportion of phosphate, the alluvial soil of Jorhat facilitates extensive growth of tea cultivation. The percentage of nitrogen content and organic matter is also found to be satisfactory.

The soils of Jorhat can be divided into two broad types–alluvial and lateritic soils. The alluvial soils are covering a wide area of Jorhat. These soils are further sub-divided into two more types–new alluvial and old alluvial soil. The new alluvial soil is mostly found in the narrow flood prone tracts bordering southern part of the Brahmaputra. They vary in texture mostly from clay to sandy loams[11]. Significantly they are less acidic and even alkaline (pH 5.5)[12] to slightly alkaline. The percentage of nitrogen and organic matters are suitably proportioned for agricultural purposes. That is why rice, jute, pulse, mustard, potato, vegetable etc. are extensively cultivated within this zone.

Beyond this zone of alluvium, there lies the wide and most important belt of older alluvium. The acid contents of the older alluvium soil are high and usually deficient in 'available phosphate', with low to medium proportion of potash. The texture of the soil varies from sandy to clayey-loam with high to low contents of nitrogen. The pH value is low (4.2-5.5)[13]. This is the belt, where tea is abundantly grown because of acidic property. Lateritic soils are generally deficient in nitrogen, potash, phosphoric acid and lime. These are highly leached soils and became less fertile. In this region, this type of soil is found only in a small patch of land in the fringe slopes of Naga hills.

II.1.(v) Climate

The climatic characteristics of the region cannot be looked separately from that of the Brahmaputra valley as a whole. The long summer is dominated by more rainfall due to influence of summer monsoon, while short winter is characterized by low rainfall. Thus, two seasons are separated by pre-monsoon and retreating monsoon period, which are transitional in character. Here the climate is marked by wide range of temperature. January is the coldest month of the year, in which minimum temperature is 9.80^0 C. Temperature rises gradually from the month of March and become highest in July month with maximum temperature recorded at Jorhat is 36.60^0 C.

The climatic characteristics prevailing and its distinctiveness, this area may be brought under the climatic classification of *Cwb* or Humid Mesothermal Brahmaputra valley type (Borthakur, 1961) [14]. The monsoon season receives the heaviest rainfall in the year with July being the rainiest month with an average rainfall of 300 mm. Thunderstorms, dust, rainy winds, prevalence of fogs etc. are some of the local climatic phenomenon of this region. Rainfall is moderate to heavy, the average being 2420.91mm in a year. About 90 percent of this rain occurs between June to August. From the trend, tendency and distribution of elements like temperature, rainfall, rainy days and fog, the climate may be divided into four distinct seasons:

1) Winter 2) Pre-monsoon 3) Monsoon and 4) Retreating Monsoon seasons

Winter Season: Winter season starts from the month of November to February. During winter the temperature varies from 10^0c to 26.7^0c. December is the coldest month with minimum temperature of 7.6^0c. During winter there are centre of high pressure over the continent, so that there is an out flow of air towards oceanic

low pressure centre. These winds are named as "The winter monsoon" or "The dry monsoon". Actually the winter monsoon is nothing but the re-establishments of the north east trade wind, which are dry except those areas where they reach after passing over the sea. Rainfall is almost absent in this season.

Pre-Monsoon Season: The month of March, April and May constitute the pre monsoon season. This is a transitional period between warm summer and the wet monsoon. The temperature steadily increases from March to May. During the month of late February and middle of March, Jorhat experiences dust storms of local origin. This is due to the prolonged desiccation and exposure of the ground and lowering of water level of the Bhogdoi river. The bed of the river Bhogdoi is the major source of supply of dust and sands, which make occasional uncomfortable weather in Jorhat. In late March, a local storm of higher intensity visits the area, which is associated with gale and hail. These are locally known as *Bordoichila*. The storm may continue for several days and develop fine weather in every evening. The recession of the stormy weather with alternating sunny days prelude the oncoming of the monsoon season over Assam.

Monsoon Season: 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 adiabatic winds the monsoon weather is associated with thunderstorm and occurs usually during the daytime. The annual frequency of thunderstorms of Jorhat is as follows compared to other stations of Assam valley.

Annual Frequency of Thunderstorms			
Guwahati	119 days	Dibrugarh	113 days
Tezpur	100 days	Mazbat	63 days
Jorhat	83 days	North Lakhimpur	69 days

Source: Indian Meteorological Department, Guwahati

The abruptness with which southwest monsoon arrives is the most peculiar feature of rainy season in Jorhat extending from the month of June to September. This southwest rain-bearing monsoon is invariably associated with thunderstorms and squall winds. The weather during rainy season is labeled as muggy. There is however a marked fall in temperature because of heavy rain. But if the rain stops the weather during the months of July and August becomes hot and enervating.

Retreating Monsoon: The monsoon retreats from Jorhat as well as from Assam in the last week of September every year. In this period, the low-pressure system becomes weaker and the monsoon 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 clears up with sunny days till the end of November month. The retreating monsoon contributes the most comfortable and pleasant weather of the year in Jorhat.

II.1.(vi) Rainfall

The extension of the eastern end of the monsoonal through into the Assam valley is the major cause, which frequently brings rainfall over the north east India. These rainstorms mostly occur during the months of June and July and receive rainfall associated with break monsoon condition. The pre monsoon thunderstorm activity prevails during the last part of April or May. Low-pressure areas forming over the

Bay of Bengal also causes rainfall over this region. The summery of rainfall data of Jorhat is given in table-3. The mean monthly rainfall data of the town is shown in figure -2. The mean monthly rainfall in the plain is minimum in July (589.91 mm) and average annual rainfall is about 2420.91 mm.

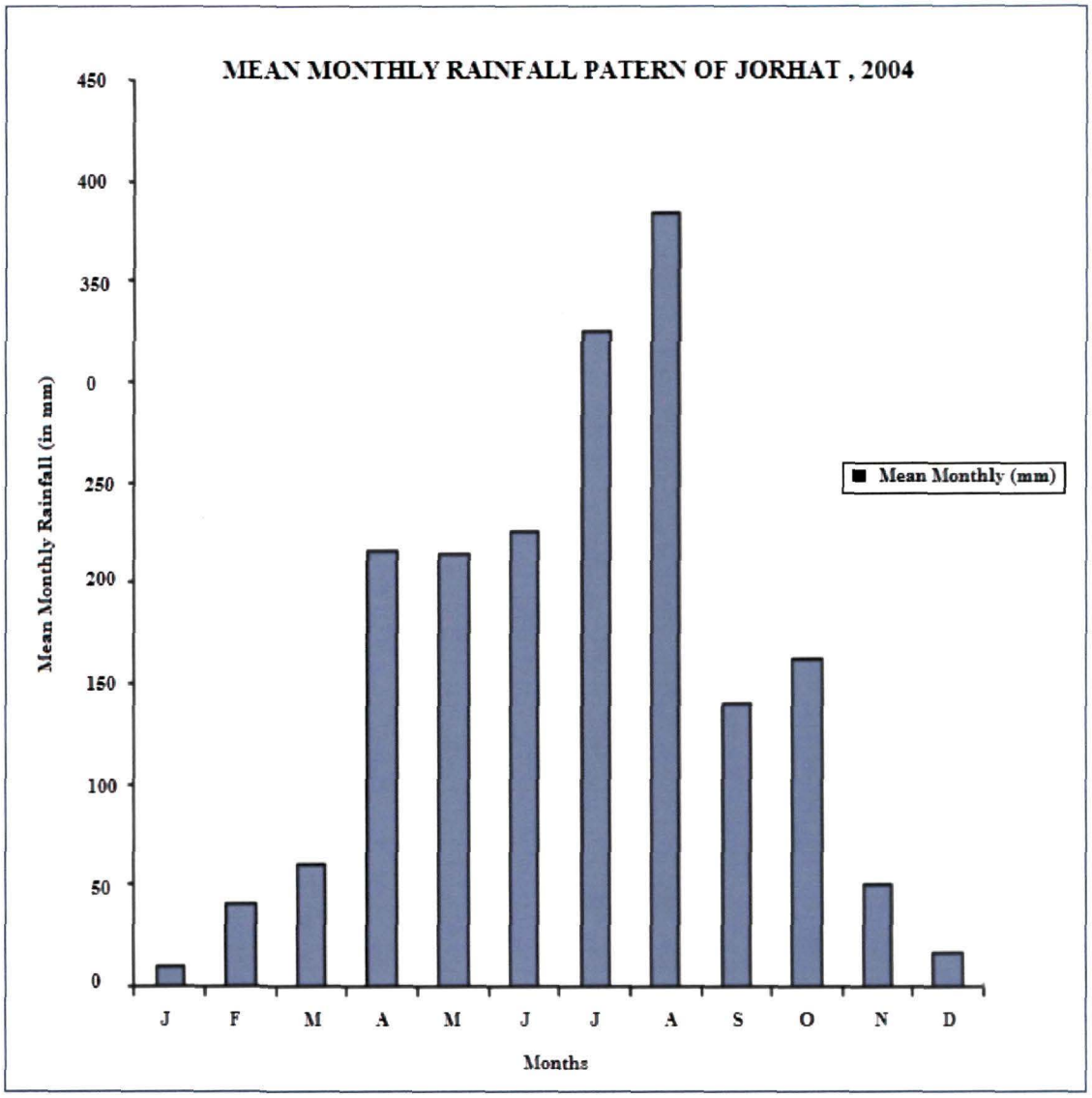
The dry season having monthly precipitation of less than 60 mm occurs from the months of November to January. Rain and thunderstorms starts intermittently from the month of March to May. Thereafter, heavy monsoonal showers start from June and lasts up to month of September. In some years, occasional heavy showers occur in the month of October and February.

Table-3: Average annual rainfall data of Jorhat, Assam.

Month	Average number of rainy days	Mean monthly rainfall (mm)	percentage of annual rainfall
January	5.00	10.45	0.57
February	7.00	41.20	2.24
March	12.50	60.10	3.26
April	17.50	216.60	11.76
May	17.50	215.00	11.67
June	21.00	225.70	12.25
July	24.50	324.65	17.62
August	21.00	383.80	20.83
September	19.00	139.95	7.38
October	12.50	161.95	8.79
November	4.00	50.45	2.74
December	5.00	16.20	0.88

Source: Rajabari Rain gauge Station, Rajabari, Jorhat. 2004

Fig-2



Evapotranspiration: The data on evapotranspiration are collected from Jorhat Agricultural University, the only available nearest station in the plains, for a period of 25 years from 1978 to 2002. Table-4 shows the monthly average of evaportranspiration at Jorhat. The monthly mean value shows that the amount of evaportranspiration is low during months of December to January and high from

March to August. The mean monthly evaportranspiration is the highest in June (3.4) and lowest in December and January (1.5).

Table-4 : Monthly average evaportranspiration at Jorhat, 2004

Year	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Nov.	Dec
1978	1.4	2.4	3.4	4.1	3.9	5.0	3.7	3.9	2.9	2.0	1.7
1979	1.6	2.6	4.4	4.8	3.4	3.8	2.8	4.0	2.7	2.0	1.6
1980	2.0	2.8	3.1	3.0	3.1	3.7	4.3	3.8	3.2	4.6	3.4
1981	2.3	2.9	3.2	4.1	4.5	5.3	5.2	4.8	3.8	2.7	1.9
1982	1.3	2.2	4.1	4.0	4.8	3.3	3.7	3.3	2.9	2.2	1.3
1983	1.6	1.8	2.8	3.5	3.6	3.9	3.9	3.8	3.0	2.4	1.4
1984	1.5	2.4	3.9	3.9	3.3	4.7	3.4	3.6	2.9	2.3	1.6
1985	1.7	1.8	2.9	2.8	4.0	3.1	3.2	4.0	3.2	2.3	1.4
1986	1.5	2.0	3.5	3.8	4.3	4.2	3.4	3.3	2.6	2.1	1.5
1987	1.9	3.0	2.8	4.1	3.5	4.0	3.4	3.1	2.6	2.2	1.6
1988	1.4	2.3	3.3	3.6	4.2	4.4	3.0	2.9	1.3	2.1	1.5
1989	1.3	2.1	3.4	3.4	3.7	3.7	2.8	3.4	2.6	1.7	1.3
1990	1.4	1.7	2.3	2.2	3.1	2.9	3.4	3.5	2.8	2.5	1.5
1991	1.4	1.9	3.2	2.8	2.1	2.9	3.9	3.7	2.9	2.5	1.4
1992	1.5	1.7	3.3	3.1	3.7	3.3	3.0	3.3	3.4	2.0	1.4
1993	1.2	1.9	2.5	2.8	2.5	2.1	2.7	2.8	2.3	1.4	1.5
1994	1.2	1.8	1.7	2.6	3.0	2.6	2.8	2.7	2.7	1.5	1.3
1995	1.4	1.6	2.5	2.8	2.5	2.3	2.0	2.2	2.0	1.6	1.1
1996	1.2	2.1	2.5	3.3	2.5	3.1	2.5	2.8	2.9	1.2	1.2
1997	1.1	1.4	2.4	2.6	2.6	2.4	3.2	2.5	2.0	1.5	1.1
1998	1.0	1.8	2.5	2.4	3.2	2.0	2.9	2.5	1.8	1.8	1.2
1999	1.3	1.9	2.7	2.7	2.7	3.3	2.4	2.6	2.1	1.6	1.3
2000	1.5	1.7	2.4	2.4	2.4	2.7	2.8	2.5	2.2	1.3	1.4
2001	1.2	1.7	3.2	3.2	2.8	3.2	3.3	3.0	2.5	1.5	1.1
2002	1.5	1.7	3.1	3.1	3.7	3.2	3.0	3.3	3.4	2.0	1.4
Mean	1.5	2.0	3.2	3.2	3.3	3.4	3.2	3.3	2.7	2.0	1.5

Source: Assam Agricultural University, Jorhat (Units in mm)

II. 1.(vii) Basin Area

The basin of the river Bhogdoi comprises both rugged hills and flat alluvial plains. It is situated on the west of Janji Basin. On its east there is Dhansiri basin and bounded by Naga hill ranges on the south and the Brahmaputra river on the north. In general the basin has a northeast southwest trend within the hills but it takes a right

angled turn to north west direction in the plains. In the hills, the trend of the basin is controlled by the strikes of local geological formations and major structures and in the plains; the regional slope of the terrain is responsible in this regard.

The basin has a latitudinal extent from $26^0$15' north to $26^0$45' north and a longitudinal extent from 94^0 05' east to 94^0 10' east. The total basin area of the Bhogdoi river is nearly 933 sq. kms.

II.2. Cultural Settings Of The Region

II.2. (i) History of Jorhat Town

For an in-depth study of the problem, as explained in the previous chapter, a concise and comprehensive history of the study area is unavoidable. History of the growth of Jorhat, its economy and structure reflects the development of drainage of the town. The name Jorhat originated during the reign of Ahom monarch Gourinath Singha (1780-1795). Before that, it was popularly known as 'Desoi Bahar', because it was 'temporary rest place' or 'Bahar' for the king Gourinath Singha. Purnananda Buragohain, the minister of king Gourinath Singha established a fortified 'Bahar' at the present site of Jorhat town for the safety of the king against Moamoria rebellion, broke out in April, 1970[15]. The name Jorhat supposed to be originated from the twin markets near 'Desoi Bahar', such as 'Phukanarhat' and 'Macharhat' ('Jor' means twin and 'Hat' means market, map-4). As a consequence of the Moamoria rebellion, the capital of Ahom kingdom at Rangpur was ruined. The then king Gourinath Singha decided to shift his capital to this place in 1974 AD and it became the focal point of administration during the last part of Ahom reign. During the British reign also the district headquarters was shifted from Sibsagar to this place in 1913 AD. Jorhat is the oldest town having its municipal administration in February 1909. From 1913 AD

onward, it remained as district headquarters for Sibsagar district (undivided Jorhat). Jorhat is still continuing as the district headquarters for the newly created Jorhat district.

The history of Jorhat can hardly be separated from the history of Assam. It was under the influence of Bodo tribes of Sino-Tibetan origin, who established themselves along with other parts of the Brahmaputra valley, possibly during the second millennium B.C. Some Austric and possibly Dravidian tribes had preceded the mongoloid Bodos in this tract[16]. The area now represented by Jorhat district was of Austric-Dravidian and Bodo race. The presence of Bodo words in the name of rivers like di-Soi, di-hing etc. indicates clearly the domination of Bodo group of people in the early pre-Ahom period.

During the epic age, the Jorhat area must have formed a part of the kingdom Kamrupa, which is said to be extended from Kartoya to extremities of Assam[17]. The king Bhagadutta of this part was an important figure in the famous battle of Kurukhetra, depicted in the Mahabharata. In sabha parva, it is specially mentioned that he fought with Arjuna and assisted Dyouryadhana with his army of 'Kiratas and Chinas'[18]. The Kiratas are supposed to be mongoloid group of people, particularly Nodos[19].

It is observed that the Brahmaputra valley keep the evidence of various social elements passing through it between India and south-east Asia, in reverse direction, left their traces in the hills and valleys of Assam[20]. Thus, the early history has links with Bodos and Shans and not with the legendary kings of Hindu mythology. The Aryan stream continued to flow into this area particularly since the beginning of the Christian era.[21] In the vedic literature this part was known as land of 'Vratyas'

(Anupdesa) and described as a Melecha country.[22] The Aryanisation of Assam, which started long before have been properly set during early Christian era[23].

Jorhat might have formed the part of Pragyotisha – Kamrupa during the time of Varman rulers, particularly during early period of seventh and eight century. In case, the extension of Kamrupa kingdom from Kortoya to Sadiya as mentioned in the Yoginitantra[24] have some truth. Then the Jorhat must have come under the kingdom of Kamrupa in the early part of the Varman rule. This political status seems to have continued until the decline of Hindu dynasty and rising of different dominion established under 'Bor Bhuyan' and Bodo chiefs. This domination perhaps continued till the advent of the Ahoms in 14th century.

The Jorhat area was the meeting ground of different tribal as well as non-tribal population migrated from the west, east and hill tracts of north and south. It is quite clear that the migration of different tribal population continued till the 15th century. It is also evident that no tribes migrated from different directions could consolidated their position for a longer period of time, perhaps because of their migratory nature in search of agricultural land for shifting cultivation. Though very little is known about the economic characteristics prevailing in the pre-Ahom period, still few points are worth mentioning here. The economy of the pre-Ahom period was essentially subsistence in nature. The shifting hoe-cultivation was dominant practice among the migratory tribal people of this part and this system prevailed as late as the 19th century.

Though the Ahom entered Assam in the early part of the 13th century, they completed expansion of their kingdom up to Dhansiri only in the early part of the 1523 AD, when they defeated the Kachari king Detchung and occupied the territory

belonged to the Kacharies. After succeeding all the hurdles with Kacharies and chutias, Ahoms became dominant all over the Brahmaputra valley and tightened their position in whole of upper Assam.

Jorhat conserves a long monotonous history of Ahom period from its beginning till the Burmese invasion and subsequent annexation by the British in 1826. But still it was very important and bright period, as the area has shaped its economy and developed a cultural and political set-up under long administration of a few strong 'Swargodeos'(Ahom kings). This is the period when the people of Brahmaputra valley developed both external and internal trade under the umbrella of Ahom administration. In addition to that, Ahom with their unique administrative system established a good relation not only with different tribes living within their territory, but also with the indomitable tribes surrounding Jorhat. They even established a trade relation with them. The union of all the small aboriginal tribes into a common folk was one of the great achievements of the Ahom administration.

The Ahom administration was not an easy sail. It had to face several invasions by Koches and Muslim rulers of the west. But, still they maintained their ways till the later part of 18th century. The power of Ahom ruler started to decline from the later part of the 18th century only due to their internal rivalry and external onslaught. The economic base built by the Ahom ruler, after prolonged struggle with the surrounding tribes was demolished by several invasions from outside the country. The political instability and economic imbalance was further intensified by the Burmese invasion and dominated the whole country till they were driven out from the country by the British troops. A treaty was made for peaceful settlement of the war on 26th February 1826, which is well-known as 'Treaty of Yandaboos'. King Gourinath

Singha of the mightiest Ahom dynasty shifted the Ahom capital from Rangpur to Jorhat in 1784 A.D. The Rajamaidam, Rajmao Pukhuri, Kunwori Pukhuri, Baliagohain Pukhuri, Burhi Goshani Dewalaya etc. are some of the historical monuments of the Ahom kingdom in Jorhat.

The British selected Jorhat as the head quarter of upper Assam in 1802. The sun of the ahom rule finally set when Purandar Singha, the last king of ahom dynasty was deposed by the British government in 1828. After the exit of Purandar Singha, the territory of upper Assam was placed under the British administration.

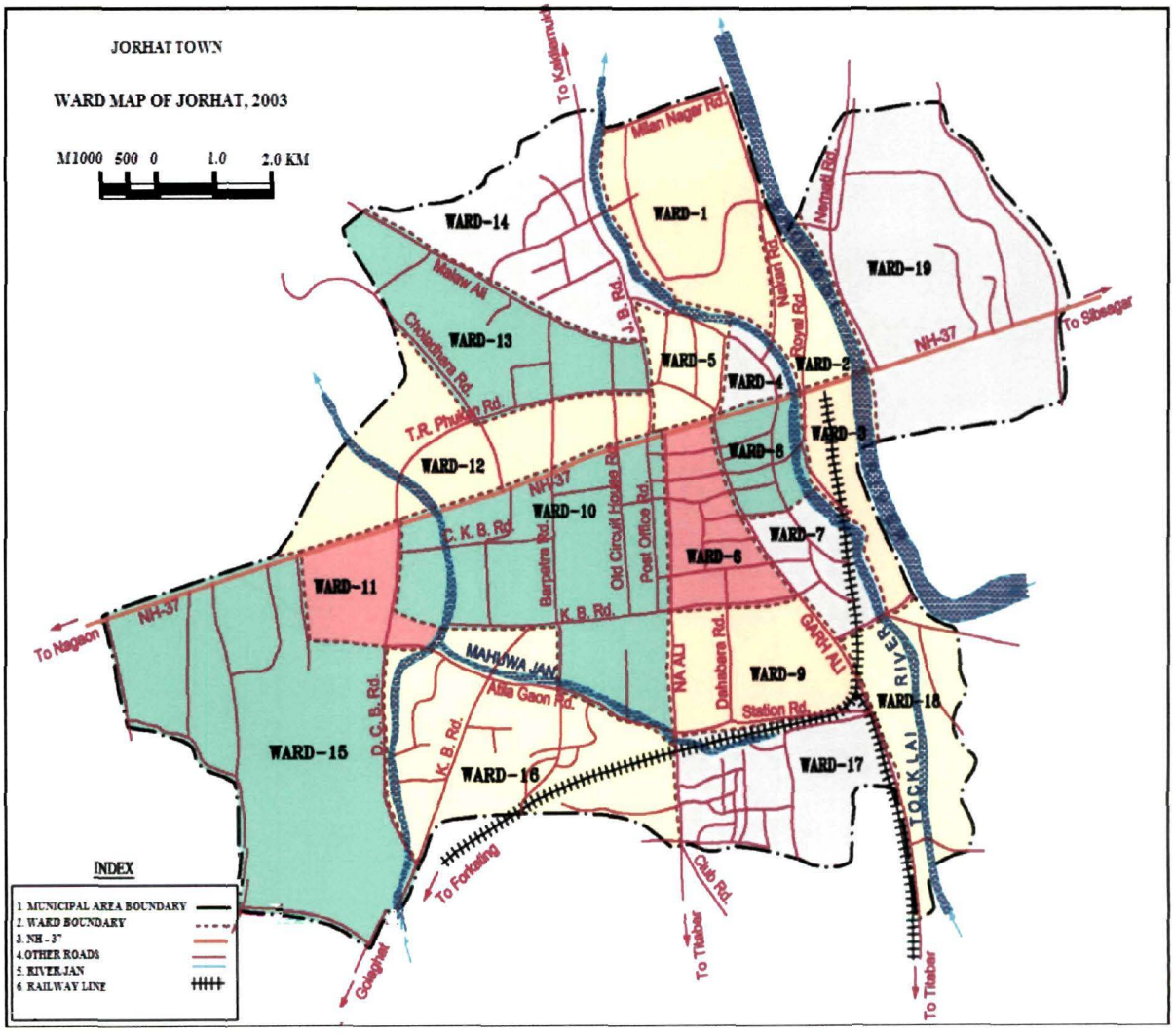
In 1826 A.D., the East India Company took over the charge of administration of the lower Assam districts. As per the term under 'Yandaboo Sandhi', Swargodeo Purandar Singha was acquired by them and annexed it to the British territory. By a proclamation in 1839 A.D, the area was divided into Lakhimpur and Sibasagar districts. Later on, the district headquarter of Sibsagar was established at Jorhat. Now also it is the district headquarter of the present Jorhat district. In 1859, Jorhat Tea Company was formed and extensive land acquisition and cultivation of tea started. The first commercial production of the tea in the world was started in Jorhat by Assam Tea Company in 1839. Rowriah Airdrome was set up in 1942 and Indian Air Force opened its first base of the north east at Rowriah near Jorhat in 1952. Way back in 1885, a railway line was laid between Jorhat and Titabor under Jorhat provincial railway. In 1926 branch of Gauhati Bank and in 1937 branch of Comilla Bank was set up in Jorhat. In 1930, Mumbai's Mutual Life Insurance Society opened their branch in Jorhat which was the first of its kind in the region.

The British hanged Maniram Dewan, the first Indian tea planter and foremost freedom fighter of Jorhat along with Piyoli Barua in 1858. Numerous luminaries of

the freedom movement like martyr Piyoli Phukan, Bahadur Gaoburah, Farmud Ali and many others hailed from this historical town.

HRH the Prince of Wales Institute of Technology was the first technical school of this region was set up in 1928. Institutes like Jorhat Engineering College, Assam Agricultural University, Jagannath Baruah College etc. have been set here considering the place of importance. Jorhat held in the overall educational, economic and socio cultural scenario of Assam. The town of Jorhat comprises of 19 wards having various cultural and economic functions (map-3).

Map-3



Source:Town and Country Planning Department,Jorhat

II.2.(ii) Demographic Structure

Demography reflects the physical quality of human population and level of socio economic development of any region. Attributes like birth rates, death rates, age-sex composition, marital status etc. are the vital aspects of population study.

Number of Population: According to 2001 census, the total number of population in Greater Jorhat area was about 2, 02,877. The total number of male population was 1, 06,029 persons while 96,848 persons were female.

Growth of population: The rapid increase of urban population in Jorhat during last few decades is a challenge to the ingenuity of legislators and administrators. 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 amenities.

Table- 5: Population Growth of Jorhat of Municipal area, 2001

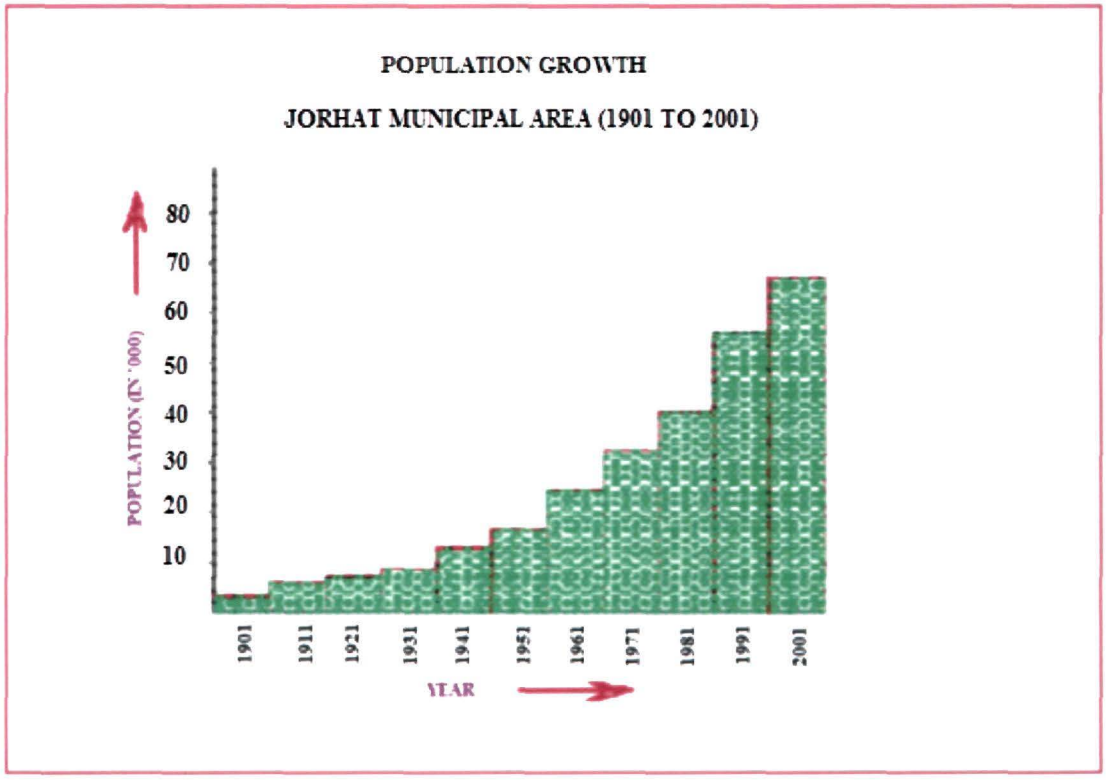
Year	Total Population	Percentage increase
1901	2,899	
1911	5,231	79.34
1921	6,626	26.67
1931	8,834	25.78
1941	11,664	39.96
1951	16,164	38.58
1961	24,953	54.37
1971	30,247	21.21
1991	58,258	92.61
2001	67,786	16.35

Source: Census of India, Assam, 2001

The study area includes the physical master plan area including the existing municipal area. Total area of Jorhat master plan area is about 7257.65 hectares out of which the developed area is about 2313.16 hectares forming about 31.9 percent of the

total plan area. Municipal area covers an area of 504.85 hectares, which forms about 7 percent of the total planning area. The total population of Jorhat municipal area is 58,258 persons and master plan area is 2, 07,877 persons as per 2001census. It will perhaps be better to mention here that the Jorhat town is expanding in such a way that its growth can be understood from the percentage increase of population as stated in the table- 5 and fig-3.

Figure-3



It is seen that the percentage of growth is the highest during the decade 1951 – 61 which is 54.37 (table-5) in municipal area. This growth is primarily due to i) Influx of population from erstwhile East Pakistan, ii) Establishment of various government offices and educational institutions and, iii) Growth of transport and commercial

activities. The 1981 census was not held in Assam. Therefore, the population figures for 1981 have been worked out by interpolation.

The lower rate of growth in the municipal area is due to the fact that after 1961 the major growth has taken place outside the present municipal limit. The total population in 72.8 sq. kilometers (28.sq miles) of the Jorhat master plan area in 1971 was 93,921 persons of which 30,247 live within the municipal area of 4.94 sq. kilometers. The growth of population in Jorhat town and rest of the areas within the master plan for the decades 1941-2001 is shown in table-6 and figure -4.

Table -6: Growth of Population of Jorhat Master Plan Area, 1941-2001

Year	Municipal Area		Master plan area (Excluding Municipal Area)		Total Plan Area Percentage	
	Population	Percentage increase	Population	Percentage increase	Population	Percentage increase
1941	11,664	-	26,979	-	38,643	-
1951	16,164	38.6	35,025	29.7	51,189`	32.5
1961	24,953	54.4	48,479	38.4	73,432	43.4
1971	30,247	21.0	63,674	53.1	93,921	31.3
1991	58,258	92.61	1,12,030	75.94	1,70,288	81.31
2001	67,786	16.35	1,35,091	20.58	2,02,877	19.14

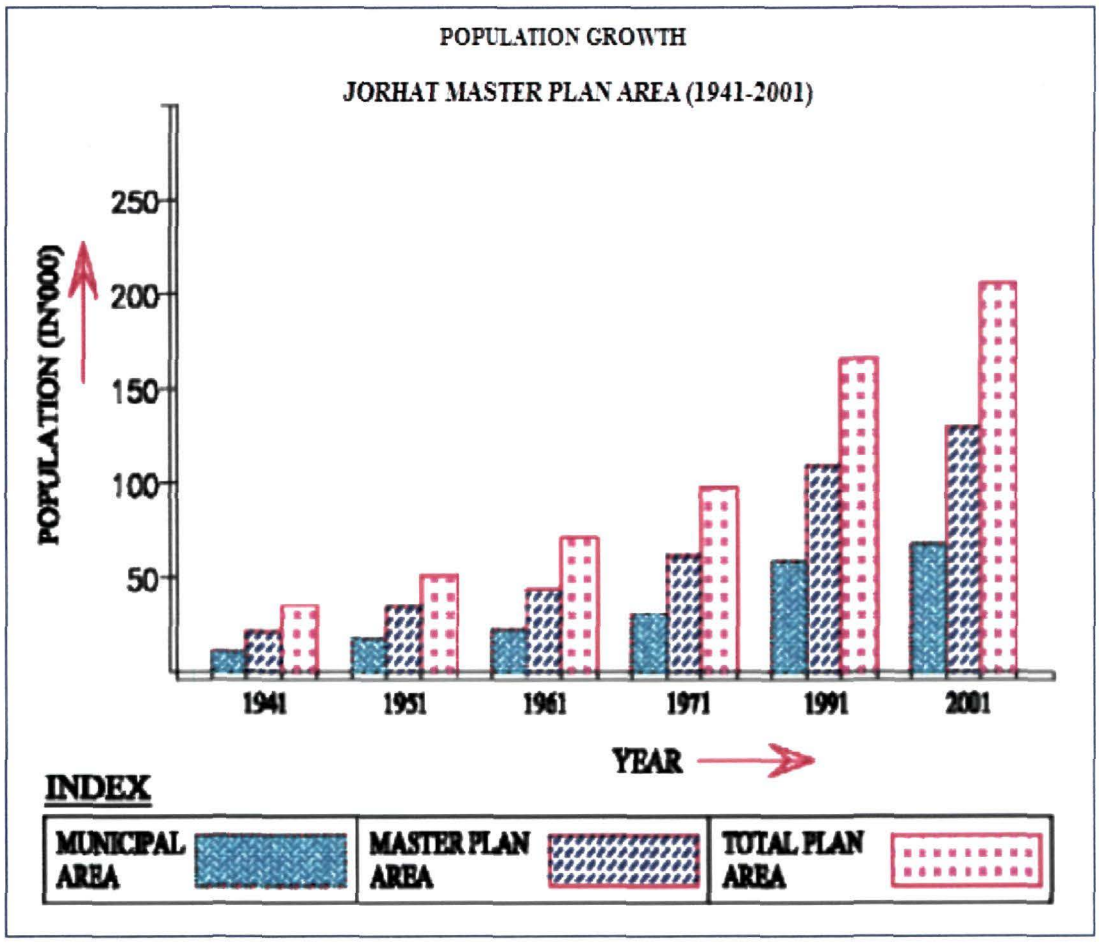
Source: Town and Country Planning Department, Jorhat

According to 1961, the total population of Jorhat municipal area stood at 24,953. In the year 1971, the total population of the area rose to 30,247 persons showing an increase of 21.21percent (table-5 and fig-3).The number of total population of Jorhat master plan area recorded at 73,432 persons (1961). In the year 1971, the total population of Jorhat Municipal area rose to 93,921 persons showing an increase of 31.31 percent (table-6).

Birth Rates and Death Rates: Fertility and mortality are the two important parameters to understand the demographic characteristics of any region of population

groups (Das, 1999). Birth rate and death rate differential indicates the natural growth of population. In Assam, the birth rate and death rates were 26.8/000 and 95/000 respectively in 2001.[25]

Fig-4



Literacy Rate: As per 2001 census, male and female literacy rate of Jorhat town is 81.18 percent and 74.66 percent respectively, which is higher than the provisional figure for the district released by the Directorate of Census Operation, Assam. Literacy rate of Jorhat town is satisfactory in comparison to the Jorhat district, which is shown in table.-7

Table.-7: Literacy Rate of Jorhat District and Jorhat Town (2001)

	Jorhat District			Jorhat Town		
	Population	Male	Female	Population	Male	Female
Total Population	1009197	530240	478957	137814	73213	64601
Literate	689414	384685	304729	107665	59434	48231
Percentage of literate to total	68.31	72.55	63.63	78.14	81.18	74.66

Sources: Statistical Handbook of Assam, 2002.

Martial Status: Marital status is associated with the demographic and social quality of human population, divorced population etc. Marital status includes married population, divorced population, widow or widower population. The marital status and age marriage of different communities are not specified in the census of India reports. An account of these aspects of demography has been given in table -8 from the sample survey 2003, census of India (Jorhat District, socio-cultural tables).

Marriage of Jorhat district total population before 20 years of the men folk were observed in 0.82 percent and female folk were observed in 125.08 percent. For the age group of Jorhat district population of males marrying between 20 to 29 years was 16.55 percent while female were 32.60 percent. Jorhat district population of male marrying 30 and above years constitutes 82.63 percent and female constitutes 62.32 percent. Jorhat district married population percentage was 51.42 and widow-widower was 8.29 (table-8).

Table-8: Marital status of total population of Jorhat, 2003

Group	Married		Divorced		Widow Widower		Below 20 Year		20-29 Year		30 and above	
	M	F	M	F	M	F	M	F	M	F	M	F
Number of Population at Jorhat District	169276	172459	300	540	9796	18610	1390	8754	28010	56214	139876	107491
Percentage	48.31%	54.90%	0.18	0.31	5.79	10.79	0.08	5.08	26.55	32.60	82.63	62.32

Source: Sample Survey, 2003, Census of India

II.2. (iii) Land use pattern

The land use pattern of an urban area reflects its physical character as well as its trend of development. In an urban area, the primary uses of land are for residential and commercial, industrial, public and semi-public and other such uses, which are interrelated and dependent on one another. Without an overall plan to guide the physical development, the properties often damaging its main purpose as well as the interests of the community.

Study of land use pattern of a town is undoubtedly a basic need for fuller comprehension of urban system. The land use pattern in the town explicitly speaks of an unplanned growth. The present trend is more alarming than it was in the past and this is positively due to conflicting and competing claims from different users. Over and above these claims, the multitudes of personal whims and desires have worsened the balanced land use pattern in the town. As a result, it has become difficult to classify the areas of land, zone wise. However in order to assess the land under different uses a comprehensive method was applied (Town and Country Planning Zoning Regulation,1972). 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 is determined. A recent survey shows that there were about 7257.65 hectares of land of which only 2313.6 hectares fall within the developed area of the town forming about 31.9 percent of the total plan area. Out of the total land area, only 2.34 percent is occupied by commercial farms whereas residential area covers 40.99 percent of the total land. The storage and warehouse spread over 0.92 percent while social and public institutions occupy 41.48 percent of the total land. The manufacturing industries and associated installations occupy 8

percent of the total area. The public utility services like road and bus stations, railways, public car park, water supply, drainage etc. cover 14.90 percent of the total land. The parks, gardens, playgrounds, public meeting places, agricultural fields, market garden, nurseries, unused lands, wood land, cremation ground, graveyards, sewage disposal , waste, lakes and swamps etc. are wide spread which account for 42 percent of the total land. All these may be classed as open space in the town complex.

The road network in the town is not at all proportionate to the size of the population. Except the national highway 37, Assam Trunk road, Na Ali and Malow Ali of the town are very narrow and are suitable only for single lane traffic. The greatest drawback of road network of the town is that these were constructed without any foresight to cope with increasing traffic and without keeping any scope for future expansion and introduction traffic control by-laws. The built up areas start from road side leaving the margin for a narrow drain which very often blocked by continuous silting, resulting overflow of water upon the roads. Though footpaths are constructed over the roadside drains because of, their low gradients and limited width fail to watch out the usual town wastewater. During precipitation the shallow drains are instantaneously filled up which is one of the cause of water logging within the town. In fact, it has been observed that land available to town drainage is extremely limited for which sanitary and hygienic condition has been progressively deteriorating with the growth of the town.

II.2.(iv) Traffic and Transport Network

Traffic as dictionary meaning, defines passing to and fro of vehicles of 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 problems of transportation are as old as civilization itself, the utilization of power has revolutionized 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 town is not at all proportionate to the size of population. The growth of Jorhat in a few limited areas and the constraint imposed by some peculiar topography has made it extremely difficult to maintain the barest minimum level of transportation facilities.

As per 1997 estimate, prepared by the Town Traffic Police, 600 trucks, 104 long distance buses and 68 city buses traverse the town several times daily. There are many licensed and unlicensed rickshaws and other slow moving vehicles in the town (chapter III). This stupendous volume of mixed traffic winds its way, through the heavy pedestrian narrow streets of the town, which would be nightmare even for a developed country. During the decade 1991-2001, altogether 198 road accidents in Jorhat has been registered by police in which 40 lives were lost. An analysis of vehicle type wise involvement in fatal accidents reveals that trucks were the number one killer groups of automobiles in the town contributing 35 percent. Buses made a distant second with 17.65 percent involvement followed by private cars 13.64 percent, motor cycle 12.63 percent, scooter 15.64 percent and jeeps 8.10 percent (source : Jorhat Sadar Traffic Police Branch,2003) . This is mainly because most of the roads have no footpaths or sufficient width with no continuity or encroachment of footpath by commercial activities. Assam Trunk road and Gar Ali are the two main roads connecting the town with other important places. These two important roads of the town carry major portion of traffic. Assam Trunk road divides the town in two

conspicuous halves and carries large number of through traffic. Other important roads like Na-Ali, Jagannath Barooah road; Kamarbandha Ali, Malow Ali, Charigaon road etc. are acting as feeders to the Trunk road. Works for a bypass of the national highway has already been completed on the northern side of the town which will undoubtedly be relieve the present congestion and enable the trough traffic to move with least interruption.

Total mileage of roads in Jorhat master plan area is about 210 kilometers of which about 49 percent is fair weather roads(2001). The total mileage of road within the municipal area is about 40 kilometres.The widths of some of the existing roads are sufficient and are likely to be able to accommodate future traffic provided some improvements are done on them. A conspicuous feature of the vehicular traffic in Jorhat is the high proportion of slow moving vehicles. Cycles and other slow moving vehicles constitute about 86 percent of the total traffic in a normal peak hours. It is estimated that about 1,900 vehicles per day pass through Jorhat town, mostly in east-west or vice versa direction, Assam Trunk road carries the maximum number of vehicles amounting to about 1,900 vehicles per hour during evening peak period. Gar Ali is the next busy road which carries about 1,600 vehicles per hour during evening peak (Source: Jorhat Transport Office, Jorhat, 1991) .

Railways: One railway loop line connects Jorhat with Mariani and Furkating. It is estimated that about 72,000 passengers and about 209,000 quintal of goods are carried by the railway annually (Source: Office, Jorhat Town Station, Jorhat, 2001). The railway level crossings on the important roads within Jorhat area create traffic bottlenecks at Gar Ali and Na-Ali.

Airways: Jorhat is connected with other parts of the country by means of air route. Rowriah airport is situated at about 9 kms from the town and is connected with regular service to Guwahati, Dibrugarh, North Lakhimpur, Tezpur, and Dimapur and Kolkata .

Water Ways: Until a few years ago, waterways on the Brahmaputra played an important role in the economy of the town. Commodities like tea, wood products etc. used to be carried regularly through Nimatighat and Kakilamukh to Kolkata. After the 1950's earthquake, the water transport system on the Brahmaputra river was very much affected.

Road Transport: Jorhat is well connected by roads with other towns of Assam. Regular State Transport bus services operate from Jorhat to Dibrugarh, Tinsukia, Sibsagar, Golaghat, Guwahati, Nagaon and Nagaland. There are several private bus routes connecting places like Mariani, Titabor, Nimati, Kokilamukh, Amguri etc. with Jorhat. Besides these, trucks are playing a vital role in transportation of goods to and from Jorhat.

II.2.(v) Public Utilities and Community Services

Health: The Civil Hospital and Christian Mission Hospital are the two important hospitals with a total number of 430 beds for general medical treatment together with special provisions for tuberculosis patient treatment. These two general hospitals are always crowded with patients and need expansion, especially the civil hospital at Borbheta area. In addition to this, primary medical facilities are also available in various tea estate hospitals. There are also two well-equipped hospitals for exclusive use of the military and for the employees of the Cinnamara tea estate. Besides, a number of modernized and well-equipped nursing homes are also there in

the town. Newly established Jorhat Medical College has also started its service from the early part of the year 2009.

Water Supply: There is no integrated grid for supply of water in the master plan area of Jorhat. Different areas have different water supply schemes. The Bhogdoi is the principal source of water for most parts of the town. The present water supply plant run by municipal board is situated by the side of the river Bhogdoi. Although, it supplies a total of 3, 40,000 gallons per day which is approximately 10 gallons per capita per day, it is grossly inadequate. The storage is get from other sources like tanks, wells and hand pumps. Big establishments like Regional Research Laboratory, Engineering College, Military establishments etc. have their own water supply system.

Inadequacy of the present water supply in the town is due to heavy silting and low discharge in dry season on the intake site. There is an acute shortage of water. As there is no other source of water supply in Jorhat town, future requirements of water will have to be drained from the Brahmaputra river by floating barges. For an even distribution, Urban Water and Sewage Department, Jorhat has completed another four numbers of high water reservoirs. These plants are distributed in the areas of Pujadubi, Lions Club area, Nehru Park and one at Jorhat civil hospital complex in Jorhat region. Aim has been made to provide a minimum standard of 30 gallons per capita per day from each plant. Distribution system should also be improved for which a scheme is said to be awaiting scrutiny by public health department of the State Government.

Cremation Ground /Graveyard: The important cremation ground and graveyard are 'Tarajan smashan", "Garmur smashan' and "Engineering College Road

smashan", "Macharhat smashan" and "Graveyard at Dhakai Patty" on the bank of Tocklai river. Since Tarajan smashan is centrally located within the municipal area, it has a greater demand. It is suggested that these cremation grounds should be improved by providing permanent platform for burning and other facilities.

II.2. (vi) Educational Institutions and Recreational facilities

Existing educational institutions: There are about 43 educational institutions within the municipality and 42 in the suburban area (within Jorhat master plan area) with student of 17,100 and 6,070 respectively (Source: Revised Master Plan zoning Regulation, Jorhat, 2001). In addition to general educational facilities Jorhat is also an important centre for technical educations in upper Assam. Jorhat Medical College is situated in Jail road area. There are three technical institutions, two in diploma level and the other that is Jorhat Engineering College offers degree in various fields in engineering. The Prince of Wales Institutes of Engineering and Technology is the oldest institution for technical studies in Assam. The Assam Agriculture College situated in the outskirts of the town has recently been upgraded into Assam Agricultural University. In 1969, the student population in various Technical Institutes and Agricultural University were 1,600 and 600 respectively. In addition to these, the Regional Research Laboratory and Tea Research Centre are situated within the master plan area.

There are 15 primary schools 13 High and Higher Secondary schools and 10 colleges and other institutions within the Jorhat municipal area. Most of the primary and secondary schools are accommodated in dilapidated houses without proper service facilities such as playgrounds, toilets and water supply etc. The immediate

need is to improve the conditions of these institutions and provide the basic essential facilities to increase their intake capacity.

Recreational Facilities: This is the most deficient public amenity in Jorhat although it does not appear so due to the wide practice of keeping big compounds in the residential houses. Out of 38 hectares of organized open space, about 23 hectares belong to the Jorhat tea company and is for exclusive use of their members. The remaining 15.3 hectares is accessible to public which comes to about 0.2 hectares per 1,000 populations and this is grossly inadequate. The *Maidam* in front of the court building is the only available space in the town for occasional public functions and outdoor games. Beside this, some of the educational institutions have provision for meeting the recreational needs partially. Except the stadium, other open spaces like Nehru Park, Maniram Dewan Park have good location but they lack maintenance.

There were six cinema halls in Jorhat town and a few public buildings but they are inadequate and lack parking facilities. Due to the threatening of extremists like United Liberation Front of Assam, against screening of Hindi cinema, four of them have already closed and other two are running. If timely action would have taken and implementation is done with careful planning and proper perspective it would not be difficult to obtain suitable areas. The aim should be reserve to suitable land for children's park and playgrounds, particularly in the residential areas and in central areas for public purposes. The large historic tanks, some low-lying lands and a part of Bhogdoi river can also be developed for recreational use.

Drainage and Sewerage: The need for a good drainage system should get top priority. Streams like Rowriahjan, Tarajan, Athubhangajan and Tocklai river should be cleaned from time to time and their misuse and encroachment should be strictly

dealt with. It would be necessary to connect the major drains to these streams. It is also necessary to mention here that with the increase of built up areas the drainage would assume a serious problem unless specific action is taken early by preparing a drainage scheme for greater Jorhat. The disposal of night-soil by manual labours will continue till all the service latrines are removed and provided with sanitary type latrines. The authority must insist for sanitary latrines to new buildings. The volume of solid waste will increase in Jorhat town with the increase in population and other activities. It is suggested that modern method of incineration to be adopted, the first of its kind may be located in the present site of garbage disposal near Toklai river.

II.2.(vii) Economic Development

The physical development of an area is directly related to its existing economic activities and the potential for future economic development of the region. It is therefore, is necessary to make a brief study of the economic potential of the region as a whole.

The economic position of Jorhat is fairly high in comparison with that of the other districts of Assam. In 1991, the per capita income of this district was Rs. 346.00, next only to Lakhimpur and united Khasi and Jayantia hill districts. Tea industry plays a significant role in augmenting the economic prosperity of the region. After the second world war , many small scale engineering subsidiary industries were installed in and around Jorhat town like other parts of Assam. The economic progress of the region is also based on the agro-industrial development. The exploration and development of oil fields at various places of the Jorhat districts has lately become an important factor for economic development of the region.

In order to correctly assess the scope of urbanization and economic potentiality, it is necessary to examine the occupation pattern in Jorhat. Table-9 indicates broad occupation pattern of the working population for 1991-2001.

Table-9: Broad Occupational Distribution (percentage working population) 1991-2001

Year	Agriculture	Industry	Trade and Commerce	Transport	Services	Total Workers
1991	28.0	22.3	13.8	5.3	30.6	9741
2001	16.0	17.5	22.5	10.4	33.6	17815

Source: Town and Country Planning Department, Jorhat

It is observed that the working population in the municipal area is engaged in trade, commerce and services. This is also true for the master plan area as a whole. Moreover, the percentage of workers in these two sectors of economy has considerably increased during the decade 1991-2001.

Table -10: Occupational Distributions – Jorhat Master Plan Area, 2001

Occupation	Jorhat Municipal Area		Jorhat Master Plan Area(excluding municipal area		Total Master Plan Area	
	Number of Workers	Percentage of total workers	Number of workers	percentage of total workers	Number of workers	Percentage of total workers
Cultivators	25	124	1936	10.87	1965	6.92
Agricultural labour	2	.02	244	1.37	246	.84
Livestock Forestry fishing Hunting and plantations orchards & allied activities	164	1.58	2130	11.00	2302	8.25
Mining & quarrying Manufacturing processing servicing and repairs household industry	7	.07	1.7	.08	24	.12
Other household industry.	1085	10.45	2261	12.69	3346	11.84
Construction	325	3.03	848	4.71	1173	4.15
Trade & Commerce	4011	30.70	2328	13.07	6339	22.47
Transport storage and communication	1262	12.15	1645	9.25	2907	10.35
Other service	3392	32.70	6101	34.28	9493	33.61
Total workers :	10,383	1006	17815	100.00	28198	100.00
Total Population	38,247		63674		93921	
Percentage	34.33		28.00		30.00	

Source: Town and Country Planning Department,Jorhat

It is also observed that the working population in the primary sector of Jorhat master plan area has decreased from 28 percent in 1991 to 16 percent in 2001 (table -9).

The predominant functions of Jorhat are administrative, trade, commerce, transport, and communication (table-10). Analyzing the population trend, their occupational distribution and economic activities of the region, occupational structure has been envisaged for the Jorhat town by 2001, in table -11.

Table -11: Total Numbers of Estimated Workers, 2001

Sector	Total Workers	Percentage of Total Workers
Primary	8,340	10.00
Secondary	16,680	20.00
Tertiary	50,380	70.00
Total ::	83,400	100.00

Source: Town and Country Planning Department,Jorhat, 2004

So far, industrial development in the Jorhat town is not significant. However, there is scope for development of small-scale industry if necessary infrastructures are provided. The development potential of some of the industries that can be easily established in the Jorhat area is discussed below.

Light Engineering Industry: This industry group is expected to make marked improvement in the industrial structure of Jorhat in the future. There is tremendous scope for infrastructure manufacturing, tea garden implements, tea set fitting, hardware like bolts nuts, grills, shutters, window frames, wire nettings etc, which are primarily needs in tea making industries.

The Regional Research Laboratory and the Small Industries Development Corporation have indicated excellent scope for establishment of small industries based on the waste, skins and hides, bones etc in the region.

Transportation Equipment and Servicing Industry: Along with the development of road transportation network, the automobile servicing industries are likely to expand further. Jorhat has also good scope for expansion of servicing industries for tea garden equipments like tractors, tea-manufacturing equipments etc.

Wood and Wood Products: The forest resources, near Jorhat provide good scope for establishments of industries as saw milling, manufacture of furniture and fixture, tea sets, plywood etc. It can also make significant contribution in establishing paper pulp, rayon pulp and board industries.

References

1. Michael, J.E: "*The North East Frontier of India*", First ed. (Delhi, 1973), p. 21.
2. "Phukhuri" stand for tanks.
3. Govt. of Assam, Gazetteer of Sibsagar, (Shillong, 1976).
4. Singh, R.L. (ed) op. cit. p. 316.
5. As quoted from Phookan,J: "*Fauna and Flora of Kaziranga*", Guwahati. 1977. p4.
6. Ibid, p.7.
7. Singh, R. L. (ed): "*India, A. Regional Geography*", (First ed.) Varanashi, 1971, p.306.
8. Mathur, L.P. and Evan, P. 1964: "Oil in India", XXII International Geological Congress. Special Branch, New Delhi.
9. Ray, D. 1981: "Structural Interpretation of Jorhat Area, Upper Assam Valley" (Workshop on Geological Interpretation of Geophysical Data). Institute of Petroleum Exploration, Dehradun, India.
10. Murty, K. N. 1983: "Geologcal and Hydrocarbon prospects of Assam shelf advances and present status", pet, Asia Journal November p.1-14.5. Singh R.L. (Ed.) op. cit. p. 316.

11. Das, M. M. "Pattern of Soil Distribution in Assam", The North Eastern Geographer, Vol. XII, (Guwahati, 1981) p.22.
12. Singh, R.L. (ed): "*India – Regional Geography*", First ed. (Varanashi, 1971) p. 313.
13. Ibid
14. Borthakur, M: "Weather and climate of Assam" North East India
15. Geographical Society, Extension lecturer, Serial no. 2.
16. Govt. of Assam, "*District Gazetteer of Sibsagar*", Shillong, 1967, p. 328.
17. Govt of Assam, op. cit. p.5.
18. Barooah, A. R: "*Ancient Geography of India*" (Guwahati, 1971) p.68.
19. As quoted by Barooah A.R. in his "*Ancient Geography of India*", Guwahati, 1971 p. 68.
20. Districts Gazettear of Sibsagar (Shillong, 1976), p.33.
21. Puri, B.N 1968: "*Studies in Early History and Administration in Assam*", Guwahati p.68.
22. Chatterjee, S.K. op. cit. p. 9.22.
23. Op. cit. p. 6-7
24. Ibid
25. Das, M. (1999): "Patterns of Social Change Among the Major Tribal Groups in Guwahati City", an unpublished M. Phil Dissertation, Gauhati University.

CHAPTER III

Urban Growth and Settlements

Industrial revolution sparked of another revolution in the world, that is, the urban revolution. While industrial revolution necessitated urban revolution, the transport revolution facilitated it. Industrial revolution added a completely new character to the urban centres. For the first time the urban centres became primarily centres of production of goods and services. The new role of production created various kinds of occupations in an increasing manner. Occupation of diversification in these centres attracted more people from other areas leading to large population concentration. Population of these urban centres was increased by the twin processes of migration and natural increase. In due course of time, higher degree of population concentrates industrial development, development in transport and communication forced urbanization process to expand horizontally and vertically. The higher degree of physical expansion is faced by many of the cities of present day's industrialized countries have resulted in urban sprawl.

The explosive increase in population and the sprawling urban growth yield many socio economic and political problems. The problems of urbanization faced by the world today are so amazing that it is often termed as urban crisis. The urban crisis is getting increasingly acute all over the world especially in developing countries like India. Understanding of the problems faced by the fast urbanizing societies has become utmost importance. So to study the aspects like water logging, drainage congestion etc. one cannot deny the importance of the urban growth as a whole.

III.1. Planned Growth

The need of advanced planning in the case of urban areas has now been realized in order to shape the physical environment to meet the evolving social and economic needs with realistic regards to investment programs and priorities. In a developing country like India, the process of urbanization is getting its momentum with the increase in population, mobility and industrial development during the last few decades. There is no doubt that our towns and cities will grow in a faster rate with the progress of our economy that we are trying to achieve through various plans and programs. Urban planning is the welfare of the urban people for the future operations that are essential for urban planning in which direction it should grow. To do this a background study of a town is a necessary requirement. Every urban planning must be based on the extensive knowledge of at least the physical area, population structure, land use, transportation and municipal amenities etc. History, socio-economic and locational characteristics of the town as well as the immediate environs must be studied since urbanization is the composite indices of development. This chapter studies with the factors – origin of growth, its functional activities and peripheral growth of the Jorhat town.

III.1.(i) Origin of Growth

It is observed that the Brahmaputra valley keep the existence of various racial elements passing through in between India and south east Asia. In reverse direction left their traces in the hills and valleys of Assam. Historically, the area now represented by the Jorhat region was a place of centric-Dravidian and Bodo race.

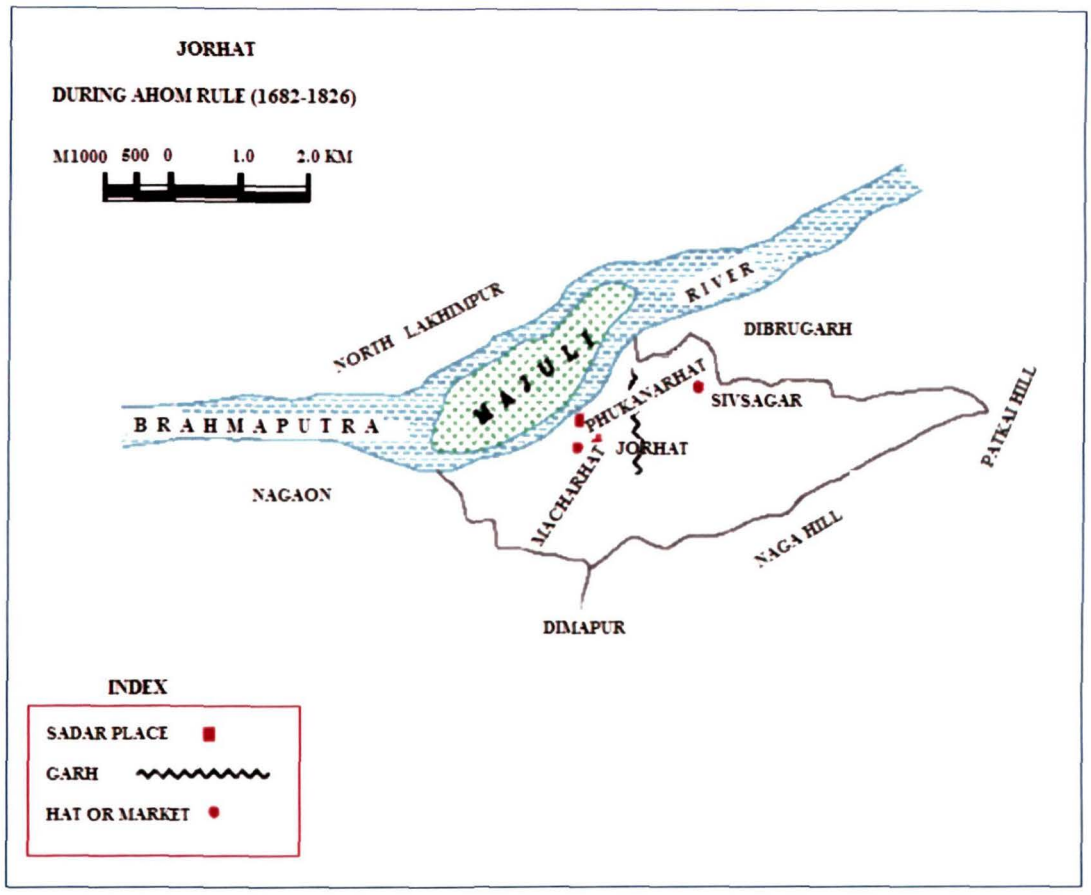
The Jorhat area was the meeting ground of different tribal as well as non-tribal population, migrated from the west, east and hill tracks of north and south in the pre Ahom period and Ahom period (13^{th} – 18^{th} Century). The prominent function of Jorhat is administrative, trade, commerce, transport, and communication. Jorhat conserves a long monotonous history of Ahom period ($13–18^{th}$ century). It was the very important and bright period, as the area had shaped its economy and developed a cultural and political set up under long administration of few strong 'Swargodeo' (Ahom kings). This is the period when the people of Brahmaputra valley, developed both external and internal trade under the umbrella of Ahom administration. Moreover, Ahom established good relations with different tribes living within the territory as well as the surrounding areas.

Under the British administration (1838– 1942) the economy was gradually developed and several market places were developed in different parts of the Jorhat region. King Gourinath Singha (1794 AD) built his capital at the present site of Jorhat town. Later on, two weekly *hats* (markets) were established in this area. It is presumed that the name Jorhat originated from these two *hats* or markets (map-4).

Simultaneously, with the location of the administrative head quarter at Jorhat, the British also established large number of tea estates in this region. In order to export tea and import other essential commodities, a river port was established at Kokilamukh in Jorhat in the year 1847. Jorhat was also connected with the rest of the country by means of railways in the year 1885.

Thus, with the gradual development of road, rail and water transport, Jorhat began to grow as an important urban centre in upper Assam. During the post independence period, with the opening of Engineering College, Regional Research Laboratory, and Agricultural Universities etc Jorhat began to grow as an important centre of education and culture.

Map-4



Source: Itihahe Suwora Sokhota Basor , Rajkumar,S,1968

III.1.ii. Functional Classification

The town grew at a rapid pace especially after 1941 and during the Second World War. The zone of influence increased considerably, with the influence of new wave of migrants. Additional areas were brought under Jorhat. The recurring addition of small villages that clustered around old tiny Jorhat made the spatial expansion, look

natural. Even up to the middle of the present century, the town area was divided functionally into five categories. (i) Religious, (ii) Administrative (iii) Educational (iv) Commercial and industrial (v) Cantonment and (vi) Residential.

The Burhi Goshani Dewalaya in the heart of the town along with other temples like Vishnu Mandir, Kali Mandir etc. still bear witnesses to the religious evidences about the past of the town. Besides, temples like Negheriting, Garakhia Dol, and Phakua Dol etc. in the western side; Rajamaidam, Lachit Borphukan's maidam in the northeastern part and many other big tanks dug by the *swargodeos* of Ahom kingdom in the town, which was originally attracted the people from rest of the country. The then premier town of pre-Ahom and Ahom period, encircled by "*Garh*" (high embankment) to defend from invaders (map-4). The relics of those still bear the evidences of the then Ahom capital and administrative town. Later, the commissioner office, court building, sadar police station of the main town in the south bank of the Brahmaputra river added to the testimony of administrative function of British period.

Further, academic institutions like Bigyan Mahavidyalaya, Kendriya Mahavidyalaya, Engineering College, Theological College in the east; North Eastern Regional Research Institute in the west; Bahona Mahavidyalaya, Sombari Bora Mahavidyalaya, Bahphala College, Mahatma Gandhi College, Sarvodaya Mahavidyalaya etc. in the north and Nobinchandra Bordoloi College, Assam Agricultural University, Toklai Tea Research Institute, Jiva Kanta Saikia Homeopethy College in the south were established just after the independence indicating systematic functional activities independent of its own. All these led to spatial expansion of urbanization. Chowk Bazar is the trade and commercial centre of the town. Cinnamara in the south, with its many small and big industrial complexes

became an industrial centre in greater Jorhat. With the progress of political consciousness in the country, army and air force cantonment were growing up much rapidly for its strategic reasons. These areas are Rowriah Airport in the southwest, Mariani and Lichubari cantonment in the south side.

As the town expanded due to the diversity of activities, the natural inclusion of contiguous region without the pronounced design from the authority makes the unplanned expansion 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 Bongalpukhuri, Atilagaon, Choladhara, Digambar Chowk, Kushal Nagar, Marwari Patty, Rajamaidam, Kenduguri, Charigaon, Jail road, Na-Ali, Club road, Chandan Nagar etc. are the major residential areas that are developed within the last few decades.

III.1.iii. Peripheral Growth

Peripheral expansion of an urban mode is a common phenomenon and Jorhat is no exception. With the initial area of 72.8 kilometers, Jorhat expanded in phase manner. This was reinforced by peripheral locations of the educational institutions and military cantonments as well as the airport. So much so that this expansion has been covered at, present an area of 87.8 square kilometers. With such an area exhibiting diverse physiographical attributes and constraints, there is an urgent need of a master plan that takes into account all major characteristics 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 thus clearly suggests a distinct need to re-orient and re-adjust the patterns of land use in the Jorhat town of its immediate environs.

III.2.Unplanned Growth

Unplanned growth of towns in India as in other third world countries has become a common phenomenon. Wherever towns have emerged and expanded, they have tended to become identified with the problems, which seem inevitably to accompany them. Many of the problems are the result of rapid and haphazard growth, excessive population density and little or complete absence of public health facilities. Jorhat is the premier town and a developing node of upper Assam. 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 limited geographical area.

III.2.(i) 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 town the brink of environmental disaster. Growing tendency of urbanization and increasing migration of the rural population to the outskirts of the town has only added more to the nightmare.

The present chaos in the town areas primarily stems from the ineffectiveness of the Jorhat municipal board administration. The Jorhat municipal board has found itself to be coping with the growing problems than it can handle. In its defence, it must be said that it has perpetually been short of funds. The reason behind it is perhaps due to nature of revenue collection policies and implementations. In short, the municipality perpetually finds itself in alleviating its priorities that 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.Besides this, Town and Country Planning itself has been neglecting in completing the master plan and zoning regulation book regularly. The last plan book was published in 1972, that is more than three decades ago. So it hampers in the planned growth of the town as a whole. This is due to the lack of skilled resource persons as well as non-allocation of governmental fund. Despite the presence of Jorhat Municipal Board, Jorhat Development Authority and Town and Country Planning Organization to look after the problems of the town, but there hardly seems to be any co-ordination between them. As such, it looks that the town itself had to find solution for its problems one way or the other.

Developing as an important commercial centre of the region, Jorhat depicted numerous lanes and by-lanes that served as important transport artery. After independence, with the growing importance of socio-economic activities and development in the state and the region these transport arteries proved to be inadequate. This has also strengthened the greater rate of migration and population pressure. This has strained the existing networks to the maximum. Moreover, with the expansion of the town 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 maintained transport infrastructure and network. In addition to this, the rapid increase of density of vehicles further exposed inadequacies of urban planning in the town.

Similarly, urban waste disposal have also been over extended, inadequate and mostly located in congested areas. This 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 utilized to reclaim land as has been normally done in other Indian cities like New Delhi, Mumbai, Kolkata, Chennai and Guwahati. This reclaim lands have been put to various land uses such as construction of residential complexes, parks and playgrounds etc.

The enactment of urban land ceiling act has been theoretically a bold step for the town of Jorhat. 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 sample lands have become an easy target of encroachment and formation of slum areas , thereby further compounding the problems and over stretching the function of Jorhat municipal board. 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 directly encouraged unauthorized and illegal urban development, which incidentally puts pressure on the resources and manpower of Jorhat municipal board and town and country planning department.

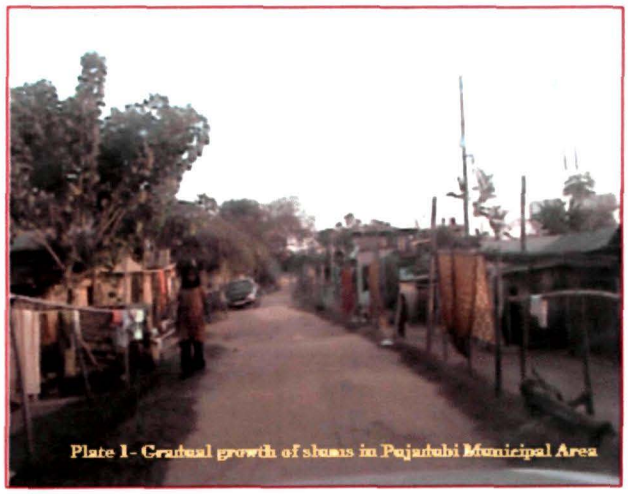


Plate 1- Gradual growth of slums in Pujarbhi Municipal Area

The above points as well as the detail field observation made by investigation clearly suggest numerous instances of encroachment of government land, illegal construction and presence of numerous slums within the Jorhat municipal board (Plate-1).

Though the reasons and motivators 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 Jorhat municipal area should remain foremost for any organization that looks after the urban planning of the town. Encroachment in greater Jorhat area has assured a menacing proportion during the last few years causing hazards to the growth of the town. Tocklai area, which is a small river site in the town, has now been covered with encroachment though the district authority once cleared them in 1999. Due to lack of foresightedness and ignorance of follow up measures to be taken by the authority concerned, the cleared lands all over the town have been re-occupied now (plate-2).

Plate 2- A post eviction reoccupied area along Tocklai River

The situation is worse in the newly sprung residential areas in the northern fringe of the town at Rajamaidam, Sweeperpatty and Digambar Chowk where drains and by-lanes have also been encroached. A vast area of Tocklai, abundant railway track between Jorhat and Nimatighat, Sarbaibandha, Atilagaon, Rajabari Mission Compound have also been encroached upon in haphazard manner (plate-3). These very areas though spacious already wear the look of an ugly slum.

The big stretch of land along the Assam Trunk road from Tarajan to Bhogdoi river bridge, Gar-Ali from Nirmal Cyclemart to Lahoti which was free earlier is occupied now, giving the entire portion a slum look where repairing shops, tea stalls, junkyards have sprung up. The most conspicuous portions are Marwari Patty area. The both bank of the Tocklai, the portion from Fanci Ali to Pujadubi have been encroached upon. Encroachment has been noticed also on both sides of Rajamaidam-Kabarstan road (plate- 4).

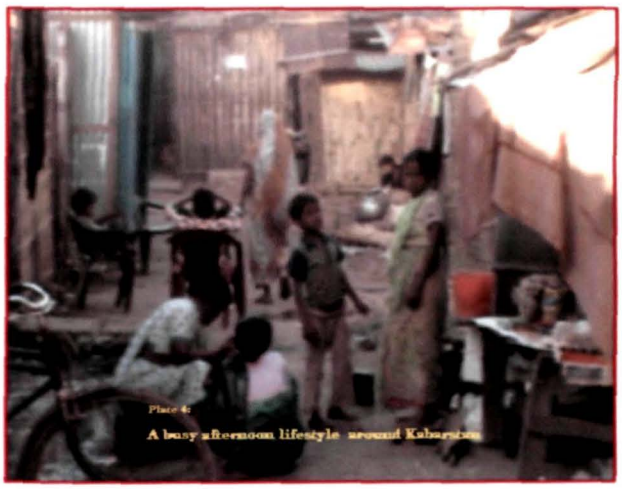


Plate 4:
A busy afternoon lifestyle around Kabarstan

This illegal occupation has not only become great traffic bottleneck but also checked the future prospects of road expansion. In view of the rapid growth of traffic movement inside the town, the existing road network appeared to be too narrow and inadequate even for the medium traffic. The peeled roads could be seen all along which is a common feature .Hence the recent eviction (1999) carried out by the Jorhat municipal board with the help of Jorhat district administration and police. The Jorhat municipal board has so far demolished a good number of unauthorized and illegal constructions on government land, which had greatly hampered widening of Jorhat-Guwahati road. There were persistent demands from the 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 Gar Ali, Assam Trunk road and some other roads in the town, large scale violations of building construction rules were evident.

The present public health (sanitation) situation in Jorhat is deplorable and deteriorating day by day. One may be inclined to feel that the citizens of Jorhat are helpless against preventing this deterioration as the Jorhat municipal board has clearly shown its inadequacy both in resource and manpower. In fact, what should be done are the creations of sewage water treatment plant to clean the urban waste before they are allowed to drain into the rivers. The by-products can be used profitably for improvement of land. Due to lack of strict vigilance of the authority, the manhole covers on foot path- cum-drain of the town stolen away. As a result, it remains uncovered for month's together (plate-5) and it becomes death trap for footpath users. As far as garbage is concerned, these can be properly and economically used, for example, to tap them for producing energy as manures (biogas) etc. Moreover, these wastes can be used to fill many of the low-lying areas that get flooded during rainy season.

III.2.(ii) Rate of growth

The rate of growth of an urban area depends upon its physical setting and cultural setting on which the population, its size and their activities act. The 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 limitations. It is often controlled or encouraged by the i) Physical landform like highlands, water bodies, forests etc. ii) Human interference like railway line, roads canals etc.

Greater Jorhat with the inclusion of Majuli, can be divided into four physiographic divisions. These are, a) Central Business District area (Chowk Bazar, Gar Ali, Marwari Patty to Truck Stand, Tarajan, Balibat, Jagannath Barooah road) b) Low lying areas in the north (Rajamaidam New Colony, Rajatia Paddy Field, Nokari Bamun Gaon and Sarbaibandha) and c) High land plain (Kakati Gaon, Atila Gaon and Ward no17) and d) Majuli (Garmur, Kamalabari, Bangaon etc.). It may be mentioned that, the highland plains of Jorhat has a potential for rapid growth although the Naga hills in the South limits a scope for its expansion.

b) Growth of population: According to 1961, the total population of Jorhat municipal area stood at 24,953 persons. In the year 2001, the total population of the area rose to 67,786 persons showing an increase of 16.35 percent (table-5). The number of total population of Jorhat master plan area was recorded at 73,432 persons (1961). In the year 2001, the total population of Jorhat master plan area rose to 2, 02,877 persons showing an increase of 19.14 percent (table-6). A detail analysis of population growth has been given in chapter II.

c) Density of Population: The overall population density of Jorhat municipal area as per 2001 census is 134 persons per hectare. In comparison, the over all urban density of Assam which is about 44 persons per sq kms, the density of population of Jorhat municipal area is quite significant (Master Plan Zoning Regulation Book, Jorhat,1972). In 1971, it was 61 persons per hectare. Within the town, the density of population varies from ward to ward. The table-12 shows the ward wise density as per

2001 census. The highest density of 116 persons per hectare occurs in the ward number II, which is the central part of the town (map-5). The density of population of Jorhat master plan area was 13 persons per hectare in 1971, which increased to 15 persons per hectare in 1991. Comparatively low density of population is due to the fact that area away from the town is sparsely populated with pockets of settlements amidst agricultural land.

Table-12: Ward wise Density of Population of Jorhat Municipal Area, 2006

No of. Wards	Population	Area in Hectares	Density of population
1	5026	494.69	10.16
2	4487	38.68	116.00
3	4192	66.13	63.39
4	4621	132.83	34.79
5	3031	123.03	24.64
6	2933	29.36	99.89
7	3814	114.82	33.22
8	1853	31.49	58.84
9	2879	393.63	7.31
10	3040	311.86	9.75
11	1453	29.38	49.46
12	2353	329.86	7.13
13	3451	319.03	10.82
14	3816	514.12	7.42
15	5350	523.68	10.22
16	3435	402.02	8.54
17	5800	398.52	14.55
18	829	212.14	3.91
19	5225	513.82	10.17

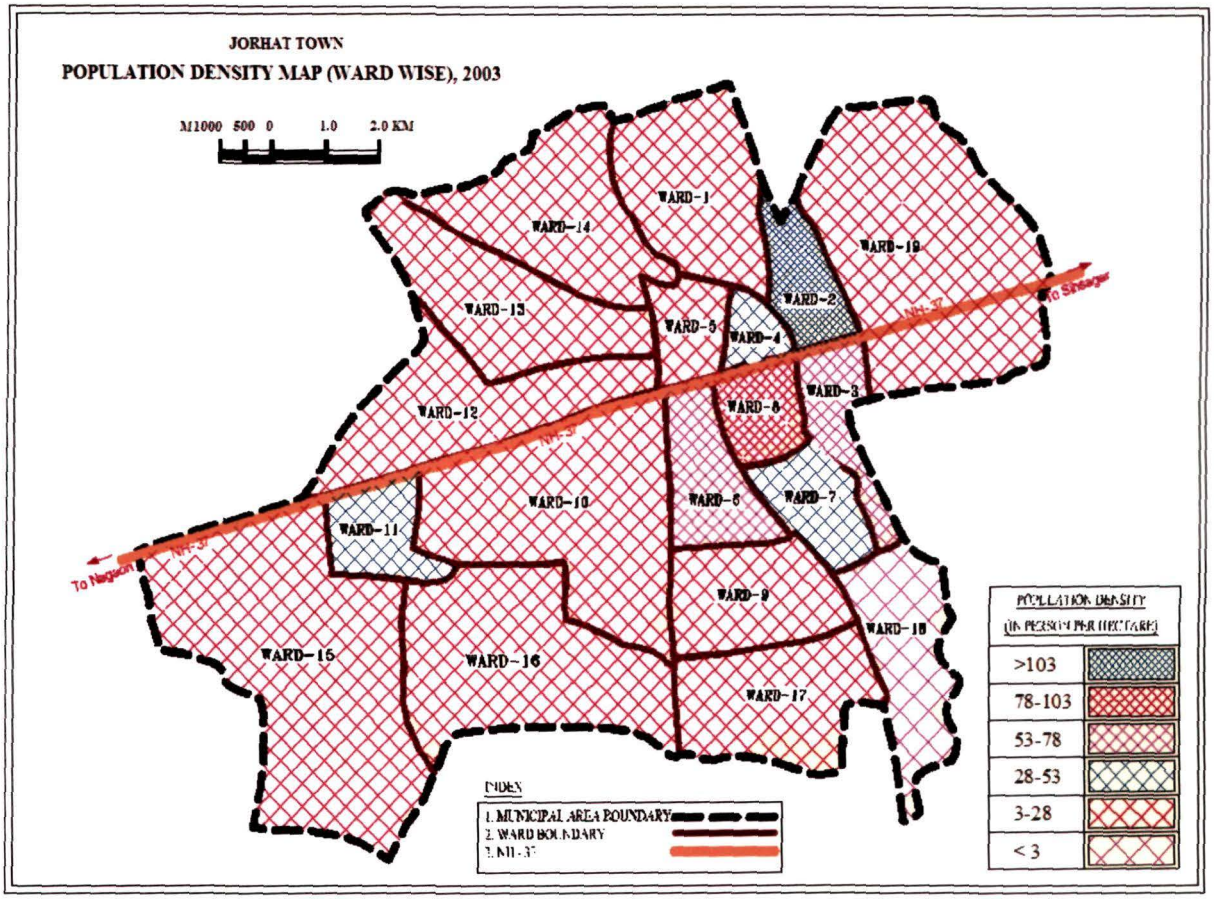
Source: Computed from the Population data, Census of India,2001

The phenomenal growth of the population in the recent decades may be attributed to the following causes:

i) Inclusion of some additional areas into Jorhat complex ii) Influx of immigrants both from inside and outside the state into the town iii) Emergence of Jorhat as the chief commercial centre in upper Assam and, iv) Concentration of commercial as well as industrial activities in the town.All these factors of increase in

population together with the encroachment of land in several new colonies with less civic amenities led to worse conditions of the town.

Map- 5



Source: Prepared by the Researcher

d) Growth Rate of Industries and Commercial Establishments: The growth of industries and commercial establishments are some of the indicators to measure the growth rate of a town. The possibility of development of large-scale industry in Jorhat is very limited. However, there is a sufficient scope for development of small-scale industries. So far, the industrial growth is concerned; it has increased from 75 units to 165 units during the period 1991 to 2005.

The table-13 indicates that the factors for the industrial growth such as location, raw materials, labours, capital and marketing facilities are favorable to some

extent and have encouraged industrial growth of the environments of the town. There are as many as 14 establishments. Food products alone claim 68.07 percent of the total establishments, which are bsically consumed by the people of the town as well as sub-areas. Wood products (7.23 percent) are the second highest unit followed by repairing and servicing units (3.61percent). Beside these, all other units possess almost same rank.

The lowest rank percentage is acquired by the manufacturing of motor vehicle units (1.20 percent). The other units are less in numbers, since it requires special attention for their growth.

On the other hand, the growth of commercial establishments in the town has nearly doubled from 1991 to 2005(table-13). The existing shopping areas are highly

Table -13: Growth of Industrial Establishments in Jorhat 1991 and 2005

Sl. No.	Major Establishment	Numbers of Units 1991	Numbers of Units 2005	Percentage of 2005
1.	Food Products	51	113	68.07
2.	Garments	1	2	1.20
3.	Wood products	5	12	7.23
4	Paper products and Printing	4	5	3.01
5.	Repairing and Servicing	2	6	3.61
6.	Miscellaneous manufacturing industries	1	3	1.81
7.	Transport Equipments and Parts	1	3	1.81
8.	Manufacturing of Motor Vehicle Traitors	1	2	1.20
9.	Manufacturing of fabricated metal products	2	4	2.41
10.	Chemical products	2	4	2.41
11.	Manufacturing of basic metals	1	3	1.81
12.	Electric Gas, Stream	2	3	1.81
13.	Repairing personal and household goods	1	3	1.81
14.	Auxiliary Transport activities	1	3	1.81

Source: Chief Inspector of Factories, Assam, 2005

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 revealed that the

percentage share of grocery (30 percent) was the highest in the town followed by service (28 percent), small clothing stores (11 percent), stationary (7 percent), pan shop (9 percent), small hotel and tea stall (9 percent) and medicine stores (6 percent). It may be mentioned that in the informal sector various kinds of activities are being run without having any formal connections or licenses (Revised Master Plan Zoning Regulation,Jorhat 2001).

e) Growth Rate of Traffic: With the limited road length of about 210 kilometers inside Jorhat area, it is extremely difficult to make the ratio between road length and width with traffic. During the decade 1997-2007, the growth rate of four wheelers and two wheelers have been increasing every year.

Table-14: Total number of registered and unregistered slow moving vehicles in Jorhat (upto March 2007)

Types of Vehicles	Registered	Un registered
Rickshaw	9,340	1,270
Bi-cycle	24,200	5,000
Bullock Carts, Hand Carts	1,900	600
Others	300	180

Source: Jorhat Municipal Board.

Besides, the registered slow moving vehicles, a significant number of unregistered slow moving vehicles are plying in the town, which created more complex situation (table-14 and-15). The registered rickshaws alone became double inside Jorhat during the year 1997 to 2007. Other slow moving vehicles like bicycle and bullock carts, handcarts etc. are increasing more than 300 percent in the last decade.

Growth Rate has been calculated with the help of the following formula,

$$\frac{Tyt - Byt \times 100,}{Byt}$$

Where, Tyt = Terminal Year of Traffic Number

Byt = Base Year of Traffic Numbers

Table-15:Decadal Growth of Registered Slow Moving Vehicles in Jorhat (1997-2007)

Passengers			Goods Vehicles	
Rickshaw		Bi-cycle	Bullock Carts, Hand Carts	Others
1997	4700	5,121	721	149
2007	9340	24,200	1900	300
Decadal Growth P.C	98.72	372.56	163.52	101.34

Source: Jorhat Municipal Board, 2007

Besides slow moving vehicles, the fast moving vehicles have also increased in manifold. The percentage of motor cycle and scooters have shown highest growth rate (244.74 percent) in last decade and is followed by trucks (143.33 percent), government vehicles (114.29 percent), buses (88.89 percent), auto rickshaws (86.82 percent) and cars (75.73 percent) respectively (table-16).

Table-16:Decadal growth of Fast Moving Registered Vehicles in Jorhat (1997-2007)

Year	Motor Cycle/ Scooter	Light Vehical Car etc	Auto Rikswa	Truck	Buses	LCV Goods Vehicles	Govt Vehicles	Others
1977	1900	721	76	30	9	260	28	89
2007	6,500	1,267	142	78	710	319	60	109
Decadel Growth in Percentage	244.74	75.73	86.82	143.33	88.89	22.69	11.29	22.47

Source: District Transport Office, Jorhat, 2007

III.2.(iii) Slums in Jorhat

The term 'slum' has been defined by Dickinson as 'an extreme condition of blight in which the housing is so unfit as to constitute a menace to the health and moral of the community."[1] It is highly congested area with falling land values, generally low economic status of inhabitants and excessive crime, mortality and disease rates. Erikson observed about the slum dwellers as, "The people whose life expectations are about the same, particularly the poor, the illiterate, the diseased, the

immigrants and other minority groups."[2] Slums, the ultimate result of human operations is a major part of the settlement of the town. When the whole world is talking about environmental pollution, one cannot just simply ignore the study of the slums, which is responsible for the blight of both geographical extension and social ecology. Local level study of slum is insignificant on academic level. Socio-economic and environmental pollution of the town is growing more and more for which the ever growing slums are responsible. The checking of this growth become important for which an intensive empirical study is very much needed for giving suggestions for remedial measure. The growth of slums is inevitable with the growth of civilization and urban centers but the growth should not be haphazard deteriorating the environmental quality of the town.

Here, a little effort has been done to give a bird's eye view on the origin of the slums of this town. Slums are those areas where spatio-social arrangements and processes are completely different from those of the town. Jorhat town has experienced unprecedented growth in its size, increasing without any perceptible thought of planning. The study area is culturally very rich and the heritage of this premier town of upper Assam is known from its history. The strategic location of the town, its physiography has helped the growth of the town as well as the growth of the slums. This has made information of slums in various pockets of the town inevitable. Moreover, the slums in the town have also indicated a high degree of informal sector activities that has totally disregarded not only municipality laws but also licensing policies, thus giving ways too many activities that have determined the town structure. It has been estimated that the slum population constitutes 10 to 60 percent of the total

population in large urban centers in India[3] and about 10 percent of the total population of Jorhat live in the Jorhat town.

The slums are scattered all over this town. Slums have grown rapidly with least interference from any agency. The cremation grounds, graveyards, industrial areas, multistoried buildings etc. have provided adequate impetus for the growth and location of the slums in the Jorhat.

There are five main slum areas in Jorhat. They have been developed on (a) the municipal land and on (b) the private land (map-6) .

A. On municipal land :

i) Puja Dubi

ii) Sweeper Basti

iii) Raibahadur Lane (Teliapatty)

iv) Dhakaipatty Area

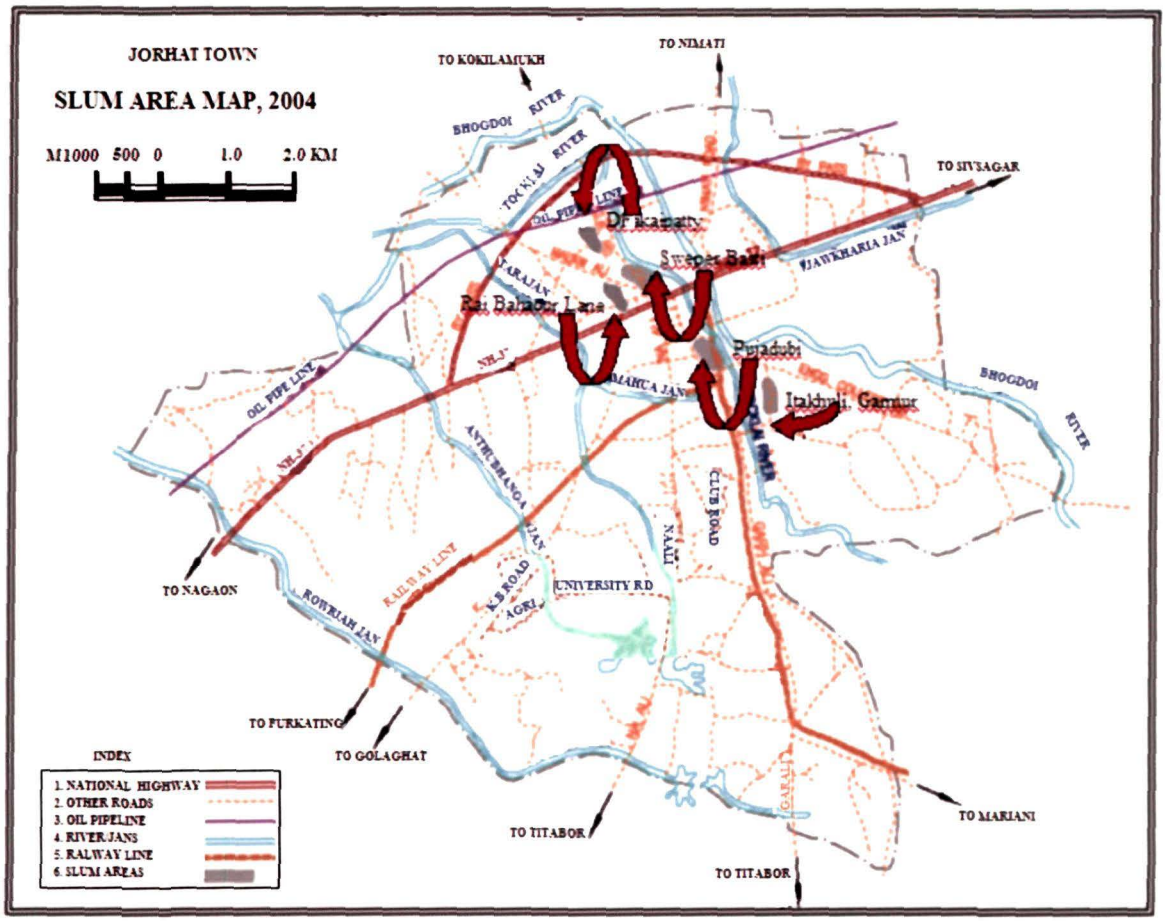
B. On private land:

i) Itakhuli Garmur area

ii) Dhakaipatty area

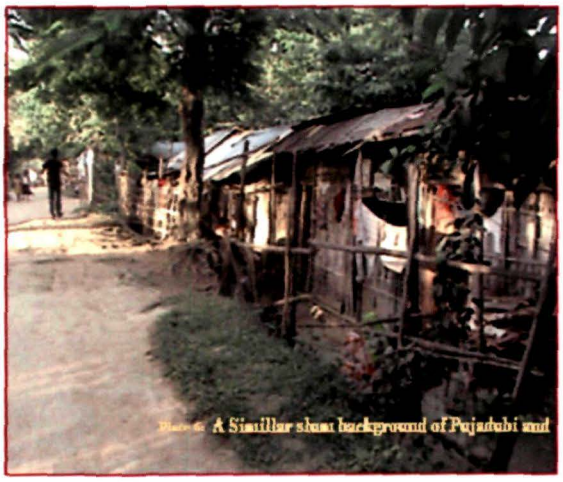
Besides, there are several other smaller pockets of slums, which are growing at a fast rate located in greater Jorhat area. These are Fancy Ali, Suwani Gaon on the river Bhogdoi embankment and Tarajan Smashan road etc. Besides, some other basti areas like railway line, Jorhat Junction and other mill and industrial areas are now exhibiting slum characteristics. The growth and origin of the slums generally seems to be almost same everywhere (plate-6).

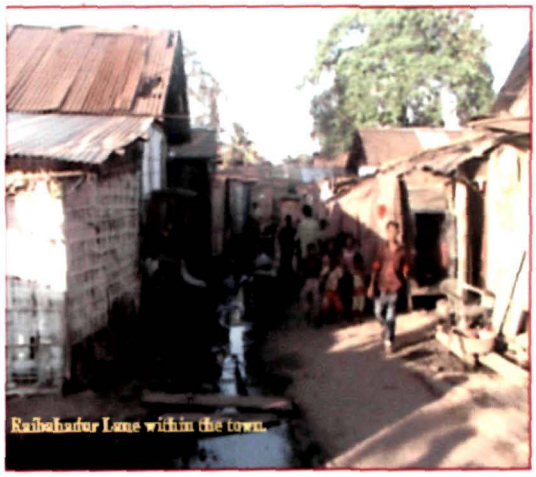
Map-6



Source: Town and Country Planning Department,Jorhat

They sprung up close to commercial areas, public parks, railway stations or near the big buildings. This was primarily to reduce the transport cost, time and available free


A Similar slum background of Pujatubi and


Railbahadur Lane within the town.

land for shelter. Population structure of slum area is peculiar. Most of them are

immigrants who cluster in groups according to the places of origin. The rates of growth of population among the slum dwellers are highest and majority of the inhabitants are children[4]. Literacy rate in slums are very low and they belong to the lower income group of the society. All members of a family above the age of ten years are engaged in various occupations, ranging from shopkeepers to daily labourers, rickshaw pullers, handcart pullers, guards and beggars. Surveys of aforesaid five slum areas were carried out in 2004. Out of these five areas surveyed revealed that the sweeper colony occupied single room house of about 72 percent, while another slum area Dhakaipatty occupies single room house of about 85.94 percent (table-17).

Table -17: Percentage of households occupied rooms in slum locations in Jorhat

Name of the localities	Occupied 1 room	Occupied 2 rooms	Occupied 3 rooms	Occupied 4 rooms	Occupied 5 rooms
Pujadubi	33.26	38.17	21.63	5.47	1.47
Sweeper Basti	72	9.46	9.72	6.09	2.73
Raibahadur Lane	38.05	32.41	22.08	.26	1.20
Itakhuli Garmur	50.26	24.15	20.71	3.71	1.17
Dhakaipatty	85.94	8.17	4.42	.91	.66
Average of all location	55.90	22.47	15.71	3.29	1.45

Source: Household Survey by the Researcher, 2004.

With ever-growing slums, all the accompanying vices - gambling, thefts etc. have risen in the town. The petty crimes have increased due to the emergence of the floating population in the town that normally finds sanctuary in the slums. Besides, adding to the crime rate of the town 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 or epidemic is often taken not so sensitively.

There are many pockets of slum areas around the town also. For example, Atilagaon, which is situated along the Jorhat-Furkating railway line, most people in these localities are migrated from Uttar Pradesh and West Bengal whose main occupations are wage earning, vendor, cart and rickshaw puller etc .The slum Dhakaipatty is opposite to the Marwari Patty and belongs to the Muslim community of low income group . There is no any approach to this location from the main street. The slum dwellers are encircled by the multistoried buildings. Some people engaged in earning their livelihood by selling illicit liquors to the labourers. The houses are constructed mostly in unplanned manner, leaving no space in between the adjoining houses. The houses are very low without ventilation and rooms are dark even in the daytime. This is a crime prone area where men of crimes and dubious character predominates others. Slums occupy a long strip of both sides of the Raibahadur Lane are mostly occupants from Bihar. The people on both sides of the abundant railway line (formerly it connected the town with Nimatighat) belong to the Bengali and Bihari people. The lands where they settled are owned by the railway authority and occupied illegally. 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 garbage dumped outside their houses, which release offensive smell throughout the day. Neither water supply nor electric supply is available here. Some shaded rooms are used for cooking and dwelling purposes. The inhabitants of this area are beggars, daily wage laborers, street vendor etc. The police authority has raided many times followed by breaking houses by the district administration. As the slum dweller found this area suitable the mushroom growth of huts again up within no time. A census of India survey revealed that a substantial number of slum dwellers of

Pujadubi area are vagrant and some of them either from Bihar, Punjab and mostly Bangladeshi refugees.

III. 2.iv. Peripheral Growth (unplanned growth)

Like other towns and cities of the country, the trend and tendency of growth of Jorhat town is being spread towards periphery. The main factor of decentralization is the cheaper rate of land in the peripheral area. Most of the residential areas of Jorhat have developed towards periphery in the last few decades. The areas are Dergaon, Teok, Nimatighat, Titabor, Mariani, Airforce etc. Commerce on the other hand follows this trend. The warehouses and retail functions moved to outer locations, suburban shopping centres with their base in the central business district (Gar Ali, Marwari Patty, Tarajan, Balibat, Chowk Bazar, Jagannath Barooah road etc.) also expanded towards the periphery. This type of peripheral growth generally hampers in town planning for future development because shopping centre always consider threshold population rather than town planning. Industries are seizing the opportunity of larger peripheral sites at lower cost; Lower taxes and fewer restrictions for maximum utility also develop some medium and light industries in Kenduguri to Kakajan on the national highway 37.

Outward migration cannot deny the peripheral growth. Though lands are less expensive outside the town but still it become expensive to redevelop for settlement. Lands lying vacant towards periphery are generally governmental lands with very little amount of patta land. These government lands are being used by the encroachers. These types of area can be cited from Rowriah, Cinnamara, Baghchung, Kenduguri, Kamargaon and many other places in the periphery of the town.

III.3. Scope of future growth and development

There are still some scope for future growth and development of the town. In view of this, a modified master plan has been prepared by town and country planning department of Assam. The plan period is up to 2021. But, it is true that the town has to function with efficiency even beyond the plan period. The existing major functions and the rate of growth have been discussed earlier (chapterIII 1.ii and III 2.ii). The impact on the future growth of a town is a desirable and obvious fact. Based on the previous studies, Jorhat town can be inferred to hold the following major functions to decide its future growth.

a) As a premier town.
b) As an administrative centre in hierarchies viz, state, regional divisions like district, local levels etc.
c) As a centre of trade and commerce in the region.
d) As an industrial centre.
e) As an educational and health centre.
f) As a transportation centre.
g) As a recreational centre.

Population study for future development is one of the major aspects to be taken into account for studying the growth and development of a town. To estimate future growth of population the past growth of population of few decades 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-18) on population of Jorhat up to the plan period is made by the department of town and country planning, Jorhat. The major snag in

estimating the growth rate of town population is the mobility of people from the rural areas to the town.The future growth of population of Jorhat master plan area depends

Table-18: Population Projection of Jorhat Master Plan Area, 1961-2021

Year	Jorhat Municipal Area		Planning Area (Excludg Municipal Area)		Total Master Plan Area	
	Population	percentage increase	Population	percentage increase	Population	Percentage increase
1961	24,953	--	48,479	--	73,432	--
1971	30,247	21.2	63,674	53.1	93,921	31.3
1981	39,321	30.00	93,107	46.3	1,32,428	41.00
1991	51,117	30.00	1,34,282	44.3	1,85,399	40.00
2001	66,256	29.62	1,35,091	8.10	2,11,347	14.09
2011	1,05,219	58.83	1,53,463	13.60	2,58,682	22.41
2021	1,98,788	88.93	1,74,334	13.60	3,73,122	44.24

Source: Master Plan Zoning Regulation Book,Jorhat, 1972

not only on natural increase but also the forces of urbanization pulling people from outside areas. It is found that the average increase per year for the entire master plan area since 1951 to 1971 is 3.6 percent. In projecting the population up to 2021, some important factors were considered. For example, i) Jorhat as an administrative centre ii) Establishment of educational institution like Engineering College, Agricultural University etc. iii) Centre of tea industry iv) Regional Research Laboratory as a booster for industrial development v) Expansion of activities of the army and air force establishments and location of Arunachal supply centre and vi) Jorhat as an air and road transport link to Nagaland etc. The decennial increase of population in Jorhat master plan area between 1961 and 1971 was 31.3 percent assuring a decennial growth of 41 percent for the first decade and 40 percent for the next decade. The projected population of Jorhat as per 2001 was 2,11,347 persons. Considering the latest decadal growth rate of 13.6 percent for Jorhat, approximate population figure for 2011 and 2021 are as shown in the table-18.

As the area of the town would remain same up to the plan period and even after the plan period there is less scope for expanding the town by space. In context of administrative functions, the town 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 houses in remote residential area, which sometimes, people find difficult to locate. Such office campuses can be set up in the government land situated here and there in the areas like Statfed Campus, Na Ali and in front of the Jorhat post office etc. As an administrative centre Jorhat requires adequate space for trade and commerce.

III.4. Regional Impact

The impact of urban influence on the surrounding areas (urban and rural) has multifaceted effects on their social and economic structures. Thunen[5] was the pioneer of model builder of city's influence on the immediate agricultural land use pattern. Further Ratzel[6] developed the concept of hinterland and recognized the interconnections of areal integration of hinterland with certain kinds of foci and spatial organization of society around such foci. However, the city-region relationship gained more importance after Dickinson[7], Smails[8], Harris[9], Bouge[10] and Ullman[11] etc. extended the relevance. Other relevant studies have been carried out to develop more theoretical models of city regions and were demarcated on the basis of spatial interactions of population of urban centers 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[12], Zipf [13], Reilly[14], Taaffee[15] Hartshorn and Alexander[16] used the same model with some modifications (without applying constant).

The selection of the criteria required for the purpose was however a problematic one because on the one hand, a proper set of criteria showing the relationship has to be taken and on the other hand, the choice of them is restricted by the problems of availability of data. It is observed that a variety of socio-economic criteria have been used by both western and Indian geographers for delineating the zone of influence of the city region or urban field, whatever term was used for this purpose. While the criteria, such as telephone service, wholesale, drug trade, radio broadcasting etc. used by the western geographers is not suitable for Indian situations, the criteria used by Indian geographers also cannot be used in all situations without examining their merits and demerits. For example, the criteria like the flow commodities, bus service, educational service, medical service, newspaper circulation etc. have wide-ranging service areas and therefore not all the areas covered by them can be brought under the influence zone in the true sense of the term. It is because the intensity of such services is considerably high only up to a certain distance from the city. Beyond this, although the areas are connected by long distance services they are not safely dependent on the city. These services are again of different types, not all of which may be useful for finding out the zone of influence. For instance, the bus services are of different types like the state transport bus services, private bus services and city bus services etc., which connect both long and short distance areas, reflecting different degrees of influence. In general, the state transport bus service covers up to a very long distance while the private buses and city buses connect the areas of important surroundings. Therefore, the relevance of first one as a criterion for defining the zone of influence as required for our purpose will be of little significance. In the same way, the different kinds of educational services and newspaper

circulations covers areas of different distances are showing different degrees of influence. Therefore, a purposive selection of these services is necessary and it should be done in such a way that it can reflect a considerable degree of relationship between the centre and its surroundings. Moreover, a single criterion may not reflect the total character of the relationship and hence the need arises for consideration of more than one criterion for the purpose.

The studies of urban influence done by the Indian geographers are worth mentioning. The problem of delimitation of rural urban fringe, the characteristics of such areas has been studied in Indian context by Singh[17], Sharma[18], Kar[19] and so on. 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 services and as indicators of city's influence which may not be applicable in Indian context and north eastern region in particular. This is because these facilities have not fully developed. However, the influence of the Jorhat town on its neighbouring area is examined in terms of geo-social and geo-economic activities as well as strategic location. Analyzing the city's influence in terms of distance, Nangia[20] delimited the metropolitan area of Delhi by daily communication to work, immediate shopping and social trips up to 25 miles. To study the gradient patterns Borah[21] included a distance of 20 kms. from the city periphery as the urban influence does not extend beyond this.

Here in this study, the zone of influence of Jorhat will be found after evaluating the theoretical and empirical analysis. For the analysis, secondary data are considered and examined. For demarcation of the influence zone boundary, the gravity potential model has been used taking into consideration the location of the

urban center of the upper Brahmaputra valley. In this model, the primary assumption is that the amount of interaction between the two urban centers is directly proportional to the number of people living in them and inversely proportional to the intervening distance. Based on this assumption, the interaction values between Jorhat and the other centers have been found out (table-19 and fig-5).

Table-19: Population interaction between Jorhat and Urban Centre, 2001

Sl. No.	Centers	Population	Population interaction (in Lakhs)
1	Jorhat	137814	-
2	Nagaon	123265	943
3	Tezpur	48550	491
4	Makum	15118	111
5	Tinsukia	101957	780
6	Digboi	20553	129
7	Lido	8571	50
8	Dibrugarh	133571	1472
9	Naharkatia	15523	142
10	Sivasagar	53854	1374
11	Amguri	6997	267
12	Sonari	17507	238
13	Moranhat	5779	93
14	Mariani	20997	1446
15	Titabor	7545	495
16	Bokakhat	8844	203
17	Dergaon	13446	741
18	Golaghat	33064	785
19	Numaligarh	8783	252
20	Sarupather	9922	122

Source: Computed from the population data, Census of India, 2001

The interaction values between Jorhat and the urban centers have found out with the help of following formula:

$$Ai = \frac{Pipj}{dij}$$

Where,

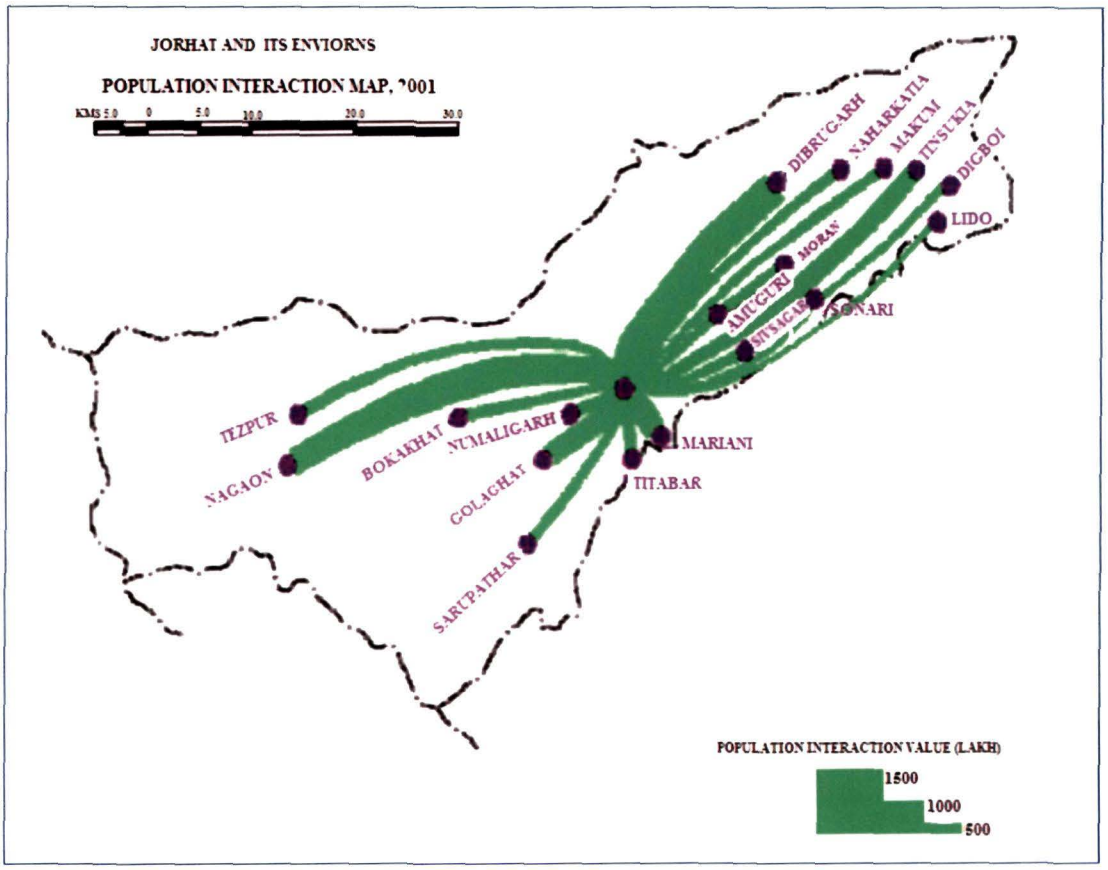
Ai = Pull of the main city

Pi = Population of the main city

pj = Population of the j^{th} town

dij = distance between the main city and the j^{th} town.

Fig -5



Further, isopotential lines have been drawn on the basis of the potential secured by each center (table -20 and fig-6).

Population potential values have been found out with the help of following formula-

$$\sum \frac{Pij}{dij} = \text{Population potential of a centre}$$

Pi = Population of the main city

Pj = Population of the j^{th} town.

Dij = distance between the main city and the j^{th} town.

Table-20: Population potential values between Jorhat and the neighbouring urban centers, 2001

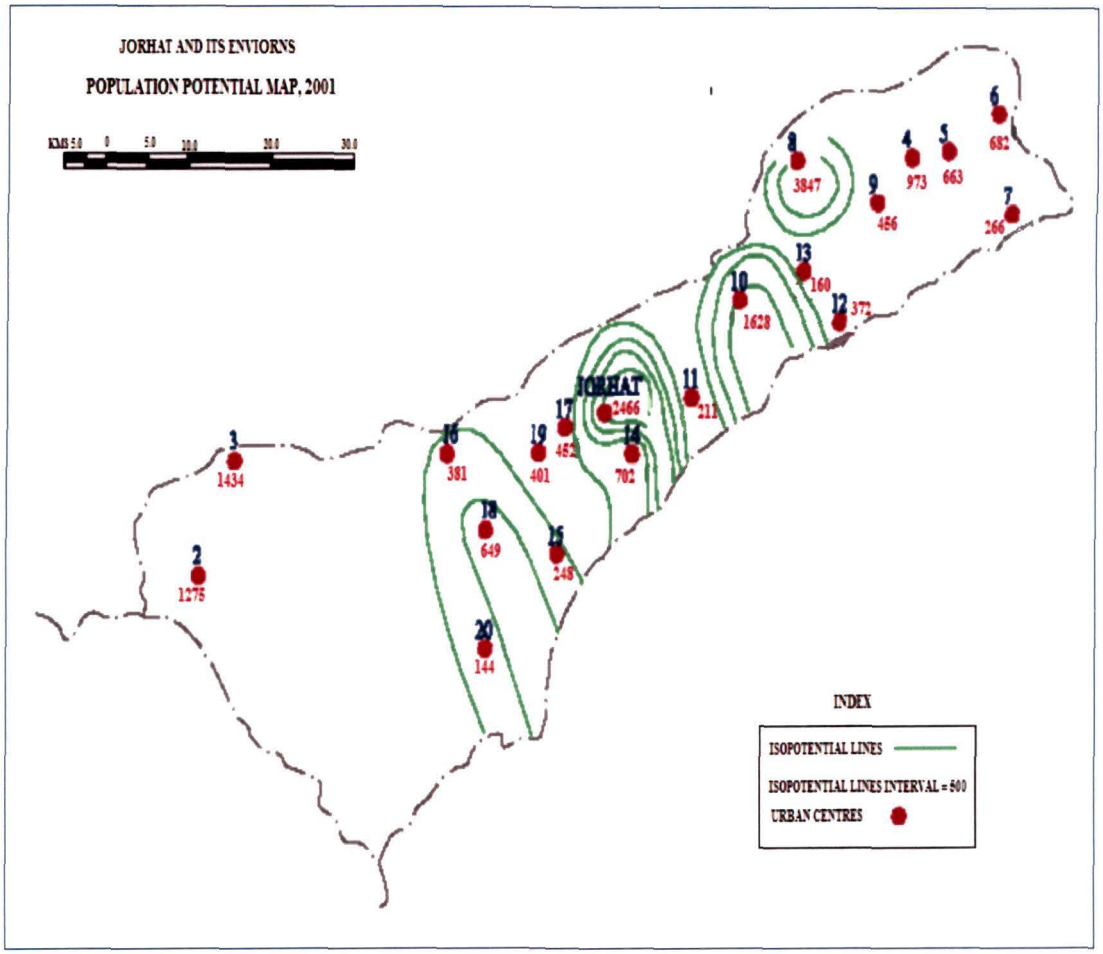
Sl. No.	Centre	Population	Population potential Value (in lakh)
1	Jorhat (Urban agglomeration)	137814	2466
2	Nagoan	123265	1275
3	Tezpur	98550	1434
4	Makum	15118	973
5	Tinsukia	101957	663
6	Digboi	20553	682
7	Lido	8571	266
8	Dibrugarh	133571	3847
9	Naharkatia	15523	456
10	Sivasagar	53854	1628
11	Amguri	6997	211
12	Sonari	17507	372
13	Maranhat	5779	160
14	Mariani	20997	702
15	Titabor	7545	248
16	Bokakhat	8844	381
17	Dergaon	13446	452
18	Golaghat	33064	649
19	Numaligarh	8783	401
20	Sarupather	9922	144

Source: Computed from the population data, Census of India, 2001

It has been observed that the Dibrugarh town formed another nodal centre (125kms away from the Jorhat). It is noticed that the values of isopotential lines go on decreasing in all the directions as the distance from the town increases. The line marked by 100 value passes through the intermediate zones between Jorhat and Golaghat in the western side, Jorhat and Sivasagar in the eastern and Jorhat and Bokakhat in the north western side. In northern side, this limit is made by the areas around Nimati due to their river side location and the absence of other urban centers. As a matter of fact, the areas in the intermediate zones marked by the

above mentioned isopotential lines are the ones which have been shown as the limits of the influence zone by bus service and retail trade services mentioned later or in other words second zone of influence.

Fig- 6



Interestingly enough, the Breaking Points concept* when used to find out the breaking point of interactions between Jorhat and other nearby district headquarters and important towns, namely Sivasagar, Bokakhat, Dibrugarh, Nagaon, Tezpur, Biswanath Chariali and Sarupather. They lead to the same breaks (table-21) in the case of the observations in the gravity potential models. The breaking point concepts

are used to find out the breaking point which also leads to the same breaks between Jorhat and its neighbouring urban centers.

$$^{*}Bp = \frac{d}{1+\sqrt{\frac{pz}{py}}}$$

Where, Bp = Breaking point

d = Distance between the two trade centers

pz = Population of the larger city

py = Population of the smaller city

Table-21: Breaking point of important towns around Jorhat, 2001

Sl. No.	Town	Population	Distance from Jorhat (in kms)	Breaking Points (in kms)
1	Sivasagar	53854	54kms	33.23
2	Nagaon	123265	180kms	92.59
3	Tezpur	98550	136kms	107.31
4	Bokakhat	8844	60kms	47.87
5	Dibrugarh	133571	125kms	62.94
6	Sarupather	9922	112kms	88.31

Source: Computed from the Population Data, Census of India, 2001

From this analysis, it is evident that the urban influence is inversely proportional to the distance from the town centre.

Regional impact can be also analyzed by empirical approaches. As far as the spatial dimension is concerned, following two categories have been taken into account, namely (1) Geo-social approach and (2) Geo-economic empirical approach.

III.4. i. Geo-social Empirical Approach

The social change due to influence of town center is rather a common phenomenon over its surroundings. A recent survey[22] revealed that the way of living standard, dress pattern, food habit, traditional practice and other social system of villages in different locations 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 restrictions of drinking and eating is being gradually eased with the close contact of other caste people. This social change is more significant in the locations where accessibilities are better with the town. The younger generations in these areas use the readymade garments and fashionable dresses 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.

Newspaper is one of the indicators to identify the social status and so also the influence zones of a city. Park[23] used Reilly's law of Gravitation in 1929-30 to define service areas of city's newspaper circulation as the criterion. As news paper is a good media for disseminating information in the society, an empirical study can be made by this parameter. The 'Janambhumi' group of paper of Jorhat is the leading publisher and highest circulated paper in upper Assam valley. Besides, reflecting the existence social association with the town, it can itself be an agent for spreading the urban influence, especially in the rural areas of the region. This is really a very sad reflection of low literacy and low standard of living prevailing in such areas. In view of this consideration, an Assamese daily and an Assamese weekly which had wide circulation in the rural areas have been considered for understanding the patterns of their influence area. It is found that the above two news papers have main agencies in Jorhat's environments up to different distances from the town (table 22) such as Teok in the east (22 kms), Dergaon in the west (25kms), Nimati in the north (12kms) and Titabor in the south (21kms). Beyond these places the circulation of these two papers are highly limited. It is mainly because of high illiteracy rate and poor economic

conditions of the areas. In the neighboring areas, the circulation of the daily news paper 'Dainik Janambhumi' has decreased from 70,000 to 40,000 during the last

Table-22: Newspaper circulation pattern in Jorhat and neighbouring areas, 2005

Important Centres	Distance from the town	Volume of Papers Daily/Weekly	Direction
1. Kakojan	17kms	300,40	East
2. Teok	22kms	330,30	East
3. Charigaon	22kms	110,4	East
4. Bahona	9kms	120,4	East
5. R.R.L.	5kms	120,4	West
6. Panichokowa	10kms	99	West
7. Dergaon	25kms	600,120	West
8. Baligaon	9kms	75.3	North
9. Kakilamukh	12kms	109,4	North
10. Nimati	19kms	150,5	North
11. Cinnamara	7Kms	200,10	South
12. Rangajan	16Kms	150,5	South
13. Karanga	8kms	75,2	South
14. Dhekiajuli	11Kms	80,5	South
15.Titabor	21kms	50	South
16. Baghdhara	9kms	75	South

Source: Data collected from the Dainik Janambhumi Group of papers, 2005

decade (Source: Dainik Janambhumi group of papers, Jorhat,2005). This is not only in the case with 'Dainik Janambhumi' but in case with other newspapers also. Evolving out of many new groups of papers to the market is the only reason for that. Another most important thing to note is that in case of the weekly paper 'Saddin", a demand is gradually decreased. After interviewing some senior citizens, it has been found that the same group of the weekly paper (Saddin) now-a-days publishes another daily newspaper 'Pratidin', that is why the people of these areas are not interested on 'Saddin'.

The zone of circulation of news paper seems to extend more towards east upto the places like Bonai, Selenghat, and Chintamonigarh etc. while in the south its extension terminate at a distance of 21kms from Jorhat. Towards north this circulation

is limited at the peripheral areas of the town for the existence of river boundary, which restricts the extension of the bus service zone. In the west, the zone extends up to Dergaon (25kms) beyond which an abrupt drop of circulations takes place due to the extensive rural areas, till the urban centers Golaghat and Kamargaon reached. Thus the newspaper circulation zone is slightly bigger than the zones shown by the other two criteria that is retail trade and bus service.

Both the education and the medical services are the important social functions of a town which extends facilities to the dwellers of the town as well as to other people of this region. A large number of students from its neighbouring areas have been coming every year for the 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 institutions like Engineering College, Science College, Agricultural University, Prince of Wales Institute of Education and Technology, Industrial Training Institute, Homeopathy College, Theological College, Law College, and other Colleges etc. attract students not only from Jorhat's surroundings but also from the entire northeastern region. Therefore, only general educational institutions (colleges etc.) can be used as indicators of town's influence in the neighbouring areas.

From this brief discussion on geo-social aspects, it can be concluded that it is difficult to demarcate a definite boundary of the impact of the town, because geo-social is a broad term under which town's influence extends the services up to its optimum limit. This is reinforced by developing communication links. For example, all districts and sub-division headquarters of Assam are well linked by transport

services. However, such relationships of different degree are found in all the three parameters that is, newspaper, education and medical services.

III. 4. ii. Geo Economic Empirical Approach

Every urban centre has its definite service area consisting of groups of villages and towns. An urban centre in other sense, define the scope of contents and services that serves the groups of villages and towns around it. This relationship may be either social or economic or have reversible relations with each other. The social relationship between the town and its neighboring areas has been discussed earlier. Here we will discuss about economic relationship between the centre of the town and the region.

The number of person in general engaged in secondary and tertiary activities in and around Jorhat, has progressively increased during the last few decades. Persons engaged in primary activities have proportionately 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 Jorhat town has increased from 15 percent and 60 percent in 1991 to 20 percent and 75 percent in 2001 respectively, on the other hand the percentage of workers in primary sectors inversely decreasing from 25 percent in 1991 to 5 percent in 2001[24].

There are many industries growing up in and around Jorhat, which has attracted non- agricultural workers from the neighbouring areas of Jorhat. This is due to lack of scope for employment opportunities at low grade in the secondary and tertiary sectors. It is seen that the traditional agricultural patterns in and around Jorhat has gradually changed, Dickinson[25] opined that the city is a human phenomenon 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 relationship[26]. Thus bus service has been found to be a very useful criterion for city region delimitation.[27]On this basis, Jorhat town is linked with roadways in all directions while the railway line is absent in west and south from the centre of the town. Hence role of bus service is highly significant in linking Jorhat and its surrounding areas. Especially the role of private bus and city bus services are highly significant in increasing the contact between Jorhat and its surrounding areas. A number of factors may be attributed to the occurrence of this phenomenon. First, Jorhat is the premier town in upper Assam and therefore it is the major trade centre for surrounding rural areas. Second, the region experiences high population pressure and therefore dependence of people on the secondary and tertiary activities are very high. As a result of these, the area like Borhola, Bekajan (south) Sivasagar, Bonai, Selenghat (in the east) Nimati, Kakilamukh (in the north) and Sarupather, Bokakhat (in the west) which were remote till recently and are now closer to the town in a variety of ways through the regular bus services that ply between the region and these areas. The areas like Bahana and Charigaon in the north, Rowriah in the south, Kakojan in the east and Charingia in the west come closer to the town due to its frequent bus services. The private buses run with an interval of 15 minutes in north and west direction (personal investigation) from morning till evening. Especially after the independence, the bus services have extended so much that it is now difficult to find even a small village being far from the town. Under the circumstances, the bus service as a criterion for defining the zone of Jorhat's influence is very much meaningful. Table-23 shows the numbers of buses, which ply between Jorhat and its surrounding areas (within a distance of 42kms from the town)

Table-23: Frequency of Bus Services between Jorhat and its Surrounding Areas, 2001

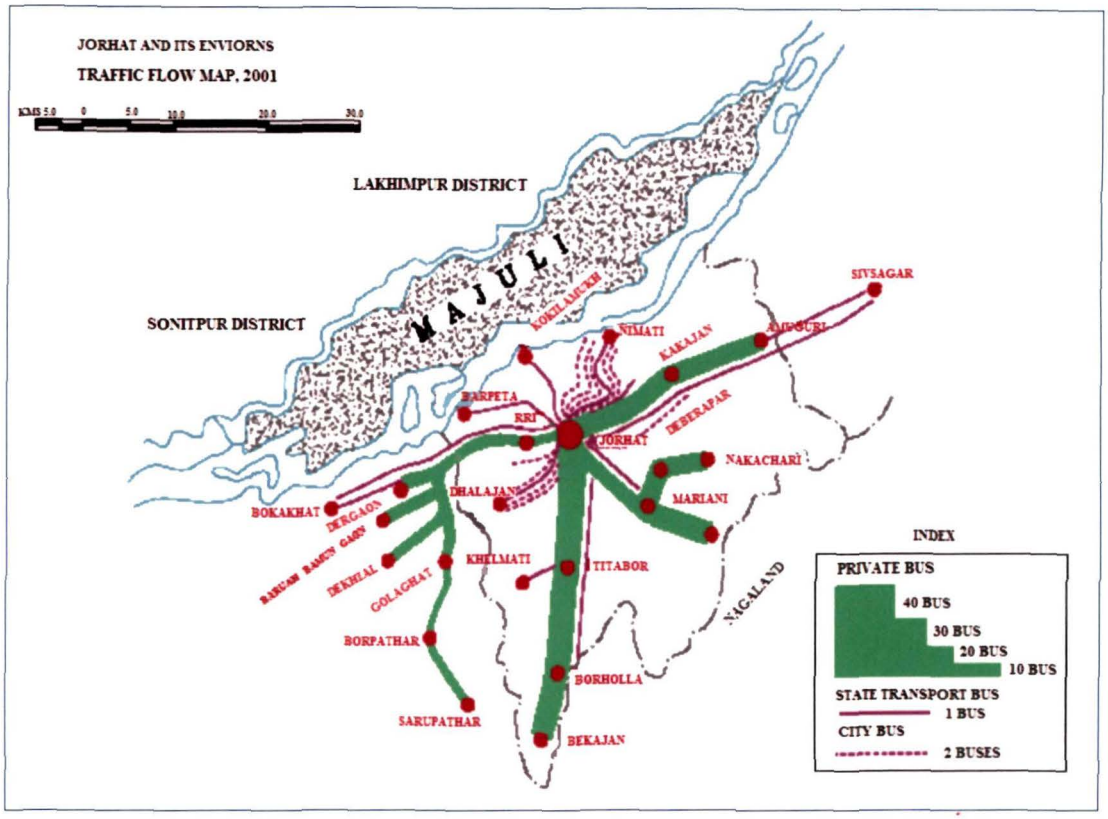
Station	Number of Buses	Distance from Jorhat (in kms)	Direction
1	2	3	4
A State Transport Bus Service. (Local)			
1. Titabor	1	21kms	South
2. Bahona	1	42kms	North
3. Mariani	1	20kms	South
4. Sivasagar	1	54kms	East
5. Dergaon	1	25kms	West
6. Golaghat	1	58kms	West
7. Bokakhat	1	60kms	West
B. City Bus Service			
8. R.R.L.	5	6km	West
9. Dhalajan	6	13kms	West
10. Nimati	11	12kms	North
11. Kakojan	2	17kms	East
C) Private Bus Service			
12. Titabor	24	21kms	South
13. Borhola	12	32kms	South
14. Melamati	1	42kms	South
15. Bekajan	12	56Kms	South
16. Mariani	8	20Kms	South
17. Nagajanka	10	23kms	South
18. Nakachari	10	30kms	South
19. Deverapara	10	30kms	South
20. Sarupather	2	112kms	West
21. Dhekial	5		West
22. Baruah Bamun Gaon	5		West
23. Bahphola	2	20kms	West

Source: Eastern Bus Owners Association and Jorhat Public Bus Association, Assam

Here, a question may arise that the number of passengers in each trip would have given a better idea about the flow of people to and from the town instead of the number of buses or trips, but it is observed that the buses under consideration are almost always fully loaded at all hours of the day. It can be said with certainty that on an average 40 persons travel in a bus. Therefore, the number of passengers have not been considered, rather the number of buses are taken for measuring the pattern of interaction between the two. The data given in the table -23 have been used to find out the limits of the bus service zones and the intensity of services to different places.

Fig-7 shows that it is the western and the southern direction from which people move to the town covering a maximum distance. The intensity of bus services are also higher in these two directions compared to that in the eastern and the northern direction.

Fig -7



It is obvious because the northern part is bounded by the Brahmaputra river and the eastern part is connected by the 37 national highways through which the various means of transports are being used by the people of the eastern region. On the other hand, for the same reason, the intensity of bus services of the western part also somewhat lesser than the southern region. The southern direction contains transport openings with many other urban centers in the midst of the extensive plain areas. It is significant to note that the role of private bus is highly dominant in the same

directions of the higher intensity bus services, whereas it is not the case with the eastern and northern directions. Therefore, the frequencies of private bus in the former two directions have helped to determine the limits of the bus service zone. Table-23 and fig-7 clearly show that as many as 12 buses ply from Jorhat to Bekajan in the south and Dhekial in the west, beyond which the frequency of bus services immediately drops down. As such, these two places may be the limits of the zone in the two directions mentioned above.

One of the significant aspects of the economic activities and its impact over the town's neighboring areas are retail trade services. The retail trade of different goods generally is carried at different levels by the centers up to the specific distances. As Jorhat is a premier town of trade in upper Assam, it has an impact over the region of varying degrees. It supplies variety of goods to the region. For retail trade services, here we will discuss about Jorhat and its immediate environs which cover the area as indicated by newspaper circulation, bus service etc. Jorhat is the town on which the people from neighbouring areas depend on machinery, stationery, jewellery, 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 town sell their goods in some of the market centres directly. Some of its kinds of the market centers are given in the table-24.

In the case of Jorhat, the economic linkages through these services between the town and its environs seem to exist in four ways:

1) The retail traders from the peripheral service centres travel to the town and collect the consumer goods for retailing it in their centres.

2) The local distributors again collect the consumer goods from the service centres for retailing in their own villages.

Table-24: Important retail centres around Jorhat, 2001

Centres	Days of the Market held	Distance from the town	Directions
1	2	3	4
1) Cinnamara	Weekly	9kms	South
2) Baghdhara	Daily	10kms	South
3) Mariani	Daily	20kms	South
4) Titabor	Daily/Weekly(one day)	21kms	South
5) Borhola	Daily	42kms	South
6) Kakilamukh	Daily	12kms	North
7) Nimati	Daily	12kms	North
8) Charigaon	Daily	8kms	North
9) Bahona	Weekly	9kms	North
10) Meleng	Daily/Weekly	12kms	East
11) Kakojan	Daily	17kms	East
12) Teok	Daily	22kms	East
13) Dergaon	Daily	25kms	West
14) Charingia	Weekly	10kms	West
15) Alengmara	Weekly	12kms	West
16) Rowriah	Daily/Weekly	10kms	West
17) Badulipara	Daily	37kms	West
18) Bihara	Weekly	49kms	West

Source: Assam State Agricultural Marketing Board, Jorhat

3) Some of the traders and retailers of the town also travel to the weekly markets located along the easy accessible roads for selling goods directly to the villagers.

4) On the other hand, the town traders themselves collect considerable amount of items mainly agricultural products from the surrounding rural areas, either from the centres mentioned in the table - 24 or directly from the villages to sell them in the town market.

It is however worth mentioning that the retail trades of different goods are carried at different levels by the centres up to certain distances. For example, cloth and machinery goods have a wide-ranging market and these are supplied by Jorhat, not only to the nearest urban centres, but also to the centers located throughout the

upper Brahmaputra valley. On the other hand, for the supply of grocery items such as rice, pulses, oil and other daily consuming goods, there are urban centres or market centres, which solely or largely depend on Jorhat. The most important of this kind are Mariani (20kms) in the south and Nimati (12kms) in the north, Teok (22kms) in the east and Alengmara (12kms) in the west.

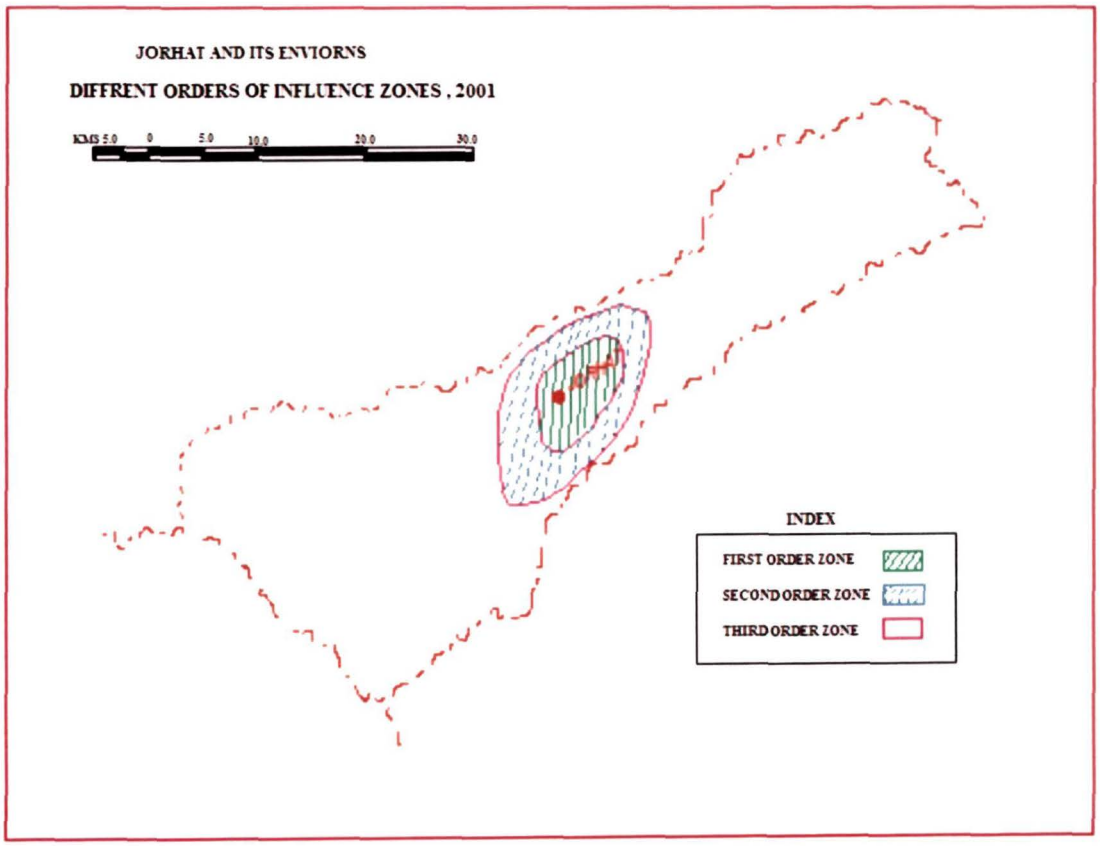
These centres in turn, distribute their goods to their respective rural surroundings. In addition, the retailers from the town also sell goods directly at the weekly or bi-weekly markets held in these centres and also other centres of local importance. Thus, the extreme limits of retail service zones are found to be marked by Mariani and Borhola in the south, Nimati in the north, Meleng and Teok in the east and Badulipara in the west. These limits coincide fairly well with the bus service zone defined earlier.

It is however significant to note that the intensity of Jorhat's influence in terms of these services varies according to distance and accessibility from the town. The field observation shows that while the places like Bahona, Charigaon (in the north), Cinnamara, Baghdhara (in the south), Dergaon (in the west) located at a distance of 8 to 25kms from the town have a very close relationship. The places located beyond such distances are although dependent on the town for the services the degree of their dependency is not very high. Therefore again a sub-zone in terms of intensity of retail trade appears around a distance of 20 kms approximately from the periphery of the town. It is however worth mentioning in this context that out of all the retail items, it is the local supply of vegetable products from the surrounding areas, which shows the maximum intensity of interaction of the areas with the town. It is because of rural vendors who directly come to the town for selling vegetables. They

come to the town for this purpose by various means that is either on foot or on bicycles or they bring their vegetables to the town by pushcarts or in buses. The local supply of vegetables as the field observation shows comes from as far as Bihara in the west and Borhola in the south, Kakojan (in the east) and Nimati in the north direction.

It is thus observed that both empirical and theoretical models indicate the existence of three types of influence zones around the town, one at the intermediate surrounding, one at the distance surrounding and the other in between the two (fig-8).

Fig-8



They may rightly be called the first, second and the third order zones of influence in terms of increasing distance from the town on the one hand and the decreasing influence of the town on the other. These zones do not have fixed boundaries and they are likely to change with the changing socio-economic conditions of the areas.

Further, more sub zones within each zone can be made depending on the degree and character of intensity of influence on the town. They therefore, represent only the limiting margins of the broad boundaries of the influence zone.

Urban growth is to be conceived of as a dynamic process. However, growth takes place not only in a definite time setting but also in a spatial or geographical setting. Urban growth involves the growth of towns and cities that changes the socio-economic and socio-cultural variables and land use etc. The explosive increase in population and the sprawling urban growth may yield many socio-economic and political problems. Jorhat town has been changing both physically and culturally in the last few decades. It has been mentioned earlier that the river Bhogdoi is deviating towards eastern side due to increasing settlements. The overall urban growth of this town is sprawling towards the western and southern side of the town. The reason behind this sprawl is mainly due to the extensive high land plain with many transport networks, absence of water logging, floods etc. and establishments of many educational institutions.

Settlements

The wide fertile plain with considerable agricultural activities provides a suitable background for development of rural and urban settlements throughout the Jorhat district. It has a total number of 787 inhabited villages and 7 big urban centers as per 2001 census, and living place for 80 percent and 20 percent of the total population respectively. It is observed that the rural settlements concentrate in the middle part of the region. It is because a long tract, parallel to the Brahmaputra river is shallow mires, while a considerable area in the south is occupied by tea gardens, leaving a small portion for agriculture and settlements. Thus Jorhat with a low density

of population (350 people per sq. km as per 2001 census) in comparison to that of other districts of Assam does not reveal the actual picture.

Since the study area comprises the major part of the Jorhat district and socio-economic data are available only at the police station, sub-division and district levels, the socio-economic background of the area can be given only at these levels. According to the census of India 2001, Jorhat has four urban agglomerations and they are situated far apart from each other. The Jorhat agglomeration includes the Jorhat (120,415 persons), Kumar Koibatra Gaon (6,347), Chekani Dhara (7,355) and Sensua Gaon (3,697). Away from these agglomerations, Kumar Koibatra Gaon is located at a distance of 3 kms from the town, Chekanidhara is about 4 kms from the town and the distance between the main town and Sensua Gaon is about 5 kms. These towns are located far apart from each other in the midst of the vast rural settlements. In any case they act as a nerve centre for their surrounding rural areas. The percentage of urban population (17.24 according to 2001 census) in the region is low like that of Jorhat district (13.00). As a matter of fact if the urban population of Jorhat town is extended, the rest of the region would be a rather vast rural area with only a few insignificant urban points. It is for this reason that Jorhat seems to exert a tremendous influence on its surrounding areas and the pull of Jorhat over these areas are very high.

The small settlements are mainly in the northern and southern periphery of Jorhat. The large sized settlements are conspicuous near the urban centres as well as near the major tea gardens. It is significant to point out that the size of the villages does have bearings on the concentration of different kinds of service facilities and therefore, on the prevalence of some degree of urban character in them. Among the other small towns and outgrowth, Cinnamara Grant has the highest population of

11,818 with 2469 households and Kamalaboria ranks second with 8,399 persons with 1899 households. Among other towns Chekonidhara has a population of 7,355 with 1596 number households (2001, Census of India). Besides, other towns and outgrowths have population and household numbers like these – Chengeli gaon (2,827; 566), Gohain Tekela (2,255;512), Dulia gaon (1,886;400), Tocklai Cha Bagicha (3,832;810), Sarbaibandha (3,538;725), Chowdang gaon no. 1 (5,234;1111), Bohotia gaon (3,408;793), Sonari gaon (2,972;680), Kamalaboria (2,911;679), Nakari Bamun gaon (2,359;498), Borbheta Chapori (1,698;339), Kumar Koibatta gaon (6,377;1337), Sensua (3,697;769) and Naobaisa (4,964 persons with 970 numbers of households).

The settlements are mostly nucleated or compact in nature. Generally two large sized settlements are linked by a linear settlement. The sides of the national highway generally from Dergaon to Jorhat and other important roads provide a good setting for linear settlements. The tea gardens, which are sufficiently large in numbers, are developing a latifundium type of settlements.

The inter village spacing is also different in the different parts of the region depending primarily on the variations in the topographic character. In the northern sides, the villages like Nakari gaon, Hazari gaon etc are closely spaced in the midst of the extensive agricultural field along the Bhogdoi river. In the same way, in the eastern sides most of the villages are along the national highway 37, where these villages are less closely spaced. Sarbaibandha is sparsely located due to the presence of extensive low lands here and there. Such spacing characters of the villages are likely to have varying impacts on the spread of urban influence in different parts of the region. Among the four town centres of this region, Mariani is the smallest town

in respect of area (1.38 sq.kms) but interestingly enough, has the highest density of 1,205 persons per square kms not only within the district, but also in the state (according to 2001 census of India). It also surpasses even Guwahati in terms of density of population. The main reasons behind this abnormal high density are- i) it is the fast growing commercial centre and tea gardens and industries around. Moreover, this is the important market centre for the Naga people who use to visit this place regularly for their daily and other necessities, ii) heavy influx of population from a) other parts of India due to a large railway colony settlements b) other districts of Assam c) ex-teagarden labourers and, iii) fast growing slums.

In addition to these towns, a large number of market centres are rapidly growing in its surroundings. All these centres are commercial as well as cultural centres of the surrounding areas. Some of the important points are Dergaon, Teok, Borhola etc. around Jorhat town.

References

1. Dickinson, R. E 1960: "*City Region and Regionalism*", London, 4th Print p. 119.
2. Erickson, E.G. 1964: "*Urban Behavior*", New York, p. 265.
3. ..... Reference
4. "Quality and status of People In Slum Areas of Assam", The Sentinel ,vol ,V, No 10,21st June, 1987.
5. Thomen, R. S. and Corbin, P.B. 1974: "*The Geography of Economic Activity*", McGraw Hill Book Company, New York, pp. 183 – 186.
6. Dickinson, R.E. 1969: "*The Makers of Modern Geography*", Routledge and Kegan Paul Ltd., London, pp. 70 – 71.
7. Dickinson, R.E. op. cit. pp. 234 – 236.
8. Smails, A.E. 1947: "*The Analysis and Delimitation of Urban Field, The Geography of Towns*", William Brendon and Son Ltd., London, pp. 151 –

167.
9. Harris, C. D. 1940: "*Salt Lake City, A Regional Capital*", University of Chicago Press, Chicago.
10. Bouge, D. J. 1945: "*The Structure of the Metropolitan Community*", *A Study of Dominance and Sub dominance*", The University of Michigan.
11. Ullman, E. L. 1976: "*Geography as Spatial Interaction*", ed, Dr. Boyce.
12. Stewart, J. Q. 1942: "*A Measure of Influence of Population at Distance*", Sociometry, Col. 5, pp. 63 – 71.
13. Jipf, G. K. 1949: "*Human Behaviors and the Principles of Least Effort*", Cambridge, Mass Addition. Wesley.
14. Reilly, W. J. 1929: "Methods for the Study of Retail Relationship", University of Texas Bulletin No. 2944. pp 1 – 50.
15. Taaffee, 1962: "The Urban Hierachy, an Air Passenger Definition", *Economic Geography,* Vol. 38, pp. 1 – 10.
16. Hartshorn, T. A. and Alexander J. W. 1988: "*Economic Geography*", Prentice Hall of India Pvt. Ltd., New Delhi, pp. 283 – 285.
17. Singh, R. L. 1955 : "*Banaras, A Study of Urban Geography*", Nandkishore and Bros. Banaras.
18. Sharma, H. N. 1975 : "Elements of Urban Impact on Rural Society in India, A Spatial Analysis", PhD. Dissertation, Unpublished. Syracuse University, New York.
19. Kar, N. R. 1963: "Economic Character of Metropolitan Sphere of Influence of Calcutta": Geographical Review of India, June p.p. 108 – 137.
19. Nangia, S. 1976: "Delhi Metropolitan Region, A Study in Settlement Geography", KB Publications, New Delhi, p. 2.
20. Borah, J. 1985, "Spatial Structure of Urban Influence in the Neighboring Areas of Guwahati City", Inter India Publications, New Delhi, pp. 7 – 8.
21. Borah, J. 1985: "Spatial Structure of Urban Influence in The Neighboring Areas of Guwahati City", Inter India Publications, New Delhi, pp. 129–131.
23. Park, R. E. 1929 – 1930: "Urbanization as Measured by Newspaper Circulation", American Journal of Sociology, vol. 35, pp. 60 – 79.
24. "Census Operation in Assam", 2001.
25. Dickinson, R. E. 1964: "City and Region, A Geographical Interpretation", Routledge and Kegan Paul Ltd., London.
26. Duncan, C. D. et al. 1960: "*Metropolis and Region*", The John Hopkins Press, Baltimore, pp. 36 – 37.
27. Green, F. H. W. 1950: "Urban Hinterlands in England and Wales", Geographical Journal, vol. 116, pp. 66 – 88.

CHAPTER IV

Human Interference on '*Jans*' and its causative factors

The rapid growth of human settlements near the streams obstructs the drainage channels due to encroachments through illegal occupations and unauthorized constructions. As a result, the existing capacities of the natural channels of Jorhat town like the Bhogdoi and Tocklai are found to be inadequate to drain away the urban storm water including surface runoff during monsoon periods (the month of April to September). During this period, frequent flooding of many areas of the town is a common feature. Both natural and man made factors are responsible for creating such a situation.

The most agreed indigenous management of flood control system is non-interference of the natural drainage behavior of a stream[1]. Various streams adjust themselves in a normal condition, when unable to carry excess water from torrential showers spill them to their banks leading to flood. Man's interference with the natural drainage system by way of settlements, laying of roads, railways and canals often cause havoc to the region. In this chapter, the studies are on the causes and effects of human interference on *Jan*s, which are discussed on following sub heads.

IV.1. Anthropogenic Factor

Anthropogenic or human related factors play an important role in the development of urban infrastructure. Jorhat town is served by many natural streams or *Jan*s (*Jan* is the local name of the natural streams). Following are some causes due to which various *Jan*s in Jorhat is interfered by men and thereby inducing various problems on them.

- The population of the town is increasing rapidly but not the habitable land with that proportion. For construction of residential houses, offices etc. man has begun to occupy the banks of the existing natural streams. These *Jan*s are encroached upon by filling earth over them. Such human interference on *Jans* and its consequences are perhaps nowhere more clearly visible than in Tocklai area in the town. In the areas of Dhakaipatty, Rajamaidam rad and Garmur the encroachment is to that extent that the bed of the Tocklai river is totally under the foundation of buildings (Plate7).

- Illegal occupance of settlers along the bank of the natural streams compels the streams to deviate from its existing locations. In Devicharan Baruah Girls' college during the class hours, the floor of a classroom of the college collapsed into Tarajan channel at a depth of about 10 feet in which altogether 15 students were severely injured. The fact is that in 1980, when the classroom was built, the stream was far from the college. The bank of the stream got deviated towards the college building due to the illegal encroachments gradually. (The Dainik Janambhumi, Thursday July 20, Jorhat, 2006).

- The growing pressure on the land for food, shelter etc. in addition to industrial expansion and consequent need for infrastructural facilities due to ever-increasing settlements have given rise to the competing and conflicting demands on limited land and water resources.

- A large number of outlets from the industries - the physical, chemical and biological properties of industrial wastewater pollute the aquatic ecosystem.

- These industries consume large volume of water and discharges huge volume of waste to the drains. Fissures, breaches and cuts made by people, along the *Jans* also affect the drains very badly.

- Interference with the natural drainage due to construction of roads, railways and other structures affect the drains and streams. Moreover, construction of buildings without following the building bylaws of the concerned authority makes the problem more acute.

- Due to the increasing population even, the permanent rainwater absorbing areas are occupied and filled by men. Some areas of the town get submerge within two hours of rainfall. The settlers for their convenience at many reaches of streams are blocking existing water outlets. Construction of buildings without any drainage plan adds more problems to the area. In this situation, the accumulated surface water lasts for longer duration and disappears slowly at least after two days towards northwestern part of the town and making these areas as permanent marsh.

- Former unplanned construction of transport artery and the railway embankments are also the reason of water logging in Dhakaipatty and Tocklai area. The abandoned Jorhat-Nimati railway track creates indescribable problem, during heavy rain.

- The mushrooming of slums in and around the town those which occupying the banks of the streams has affected the natural streams in discharging water. Due to their illegal encroachments by means of construction of huts, shops or other activities, streams are becoming narrower and shallower.

- The drains carrying industrial as well as residential waste are making the bed heavily silted. As a result, during rainy season water overflows and inundates the areas. Moreover, as these drains are not planned properly to carry even the regular water, this flows the drains outside its area and thus creates water logging.

- Due to the heavy growth of reeds and siltation on the bed of the streams, water carrying capacity has reduced and water logging became a regular feature. The excessive growth of water hyacinth plant over Tocklai and at the lower reaches of Tarajan channel proves the shallowness of the streams. (plate -8)

Plate 8: Out growth water hyacinth Plant on Tocklai River near Garamur Market

- Garbage is an individual problem directly related to the level of cultural development and aesthetic sense of the people. In an urban centre garbage is produced from households, commercial and industrial activities. The amount of garbage produced in the urban areas needs to be disposed to a safer site, which is an important activity of the municipal authority relating to planning and management of ecology. But in the unplanned cities and towns, where municipal authority is not properly functioning, the garbages are dumped in open

Plate 9 -An usual uses of Bhogdoi River water

spaces without considering the neighborhood and environment. The drains of the town are also becoming a regular garbage-dumping site.

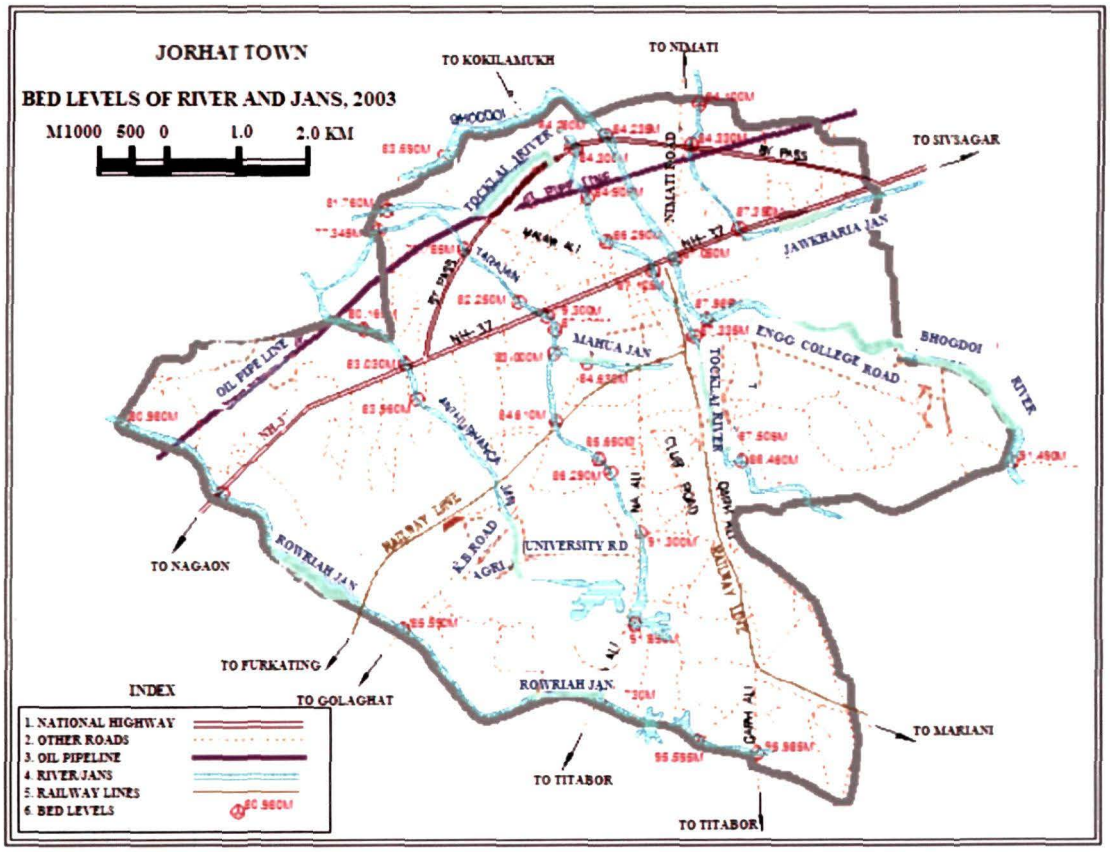
- Sewerage, which is a measure of municipal efficiency, is one of the vital problems of the drainage environment. The municipal authority of Jorhat is so far not taken such measures like sewerage treatment or diversion to prevent pollution in the drain cum river water. The black coloured, bad smelled water packed with pollutants obviously make the feeling of unhealthy atmosphere in the Tocklai region. A field survey on the surrounding areas of this channel and discussion with medical practitioners reveals that the people of the area mostly suffer from water borne diseases. It is a fact that the poor people living in this area (plate-9) use the polluted water of the stream daily for bathing and washing of cloths.

- The encroachment on the river Bhogdoi is rampant due to which, the river becomes shallower and narrower. Another most important point to be mentioned here is that the bed level of the river Bhogdoi of the town is higher than the normal surface height of the town(map-7), thus making it more difficult to drain out the storm water directly.

- Due to unprecedented and concentrated rainfall in 1977, experienced in the town on dated 29/05/77 to 31/05/77, the town as well as its suburbs was submerged. The situation was further aggravated due to inadequate drainage sections of Tocklai and Tarajan. Besides this the higher bed level of the Bhogdoi created flood congestion due to back water flow that caused inundation and water logging .

- Negligence of state government as well as district officials in the desiltation of the drainage and sewerages in the pre monsoon period is an important cause for which drainage problems are becoming more acute.

Map-7



Source:Town and Country Planning Department,Jorhat

- Inadequate space facility is the vital factor for human encroachment considering this spatial aspect. Some temporary (both seasonal and periodic) slums developed along the Bhogdoi river bank. The side of this river is also an open-air toilet for their use.

- On the bank of the Tocklai river slums have developed in a rapid manner due to the establishment of some small industries.

- The Oil India Limited pipeline is crossing the bed of the Tarajan channel perpendicularly which is creating more problems due to its alignment with the topography. Tarajan channel drains out 85 percent of surface water of the town. But due to the blockade by the pipeline hampers the normal flow of water. Huge dome shaped garbage dump including the dead animals is a common feature at the rainy season at this point which creates overflow and water logging.

Plate 10 -

- Duborijan has the catchments areas of Na-Ali, Bangalpukhuri, Club road and Jail road area. Most areas are encroached by the people at many reaches. One can easily notice illegal constructions along the Duborijan at Bangalpukhuri area. Residential and commercial garbage, which are thrown into the channel, is making it shallower and narrower. As a result, after heavy rainfall, it overflows and inundates the adjoining areas. It is also seen that the wall of the Jorhat Medical College campus has completely blocked the path of Duborijan at Jail road area, thus creating new water logged areas. The channel water accumulates at the southern side of the college campus (Plate-10).

- Slums are found at the low-lying areas of the town. The fallow marshy lands are used by the slum dwellers, thus diminishing the excess rainwater absorbing areas of the town (Plate-11).

- As commercial and economic activities of the people have grown phenomenally, the magnitude and ramification of eco-degradation and pollution have also increased. As a result, the environments of the *Jans* have been adversely affected leading to impairment of health and destructing of the aesthetic estate. Thus the *Jans* receive threat to its survival due to a host of geo-environmental problems. These problems may be identified as the problems of garbage dumping pollutant inflow, human encroachments and need infestation (Plate 12).

Plate - 12, Man made dumping ground at Dubori Jan, Club Road Area

IV .2. Human Interference on Ecological Balance

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 orchestral, 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 unfavorable alteration of our surrounding partly or largely due to impact of increasing urbanization and related human activities. With increasing industrialization air, water, and soil pollution have grown in alarming proportions, which have raised serious concerns about the survival of urban dwellers. Environmental pollution is not only associated with the population pressure, but also on scarce natural resources. Urbanization without proper (town) planning is one of the causes of land pollution. Lack of basic civic amenities, such as sanitation, water supply and housing in urban complex are some other reasons, which lead to problems of waste disposals. Jorhat is also not an exception. It has its own serious pollution problems. Improper location of industries, the use of polluting technologies and inadequate waste treatment facilities are chiefly responsible for deterioration of air and water qualities. Other indirect stresses on the environment are enhanced by the localities of slum colonies. 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 town to assess the ecological imbalances of greater Jorhat.

It is observed that within Jorhat town, no sewage treatment plants[1] exists and most of the houses inside the town are equipped with ordinary septic tanks. These septic tanks do not function during the rainy season because of high water table, thus polluting the surface water as well as ground water of the area.

Originally, Jorhat was rich with ecological endowments of mixed vegetation, uneven topography of high and low areas. The total environment of Jorhat area (natural and cultural) had an overall adjustment. As the rural Jorhat areas

transformed into semi urban areas, the environs of the town is infested with unplanned and indiscriminate growth of settlements.

The ecology of the area is destroyed due to clearing of original vegetation by wanton felling of trees, shrubs, bushes etc. Moreover, the cutting of highlands for construction purposes augmented the deterioration of the natural landscape at a faster rate. The natural habitat of animal is completely obliterated from the town area. The construction of the broad gauge railway line through the heart of the town has further caused a deathblow to the ecosystem of the congested town. For example, the high pavement of the Jorhat–Nimati railway track has blocked the free movement of water. Thus, it has worsened the water logging problems due to the amalgamation of abandoned old meter gauge railway with the broad gauge line.

Population of Jorhat town (chapter II) has increased tremendously during the last three decades. Though man is a social and rational animal, yet among the different racial groups, there are attempts to annihilate the other. An example can be cited in this case. Some of the original ethnic groups of settlers of Jorhat town has migrated out to look for a better environment due to congestion and destruction of natural landscapes and ecology.

It can be summarized that these was due to the following reasons:

a) The development and growth of science and technology have failed to maintain the balance with environment – the real gift of nature.
b) The industries based on utilization of some deadly chemicals have not provided neutralization of plants for the affluent.
c) The town with such a huge population is devoid of green belt, natural park, recreational park etc.

d) Most of the original cultivable land has been converted into residential areas.

e) The encroachment on natural landscape through construction and unplanned development had further deteriorated the environs of the town.

As a whole, the drainage system in the town can be described as very inadequate. Only some areas of the town have *pucca* road side drains. Haphazard construction of residential and commercial establishments without making any provision for drain has led to water logging problem.

The erosion problem on the banks of Bhogdoi was very serious due to very close spacing of the embankment system. Canalization of the river at some of the very vulnerable reaches was taken up with a view to develop the banks and deepening of the channel to reduce the increased flood levels and to tackle the erosion problems of Jorhat town. These works in the form of bank bars and dampeners have been successful in developing the riverbanks. In many reaches the direct erosive attack of the river could be stopped, but the bed is not deepening and the flood levels do not show any sign of reducing. In view of the diversion of the Tocklai drainage channel in the upper reaches, which will further increase the high flood level of the river Bhogdoi, raising and strengthening of the embankment system is therefore very essential. Besides, anti-erosion works on a continuing basis may be required to canalize the river in the reaches both upstream and downstream of Jorhat to tackle the flood and erosion problem.

Thus it is observed that the above mentioned anthropogenic factors are responsible for present spoiled conditions of drains and they affect adversely on the town environment too.The non-anthropogenic factors are discussed in the chapter V.

References

1. United State Public Health Service (USPHS), "Drinking Water Standard for Coliform Organism" specifies that the most probable number (M.P.N.) shall not exceed 10,000 coliform organisms per 100 milliliter of water.

CHAPTER V

Water Logging and Drainage System with Urban Planning

The water logging has been by far one of the important factors that have given way to series of problems to Jorhat town. Many natural and manmade factors are responsible for it. The anthropogenic factors that are responsible for water logging in the study area have been discussed in brief in chapter IV. Moreover, one cannot deny the importance of natural factors like the average slope , discharged capacity and water level of a river, elevation, precipitation, land use etc. of a particular area also in this context. In chapter V, an attempt has been made to study and analyse the same in detail.

Water logging => $I - O = \pm\triangle$, where I = Inflow, O = Outflow, $\triangle$ = Storage

"Inflow" here means runoff or rainfall; while water percolation, evapotranspiration or other means of discharging water are called "outflow". When there is excessive inflow than out flow, "storage" occurs. Excessive non-drained accumulated water deposited at some low-lying areas creates water logging. More rainfall worsens the situation. Slowly the depth and volume of these areas increases and gradually covers more areas. Now-a-days water logging is a common feature in a developing town or cities during rainy season. In Jorhat town, though rain starts from middle of the month of April, the actual monsoon sets from early part of June and continues till middle of September. The average annual rainfall is 2420.91 mm. About 60 percent of the total annual rainfall is received during the monsoon season in this region. July being the month of maximum rainfall, the accumulated runoff increases during this period and

causes waterlogging and inundate most part of the town area. To get relief from water logging proper planning of drainage is essential. Planned drainage network is a necessary requirement for the rich urban infrastructure of a town. Where urban planning is authentic, drainage networks are found to be perfect. Lesser is the drainage planning, more will be the water logging. Thus the drainage system is directly proportional to the urban planning, but inversely proportional to the water logging.

V.1. Average slope analysis

The term slope, as used throughout the science of geomorphology, designates some small elements or area of the land surface, which is inclined from the horizontal[1]. The gradient of the land surface over an area can be analyzed from a slope map. This method was used since 1890 by Finsterwalder and thereafter Pencker. Tricart and Muslin also used this laborious and complicated formula (by measuring the total length of all contours with an epistometer).[2]

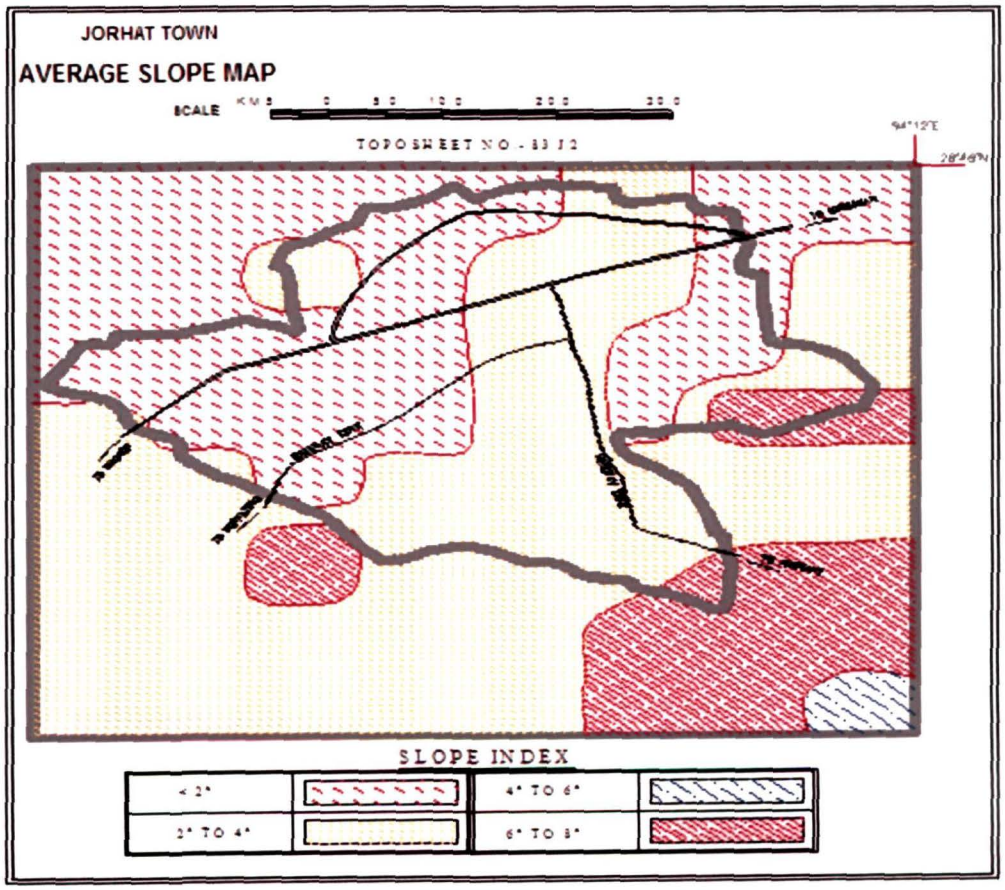
Wentworth[3] criticized the earlier formula and simplified it in 1930. Smith (1935), Raisz and Henry (1937), Robinson (1948) etc. attempted other method to determine the average slope of their own area. In fact, all the methods have merits and demerits for their particular landform. From the point of its landform and limited extension of greater Jorhat area the Wentworth's formula* was found suitable for determining the slope of land surface as the formula bears constant**. Hence Wentworth's formula has been applied for the topography of Jorhat and satisfactory results have been obtained.

$$*_{\text{Tan }\theta} \quad \frac{N \times 1}{3361 \text{ (constant)}}$$

Where, N is the average number of contour crossings per mile, I in 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 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. The average slope of the town of Jorhat (map-8) varies from 0^0 to 8^0. The maximum slope is 8^0 and is noticed in the Tocklai area ($6^0 - 8^0$), Rajamaidam, Kabarstan road area ($2^0 - 4^0$) and Malow Ali bears a slope of 0^0 to 4^0. In the same way, the central part of Jorhat is of 4^0 and all the adjacent area bearing the same slope make this part even. Borbheta area in the southwestern part of the town shows lowland and has a slope of 2^0 to 4^0.

Map-8



Source:Prepared by the Researcher

Thus it is seen that the average slope of the greater Jorhat gradually falls southeast to northwest. The topography of Jorhat is almost plain. There is no permanent blockade of surface water flow in the town. It has been observed that the flood and water logging in Jorhat town is a manmade feature. Hence, there are possibilities of identifying physiographic basis of solution to the problem.

V. 2. General Elevation of Bhogdoi River Basin

Almost one-third, that is, 35 percent of the basin area of the Bhogdoi falls within the Naga hills and the rest in the plains. Therefore, there is a wide contrast of relief representing these two parts. Maximum elevation within the basin is 1350m and minimum at the mouth of the river is about 80 m. A hypsometric curve (hypsographic curve) indicates the proportion of a given area of the earth surface at various elevation (or depth) above (or below) a certain datum. The hypsometric curve of the drainage basin of the Bhogdoi is prepared by selecting the contours at 100m. 200m, etc. to

Table- 25: Area-altitude data of River Bhogdoi

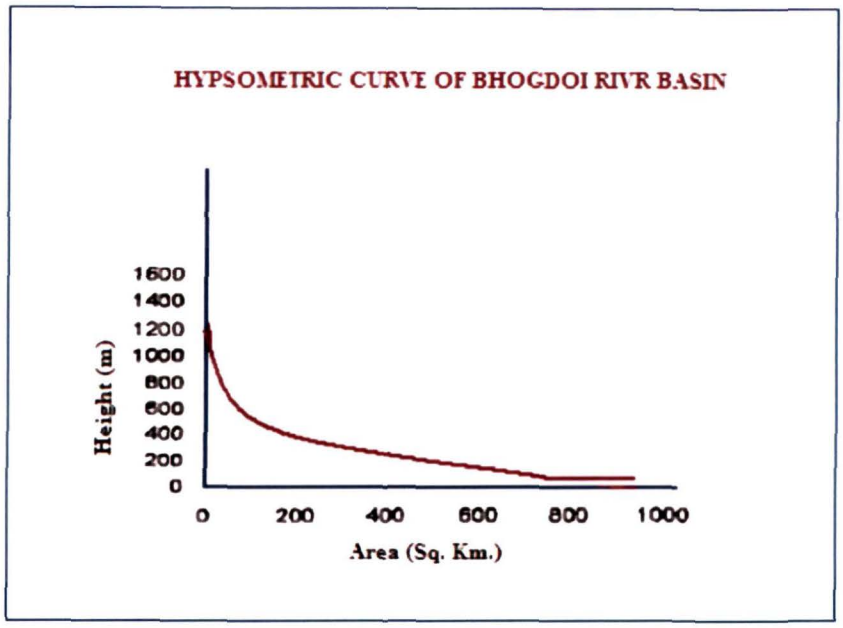
Contour interval (m)	Area (km^2)
Above 1200	0.225(0.02%)
1200-1100	1.375 (0.15%)
900-800	5.4756 (0.59%)
800-700	5.7 (0.61%)
700-600	14.705(1.57%)
600-500	24.545(2.63%)
500-400	40.45(4.33%)
400-300	64.6(6.92%)
300-200	163.2(17.49)
200-100	237.454 (25.45%)
Below 100	370.3 (39.70%)
	Total area- 932.975 = 933

Source:Computed by the Researcher

1400m from Survey of India toposheets. The area in between two contours are calculated by a digital planimeter and later converted to percentage. The data are presented in table-25. The hypsometric curve of the Bhogdoi is shown in the figure-9.

The figure shows that about 60 percent of the total basin area of Bhogdoi river is above 100m elevation. The curve is steeper in between 700m and 1350m.

Fig-11: Hypsometric Curve of the Bhogdoi River Basin



V.3. Drainage System Analysis

The present analysis on drainage system of the town of Jorhat is purely based on local situation. Hence, drainage primarily means the natural drainage of local origin in this study. A brief description of the existing drainage has been given in this chapter.

Bhogdoi River System: The river Bhogdoi is one of the south bank tributaries of Brahmaputra river originating at Mokokchung in Naga hills. At the initial stage, the river is known as Tsuing or Desoi and runs from northeast to southwest direction for a length of 25 kms and then it turns from southwest to northeast direction. After covering further length of about 25 kms, it turns from northeast direction to north direction for a length of 16 kms. Then again, it flows for a length of 32 kms from

north to northwest direction up to Jorhat town. From the town the river changes its direction towards north-west for a length of 60 kms. Before joining Dhansiri near its confluence through Gelabeel the river flows parallel to Brahmaputra.

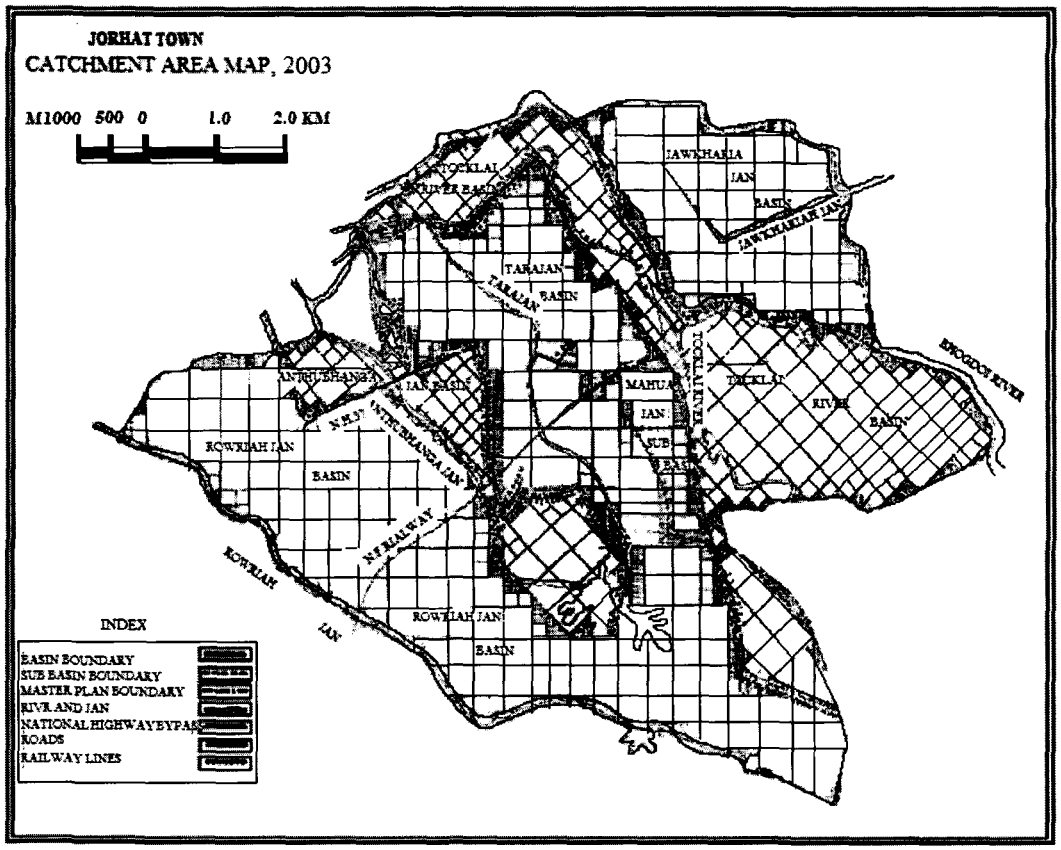
The length of the river from origin to outfall is 160 kms out of which 95 kms in hills and 65 kms in plains. The total catchments of the river (map-9) including the catchments of its tributary Kakodonga is 2028 sq.kms. The river before meeting the Dhansiri river at its end flows into Gelabeel. The total catchments area covers 920.00 sq kms. Though the area is being built up, yet some portions are left out as original paddy fields. The channel of the Bhogdoi river is rather narrow. Most part of the Bhogdoi bank is occupied by recent settlers. Bed of the river is generally silted up due to the encroachment caused by the new settlements. As a result, the river is rendered incapable of discharging the load of catchments area.

Almost all the low-lying areas have been filled up; buildings are constructed in an unplanned manner within the drainage basin. The basin area is more or less flat. Roads have been constructed in certain areas at a higher elevation than the adjoining areas. These roads with limited number of culverts usually blocks free flow of rainwater.

Rowriahjan Basin: The Rowriahjan basin covers catchments area of about 1962.0 hectares and is delineated by the Mariani road on the east, master plan boundary on the south and western part and has catchment's boundary line with Athubhangajan on the north.

Important institutional establishments like Regional Research Laboratory, part of Assam Agricultural University, Rowriah Airfield, Air Force base and major

Map-9



Source:Town and Country Planning Department,Jorhat

part of 41 sub-area of army base are located in this basin. There is no proper drainage outlet connecting the establishments with the main channel.

Anthubhangajan Basin: This drain has a catchments area of about 593.00 hectares that extends up to Na-Ali on the east and bounded by Defence road, Kamar Bandha road, Sonarigohain gaon and Bohatia gaon road on the northeast and Bhatemara gaon road, Assam Trunk road and Hazari gaon road on the west and south western part. This catchments area mainly covers Sonarigaon, Jorahat Jail and Police

Reserve and parts of Assam Agricultural University campus. Resectioning of the Anthubhangajan is important and the low-lying areas near Assam Agricultural University campus need to be conserved as natural reservoir.

Tarajan Basin: The Tarajan originates near Agricultural University and traverses nearly 4 kms before entering the Jorhat town. After crossing the town area it outfalls into Gelabeel in the down reaches of Bhogdoi river beyond Changeliati village. It covers a major part of the municipal area of Jorhat extending up to Gar-Ali on the east and national highway by-pass, Jagannath Barooah road on the north and northeast, the catchments area of the basin is about 1590.00 hectares. This catchments area also covers Club road, Na-Ali, headquarter of 41 sub-area of army base, Borbheta gaon and Chaodang gaon. The Tarajan is the main drain through which about 85 percent surface water of Jorhat town is drained out. It is the lifeline of Jorhat municipality.

Mahuajan Basin: Mahuajan sub-basin is a sub-ordinate basin of Tarajan basin, which covers about 265.00 hectares and mainly covers areas of western part of Gar-Ali, Na-Ali, Club road, Jorhat town railway station, Dohabara, Atilagaon and Kamar Bandha road. The Mohuajan originates from the southeast of Jorhat town and outfalls into Tarajan. Mahuajan is an important drainage channel for the old and new residential areas at Dohabara, Na-Ali, Club-road areas where water logging problem is a common phenomena even during a small shower of rain.

Tocklai River: It is bounded by the river Bhogdoi on the east and northeast and national highway by-pass, Gar-Ali, Mariani road on the west and southwest and covers a total catchments area of about 1544.00 hectares.

Tocklai originates from Doklongia tea estate near Mariani and traverses nearly 12 kms before it enters the heart of the Jorhat. Originally (till 1978) the river flowed in parallel to Bhogdoi river and meet the river Bhogdoi near Jagannath Barooah road at down stream but in 1978 diversion works of Tocklai river was carried out by the Jorhat Embankment and Drainage Department, joining the Tocklai river with Bhogdoi river at upstream near immersionghat (Plate-13).

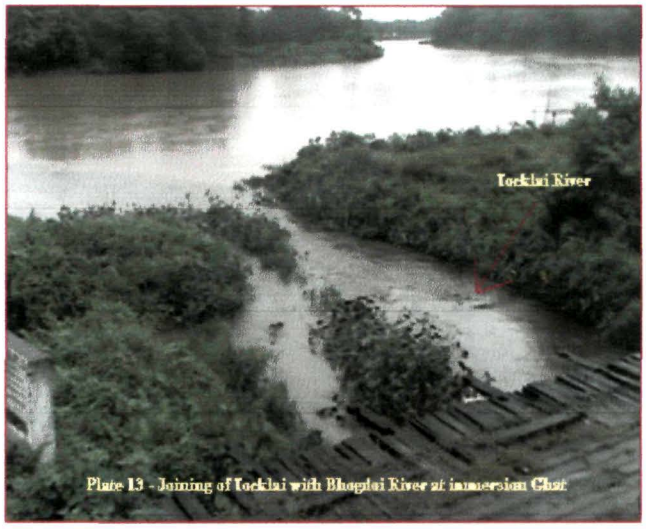


Plate 13 - Joining of Tocklai with Bhogdoi River at immersion Ghat

Thus, the river Tocklai mainly drains out the local runoff of the area including Jorhat as well as some tea gardens in the upper reaches and jungles. Therefore, part of the character of the catchments is also urban in nature comprising of buildings, roads etc with higher intensity of rainfall. Tocklai river basin covers a part of Jorhat municipal area, main commercial establishment at Assam Trunk road and Gar-Ali, Assam Engineering College, Tea Research Centre, upper Assam Commissioner Office, Head quarter of Dhansiri valley project, Oil and Natural Gas Commission at Cinnamara etc. Tocklai river is another most important drainage channel in Jorhat municipal area and immediate attention need to be drawn to protect this from misuse and encroachment on the banks.

Jawkhariajan Basin**:** It is surrounded by the master plan boundary in the north and east and by the river Bhogdoi and its catchments on the west and south. The catchments area of this basin is about 963.00 hectares.

V.4. History and Present Situation of Water Logging in the context of Bhogdoi River, Tocklai River and Tarajan

Though there are many natural streams in Jorhat, yet only three of them carry the entire waters of the area, namely Tocklai, Tarajan and Mahuajan. The history and the present situation of these streams have been studied to some extent.

Bhogdoi river

Bhogdoi is a shallow river and therefore flashy in nature and meandering in behaviour. The river carries sufficient silt in its course and thereby decreasing the depth of river every year.

Dyke System: The river flow has been restricted by the construction of embankments on both sides of the river with a proper plan.

a) Bhogdoi bund both bank from Immersionghat to Jagannath Barooah road, right bank. 0 to 6.00 kms, left Bank = 0 to 5200 kms

b) Bhogdoi bund both bank from Jagannath Barooah road to Chengeliati Village, left bank = 0 to 11.50 kms, right bank = 0 to 12.425 kms

These bunds were constructed in the year 1954. The existing embankment system of Bhogdoi and both banks of Immersionghat to Jagannath Barooah road for a length of 5200 kms (left bank) and 6000 kms (right bank) protects Jorhat town and its neighboring areas from flood. The reach of its left bank with a length of 200 kms from Immersionghat to Rajamaidam mainly protects the heart of the Jorhat town with all its administrative, industrial and business complexes. As this reach passes though the heart of the town, its safety during flood season has been a major problem to the

department of handicraft due to limitation of borrowing area for earth collection. The river Bhogdoi experiences more flood waves than any other rivers on the southern bank of the Brahmaputra river. The river bed is very shallow (map- 7) and as a result during flood season, the river crosses danger mark within 12 hours of the precipitation. Due to shallowness of the river section and low lying adjoining areas, the river has a great tendency to change its course during high flood period. The main problem of the town and its adjoining areas are flood and water logging. The section of the embankment provided earlier is not adequate and the embankments have been kept quite close to the riverbank. Hence, raising and strengthening of entire length of embankments is very essential.

It has been observed that since the construction of the embankment, there are no major works carried out till date. The existing section of embankment is not at all sufficient to restrict any flood. Free board is not available in most of the reaches of the embankments. Moreover, due to the heavy deposition of silt at its riverbed, the bed level is 2.0m higher than that of Jorhat town. Therefore, raising and strengthening of embankments at this dyke is essential. The dyke particularly at 2200 to 2300 m, 2800 to 2900 m and 4200 to 4300 m on left bank and 2450 to 2600 m, 3500 to 3575 m, 4500 to 4600 m and 5900 to 6000 m on right bank are suffering from severe erosion at the top reaches. The river slope and half of the crest have been eroded in most of the reaches due to flood. In addition, the dyke is so located so close that there is no scope for constructing a retrenchment dyke in the area as protective measures. The side of the dyke locates thickly populated villages, paddy fields and properties. The people of the area are pressing hard to this department for taking immediate measures against this vulnerable reaches. Moreover, on the right bank of Bhogdoi, there is a

Bejijan channel, which drains substantial areas and was constructed in 1959 for 10 kms. Presently this channel creates water logging and inundates adjacent areas like Alengmara, Pulibor etc. These areas remain under water for many days during rainy season.

Tarajan and Tocklai River

Almost 85percent surface water of Jorhat municipal area is drained by Tarajan only, which comprises of catchments about 1590 hectares. The catchments area of drainage basin of Tarajan is both rural and urban in character. The drainage system of Tocklai river and Tarajan is inadequate to carry the load of water flow. Also due to the higher bed of the river Bhogdoi than the bed of other streams in the town creates flood and water logging. Moreover, prior to 1978 no definite drainage system was existed except Tocklai channel in the Garmur area in the southeast.

Measures so far taken up to control water logging and flood:

In 1978, the Jorhat Embankment and Drainage division took up following works:

a) Diversion of Tocklai to Bhogdoi near Immersionghat.

b) In order to protect the area from back flow of Bhogdoi, marginal bund on both banks from Immersionghat to upstream were provided.

c) Provision for Hume pipe culvert with cement concrete base were provided to have cross drainage works near diversion in Garmur area that joined the remaining channel of Tocklai.

d) Resectioning of Tocklai at down reach from the origin to outfall (near Jagannath Barooah road) towards downstream of Bhogdoi which was linked with Tarajan at downstream.

The above works were executed in 1978 that acted successfully for many years effectively to carry out the task of draining out the accumulated runoff. But in recent years (since 1985) Jorhat town has outgrown with population and constructions of new buildings and houses. Therefore, the above channels are inadequate to carry the discharge to its maximum as the runoff increases with the increase of settlements. Gar Ali is in the extreme northern limit of the catchments area of Tocklai. The shape of Jorhat town is like a parabola. Along Gar Ali, natural slope takes an eastward turn towards the east while on the western part the gradient is towards west. To drain out the excessive water from Tocklai river in 1978, one diversion channel was made along the Bhogdoi towards west. After crossing the by-pass, the channel turns to south and meets Tarajan.

Plate 14: 'L' type turn taken by the Tocklai River by the side of the Maternity Home

Plate 15: A front view of city university house at Milan Nagar area.

The drainage act of 1953 strictly prohibited the interference with natural streams to all the citizens in India in the greater interest of the people. But in reality no such rules are followed. Citizens are not aware of the channel encroachment problems. For example, Tocklai river is blocked by the walls of Jiba Borah City

Maternity Home at Milan Nager in the north western part of the town. At this point, the channel has to discharge its load by making an 'L' type of turn, which reduces the carrying capacity (plate-14 and 15). Due to that within a few hours of precipitation, the whole area normally is inundated.

V.5. Water logging and Inundation problem of Jorhat Town

Water logging is an environmental problem of a town which not only causes inconveniences to pedestrians but creates traffic congestion, road blockade, accidents and pollutions. A heavy shower of one hour is enough to inundate roads and residential areas of Rajamaidam, Pujadubi, Bongalpukhuri, Choladhara and Malow Ali area. There are areas like Dohabara, Atilagaon, Rajabari Mission compound, Sonari gaon experiences water logging occassionaly. The causes of this phenomenon are -

a) Due to the higher bed level of river Bhogdoi than the other streams and *Jans* in the town (map -7). During flood Bhogdoi flows reverse direction from these streams or *jans*.

b) Concentration of heavy rainfall for 2/3 months in a year is the cause of water logging. The average annual rainfall is 2420.91 mm (average of 1985–1995). About 60 percent of this rainfall occurs only in 80 to 100 days in a year, which inundates many areas.

c) With the increase of dwelling units, offices, business establishments the existing roadside drains are becoming inadequate to discharge the rainwater and wastewater of the town. Moreover, many small drains are connected to the main drains at right angle for which natural flow is greatly hampered. In

addition to this the silt accumulated in the roadside drains, carrying capacity of storm water is reduced.

d) Earth cutting is causing siltation in the low-lying areas and that creates water logging in many parts of the town. The soils of this area become very hard when it dries and in wet condition, it is soft and are eroded easily. The eroded soils are deposited at the bottom of the drains and low-lying areas.

e) Due to constructions of houses, roads and other structures, the storm water retention capacity is losing in such areas. As a result, new areas are getting water logged. The wetland encroachment is a common phenomenon in Jorhat. For this encroachment, the wetland lost its water holding capacity to retain storm water. As a result, nearby areas being frequently inundated during rainy season.

f) Loss of forest cover due to construction of buildings soil erosion is increasing. This erosion is increasing siltation and causing water logging.

g) Defective drainage network and adoption of adhoc measures to control water logging is another problem.

The topography of Jorhat controls the natural drainage system. The relief of the town gradually falls towards southeast to the northwest (map-8). The major natural drains are originating from the hills and highlands. Mushrooming of settlements on either side of the perennial drains in and around Jorhat town restricts easy flow of water. Between the natural drains, the presence of depressed areas usually prompts the collection of water in scattered areas after every shower.

The cultural morphology of the town on the other hand has brought a change in the structure and shape of Jorhat town. Most of the drains are relentlessly constructed on the physical slopes.

The composition of the soil plays a major role for water logging. The depressed areas are composed of deposion of soils from the highlands and the built up areas are newly filled soils. The water percolation rate reaches the lowest point during the monsoon may attribute to this phenomenon.

Illegal encroachers cover up most of the natural water reservoirs. The swampy areas in between Sarbaibandha and Sweeper patty are packed with settlements. The Malow-Ali and Shastripith low-lying areas of Choladhara are also covered up by construction of residential quarters which causing permanent blockade of rainwater.

The basti-bylane adjacent to Pujadubi is covered up by sewage water. The Malow-Ali area faces water logging primarily due to the blockade of the local drain. Roof and pavement with considerable elevation leading to the adjacent lower grounds are causing water logging too. Examples can be cited from the Jorhat Head post office area.

V.6. Water Discharge Study

The quantity of water that passes a given point in a unit of time is called discharge[4]. Discharge is generally measured in cubic metres 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 increases in the downstream as more and more tributaries add their water to the main channel. The river Bhogdoi has many tributaries from its source to mouth.

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

Discharge = channel width X channel depth X water velocity

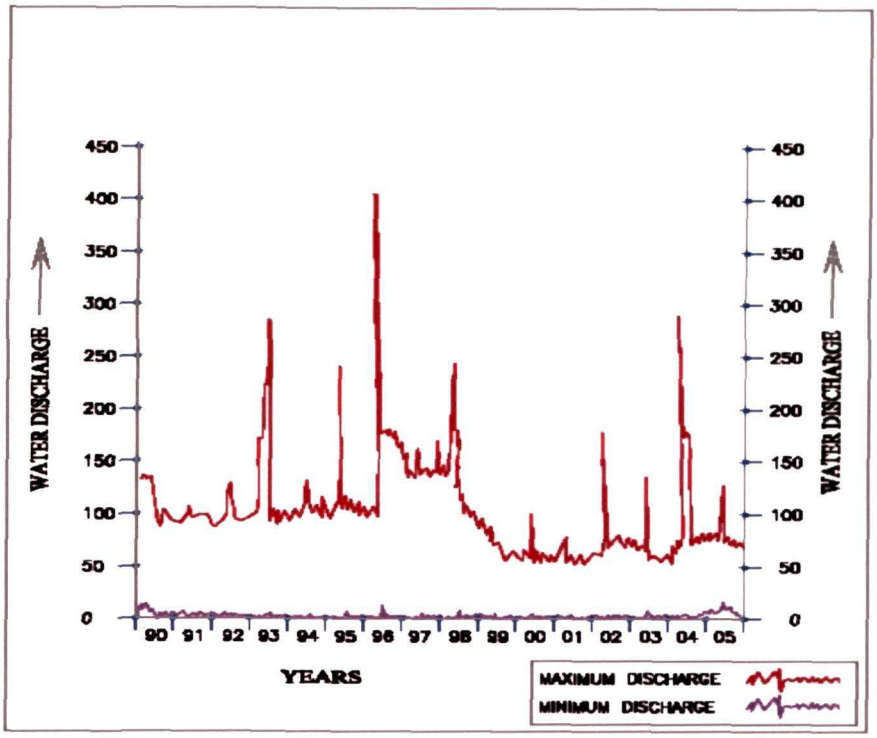
Discharge data of Bhogdoi river for 16 years were obtained from the flood records of Flood Control Department, Government of Assam. It records that the maximum average discharge of water is 64.02 cumecs during the monsoon season while minimum average discharge is only 10.0 cumecs in the lean period. From the table-26, it is observed that in the year 1996, the maximum discharge of Bhogdoi was 410.98 cumecs while the lowest discharge was recorded at 0.11 cumecs in 1982. Fig-10 shows that the second largest discharge occurred twice during the last 16 years.

Table-26: Maximum and Minimum Discharge of Bhogdoi River at Assam Trunk Road Crossing Site (1990–2005)

Year	Maximum Discharge	Minimum Discharge
1990	146.72	1.06
1991	116.84	1.57
1992	134.99	2.83
1993	292.4	1.35
1994	126.64	1.22
1995	278.88	2.08
1996	410.98	3.1
1997	163.04	1.97
1998	248.1	2.46
1999	95.05	0.64
2000	98.66	0.91
2001	80.29	0.6
2002	201.75	0.59
2003	136.41	2.61
2004	292.4	1.3
2005	113.08	4.3

Source: The Embankment and Drainage Department, Rajabari, Jorhat

Fig -10:Maximum and Minimum Discharge at Assam Trunk Road Crossing Station (1990–2005)



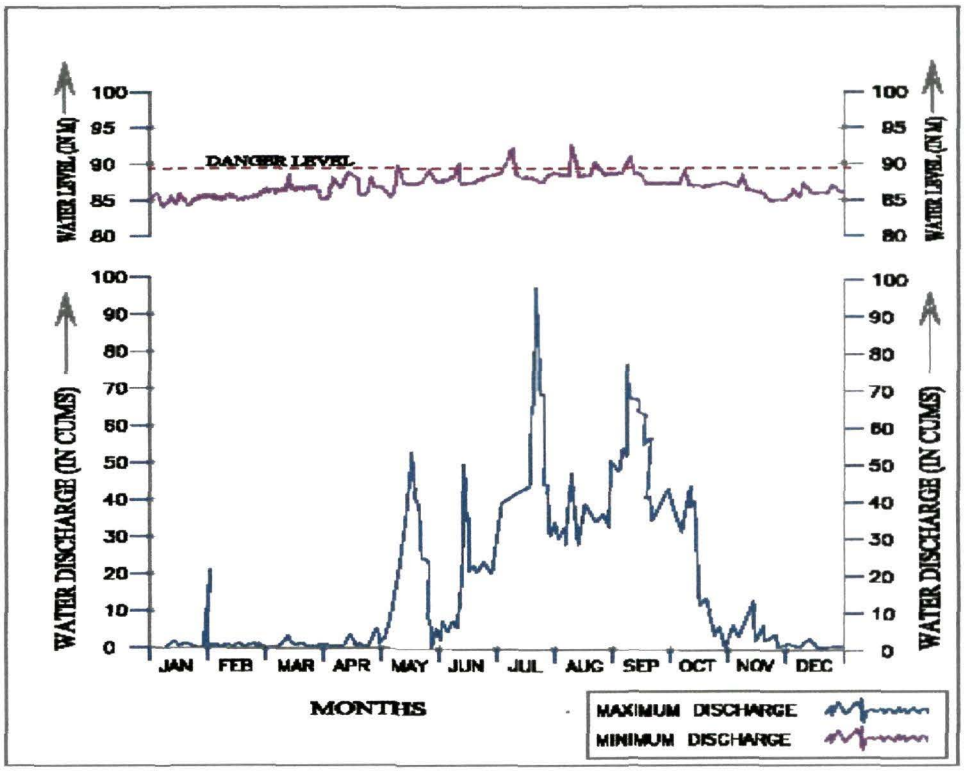
This is quite obvious that the water level has a close relationship with discharge of the river. The water level and discharge both increases from the month of May to September (table-27 and fig-11). From the fig-11, it is noticed that the highest

Table-27: Water Discharge and Water Level of the Bhogdoi River at Assam Trunk Road Crossing site Jorhat, 2000

Months	Water Discharge (in Cumecs)	Water Level (in Metres)
January	1.89	86.1
February	0.91	86.12
March	2.3	88.59
April	2.4	88.64
May	51.2	89.13
June	48.2	89
July	98.66	90.41
August	45.01	90.56
September	75.8	90.1
October	42.1	88.3
November	10.1	88.01
December	1.99	86.28

Source: The Embankment and Drainage Department, Rajabari, Jorhat

Fig-11: Water Discharge and Water Level at the River Bhogdoi at Assam Trunk Road Crossing Site, 2000



peak of water discharge is observed in the last part of July. The second highest peak is observed in the month of September, while third and fourth highest peak of discharge are recorded in the months of May and June. During these peak periods of discharge, the water level of Bhogdoi rises up and even crosses the danger level. When water level crosses the danger mark, the back flow of the Bhogdoi to other streams starts. The water received from the catchments area of Bhogdoi, automatically accumulates and if the water level of Bhogdoi remains constant for few days the surrounding areas are flooded. As a result, the low-lying areas of the town are normally submerged during this period. It is seen that the valley section of Bhogdoi is not large enough to carry the entire load of water of its catchments area. In addition to this, the industrial wastewater from Tocklai area considerably increases the load. Moreover, the bed of

the Bhogdoi river is being silted up and these silted areas on the river is trespassed by settlers. Hence discharge capacity of the Bhogdoi river inside urban stretch has been progressively reduced.

Annual hydrographs of Bhogdoi river: Annual hydrographs of Bhogdoi river is also prepared for all the years from 1977-1988 taking 24 hours of mean discharge representing one day. Some representative examples of the annual hydrographs of Bhogdoi river for the entire study period are shown in table-28 and fig-12a and 12b

Table-28: Annual Discharges of the Bhogdoi River, (1977-1988)

	Discharge (m^3sec^{-1})											
	Year											
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
January	0.9	0.10	3.8	0.1	4.8	1.00	1.3	17.5	.90	1.9	1.89	1.62
February	0.8	0.8	2.5	0.9	.31	0.11	.71	15.3	1.3	2.3	.79	1.62
March	0.6	0.6	.43	.78	3.2	.89	.81	0.75	.69	.71	2.3	1.59
April	20.3	0.5	2.3	.74	60.2	42.3	.82	10.9	53.9	43	2.4	1.99
May	40.89	13.0	5.2	23.4	78.9	51.3	82.3	41.3	45.3	38	3.9	3.89
June	401.98	53.4	20.3	53.3	40.2	239.45	83.0	65.3	239.79	25.3	51.2	81.8
July	150.3	100.3	43.4	152.8	60.0	103.3	346.81	101.71	55.39	43.5	221.34	105.1
August	250.08	369.9	13.2	225.9	63.2	225.3	125.3	39.2	45.3	64.0	201.4	103.17
September	120.30	58.5	56.3	279.8	83.1	68.3	101.3	39.0	82.3	41.3	48.2	68.3
October	39.2	15.3	52.3	100.2	21.0	72.3	95.2	24.2	48.2	91.3	50.2	115.1
November	23.3	15.3	10.3	140.0	15.2	25.0	48.3	15.2	42.5	20.0	10.1	14.2
December	0.1	9.5	5.0	29.0	4.2	11.0	28.3	5.8	2.0	1.5	1.99	7.5

Source: Investigation Division, Flood Control Department, Govt. of Assam

An in-depth observation on the hydrographs covering 21 hydrological years evidenced the following relationships:

a) All hydrographs indicate that the initial part of stream discharge is made up of flash floods, occurring at different times. In more common cases during the month of April but sometimes it occurs even May also, example 1981, 1985 and 1986.

Fig-12a

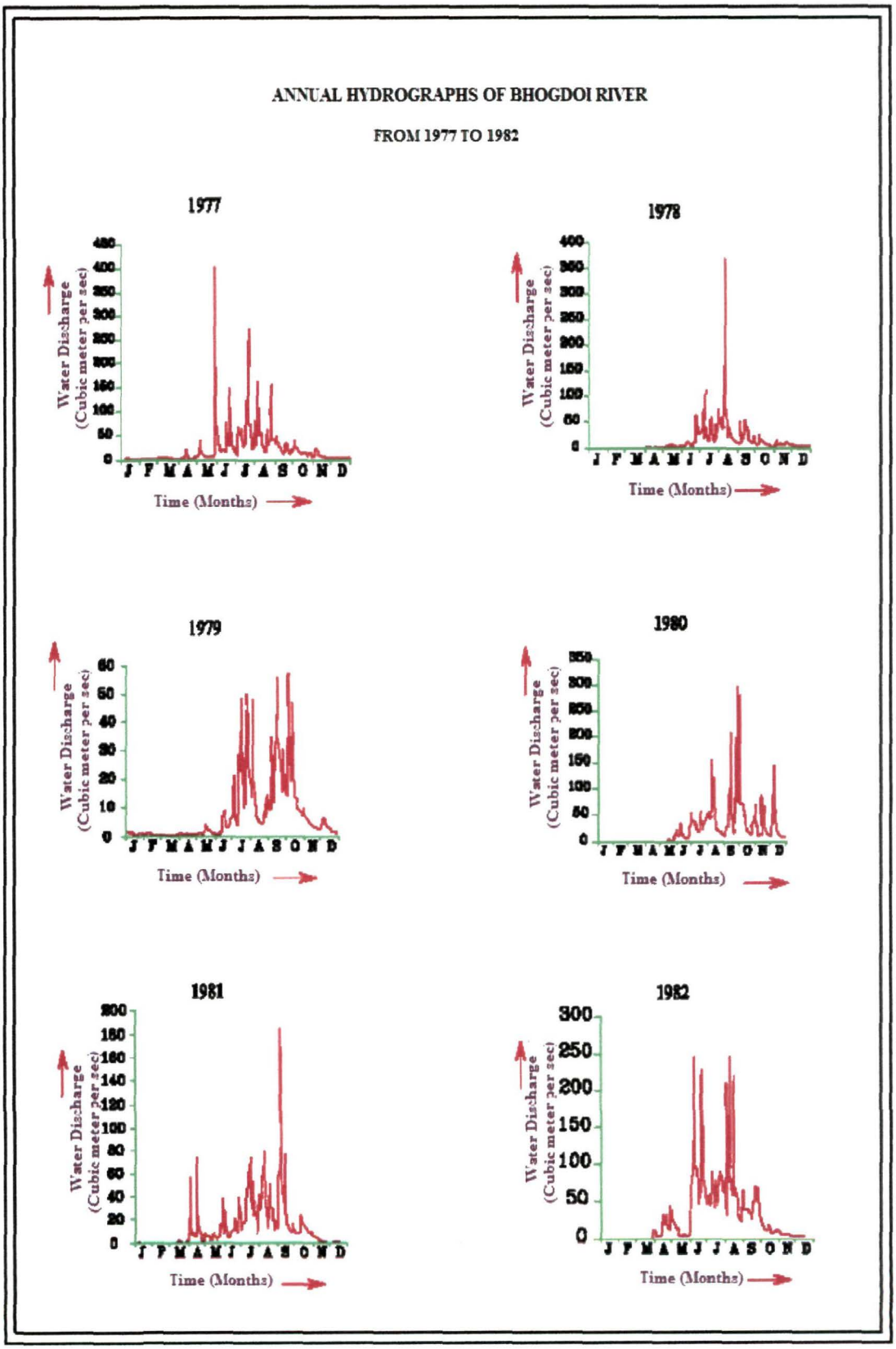
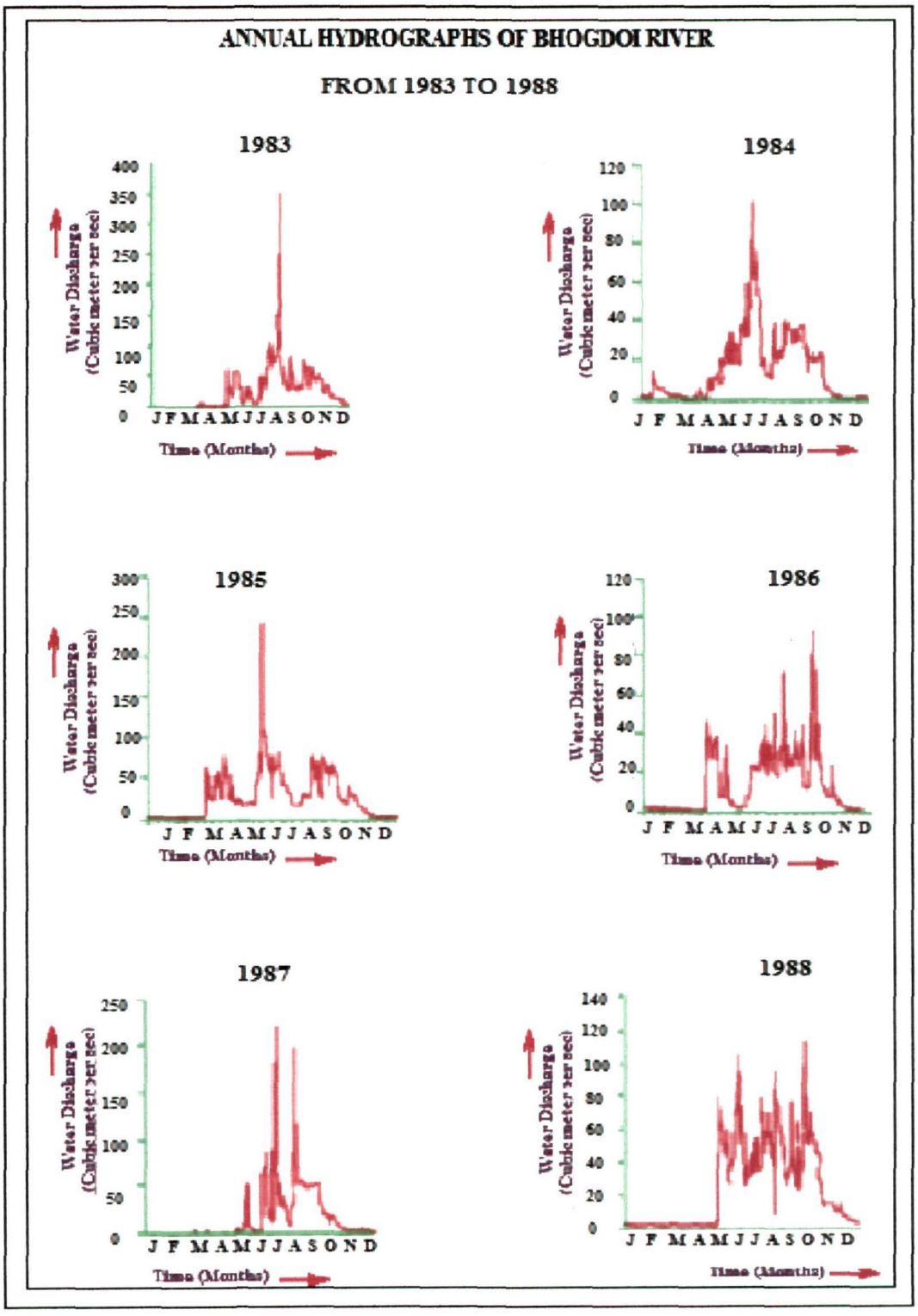

ANNUAL HYDROGRAPHS OF BHOGDOI RIVER
FROM 1977 TO 1982
1977
1978
1979
1980
1981
1982
Water Discharge (Cubic meter per sec)
Time (Months)
J F M A M J J A S O N D

Fig-12b


ANNUAL HYDROGRAPHS OF BHOGDOI RIVER
FROM 1983 TO 1988
1983
1984
1985
1986
1987
1988
Water Discharge (Cubic meter per sec)
J F M A M J J A S O N D
Time (Months)

b) Flood peaks occurring from April-May are generally smaller as compared to those during June to August example, 1981and 1986.

c) Variation of discharge over very short interval of time is frequent during the flood period that is in the month of June through August. Maximum difference of 293.51 m^3sec^{-1} in 24 hours (August, 10-11, 1978) is recorded in the rising limb of the flood hydrographs.

d) In some years the hydrographs are represented by a single prominent peak (1978, 1981, 1983, 1985) occurring at different months from June to September.

In other years, the hydrographs show a number of distinct peaks well separated from one another. Hydrographs of the year 1988 shows that discharges were continuously high from the months of June to October and represent a number of closely spaced peaks occurring throughout the period of high flow.

All these hydrographs indicate positive increase of trend from April onwards to middle of September. It is quite natural that during the period of low rainfall, the trend is decreasing. This decreasing tendency, which starts from the post monsoon period, experiences tendency of discharge distributions at low rates. This means that the flood or water logging mainly occurs in the monsoon period when the discharges are very high. July and August months are the peak months of water logging.

V.7. Water Level Study

The behavior 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 riverbanks. The rivulets of Bhogdoi inside greater Jorhat are renders inactive in discharging their water level to the master drain. On the contrary, backflow from the

river Bhogdoi enters through the natural drainage and increases both the levels and volumes of water in the rivulets. Normally, backflow through Tocklai river causes flood inside the town at every spate of high water in Bhogdoi.

From the table-29, it becomes clear that Bhogdoi water level rises above danger level throughout the year at Assam Trunk road site. It means no year was free

Table-29: Water Level of Bhogdoi at Assam Trunk Road Crossing site (1985–2005)

Year	Maximum Water Level (in Metre)	Date	Minimum Water Level (in Metre)	Date
1985	90.15	18.6.85	88.31	27.2.85
1986	89.75	7.10.86	88.29	9.4.86
1987	90.05	25.7.87	88.31	3.2.87
1988	89.70	4.10.88	88.31	1.3.88
1989	90.45	29.7.89	88.28	29.3.89
1990	89.75	10.7.90	88.29	21.3.90
1991	89.85	19.9.91	88.32	21.12.91
1992	89.73	22.7.92	88.30	6.4.92
1993	90.06	23.6.93	88.32	31.12.93
1994	89.68	2.7.94	88.30	9.1.94
1995	90.2	26.8.95	88.24	2.2.95
1996	90.45	31.7.96	88.3	31.12.96
1997	89.8	10.8.97	88.25	5.4.97
1998	90.17	11.7.98	88.2	16.2.98
1999	90.15	29.8.99	88.17	20.3.99
2000	90.41	17.6.00	88.23	8.4.00
2001	89.65	2.10.01	88.2	21.2.01
2002	89.98	12.8.02	88.22	12.3.02
2003	89.58	16.7.03	88.21	28.1.03
2004	89.65	12.8.04	88.2	21.2.04
2005	89.67	20.8.05	88.23	11.2.05

Source:The mbankment and Drainage Department,Jorhat,2006

from flood out of these 21 years. On the other hand, water level of Bhogdoi at Malow Ali site (table-30) rises 15 times than danger level in 17 years duration. It means only 2 years were free from flood out of 17 years.

Table-30: Waer Level of Bhogdoi at Malow Ali site, Jorhat (1990–2006)

Year	Maximum Water Level (in Metre)	Date	Minimum Water Level (in Metre)	Date
1990	86.24	9.6.90	88.94	28.1.90
1991	89.36	11.7.91	87.62	11.2.91
1992	86.08	26.6.92	80.2	5.3.92
1993	89.6	6.7.93	80.08	31.12.93
1994	89.47	22.6.94	79.73	24.2.94
1995	90.25	7.7.95	79.95	14.2.95
1996	90.15	20.7.96	82.89	21.2.96
1997	89.82	10.7.97	82.79	6.3.97
1998	90.79	4.7.98	80.22	20.2.98
1999	90.66	26.8.99	80.05	24.2.99
2000	90.05	4.8.00	80.14	29.2.00
2001	89.7	23.6.01	79.65	17.2.01
2002	89.41	22.7.02	79.69	27.2.02
2003	89.6	9.7.03	79.59	31.1.03
2004	89.17	22.6.04	79.8	2.3.04
2005	89.15	25.8.05	79.97	13.2.05
2006	89.08	13.6.06	80.39	14.2.06

Source: The Embankment and Drainage Department,Jorhat, 2006

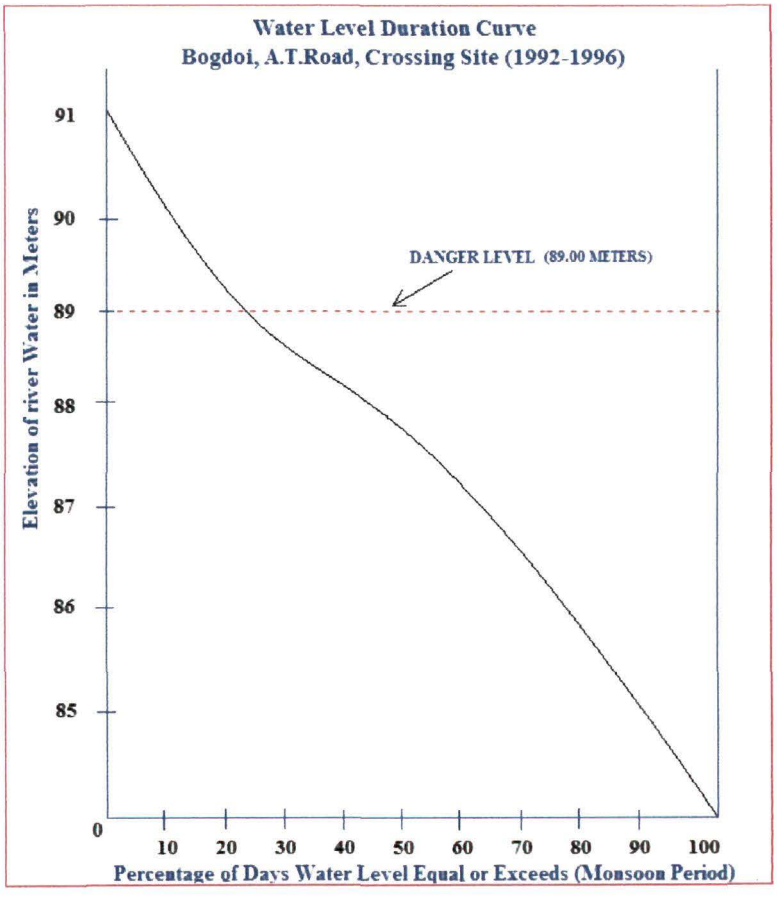
Maximum and minimum water level of Bhogdoi River: For detailed study daily water level data of Bhogdoi has been collected from embankment and drainage department for seven years (1990–2006) at Assam Trunk road crossing site. The water level data for the last consecutive years were arranged at every one-metre interval between 85 and 90 meters. On this basis, the average rising of water level for each metre rise has been calculated. The results of the observation have been tabulated in percentage (table-31) for 150 days that is the month of May to September which are represented in cumulative graph (fig-13). This curve shows that about 41.07 percent of 150 days, the water from the Bhogdoi enters to the other streams and rivulets of Bhogdoi and inundates the town area. An analysis of Bhogdoi within greater Jorhat alone does not help to avoid flood in the town. The factors responsible

Table-31: Number of Days of Water level above Mean Sea Level of River Bhogdoi at Assam Trunk Road crossing Site (1990-996) (Danger Level 89 metre)

Year	91 m	90 m	89 m	88 m	87 m	86 m	85 m
1990	8	27	32	43	20	29	31
1991	0	27	24	38	16	38	41
1992	0	14	34	29	10	22	20
1993	0	22	22	30	39	15	20
1994	10	37	39	32	20	28	30
1995	0	44	23	37	17	9	18
1996	0	6	30	18	14	13	6
Total	18	177	204	227	136	154	166
Average days	2.6	25.3	29.14	32.43	19.43	22	23.71
Percentage of days	1.7	16.8	19.43	21.62	12.95	14.67	15.80
Cumulative	1.7	18.5	37.93	59.55	72.5	87.17	100

Source: Computed from the data of Brahmaputra Flood Control Department, Rajabari, Jorhat.

Fig-13:Water Level Duration Curve of River Bhogdoi



for the floods owing to heavy silt deposition need to be studied from the source to mouth. An expert committee report says that the silt being deposited along the river course and elevating its bed at a greater height every year. This reduces its carrying capacity and thus causing wide spread floods.

V.8. River Gauge Analysis

The river gauge records are maintained at Assam Trunk road crossing at Jorhat and its records available here are from 1987 to 1996. The danger level of the site is 89.00 metre, while the maximum water level observed is 90.27 m (on 15.7.96). During the period 1987 to 1996, the high flood level varied from 89.24 m to 90.27 m. The maximum flood lift at this site is 2.14 metre. During the flood season, the flood comes very frequently. The frequency and duration of flood can be easily understood from the table-32.

From the table-32, it is seen that out of the 120 days (June, July, August and September months) the water level remained above danger level for a period of 75

Table-32: Number of days water level remained above danger level,2001

Year	Flood waves (numbers)	Total number of days the water level remained above danger level	Magnitudes
1987	7	23 days	89.59 M
1988	13	37 days	89.68 M
1989	7	18 days	89.94 M
1990	18	43 days	89.61 M
1991	19	75 days	89.84 M
1992	7	46 days	89.99 M
1993	13	61 days	89.71 M
1994	15	58 days	89.53 M
1995	18	59 days	89.49 M
1996	14	56 days	90.23 M

Source: Rajabari Raingauge station, Rajabari, Jorhat.

days (maximum). The minimum number of days the water level remained above danger level is 18 days in 1989. It appears therefore that the flood wave in Bhogdoi river is comparatively higher than the other rivers on the south bank of Brahmaputra.

The reason for so many flood waves and long duration of flood is that the danger level of Bhogdoi has been fixed with respect to Jorhat town and the adjoining areas, which are situated at a lower level than the Bhogdoi river.

Such a long duration and quite a high number of flood peaks are a constant danger to the town and the adjoining areas and consequences are water logging.

V.9. Rainfall Analysis

The water logging problem may be looked into from the point of view of rainfall variability. The consequent results may be analyzed with the help of three distinctive parameters.

1. Intensity of rainfall
2. Diurnal variation of rainfall and
3. Runoff determination.

However the data for runoff* are not easily available (*Runoff = Rainfall – Infiltration + Evaporation + Transpiration). Hence, more emphasis has been given on the first two parameters. For the above two parameters, rainfall data for each hour has been collected from the rainfall records of the Indian Meteorological Department, Guwahati. One year data (2001) has been used for calculation of intensity of rainfall and seven years of data (2000–2006) have been used for the analysis on hourly variation of rainfall in Jorhat.

1. Intensity of rainfall: To find out the intensity of rainfall per hour the following formula has been used:

$$I = \frac{A}{n}$$

Where I = Intensity of rainfall

A = Total rainfall in a given period

n = Total number of hours of rains

The Intensity of rainfall from the hourly data have been calculated and presented in table-33. Intensity of rainfall per hour for each monsoon month that is May to September is shown in fig-14. The intensity of rainfall is not uniform in each day and each month. The graph shows high and low intensity at different time. The maximum intensity of rainfall per hour occured on 27th June, while the second maximum occurred in 23rd August. Intensity of rainfall of 5 mm column exceeds twice in May, once in the months of June and July, thrice each in August and September. It means intensity of rainfall of 5 mm per hour is experienced on ten occasions during the year 2001.

The high intensity monsoon rainfall the town receives is normally cited with thunder storms, massive cloud burst etc. This causes serious land erosion, flash floods and water logging in a dispersed but congested town like Jorhat. A study in this parameter provides adequate background information not only on the climatological processes and hydrological forecasting but also for town planning. It provides a focus on which the problem related to water management, drainage and so can be better

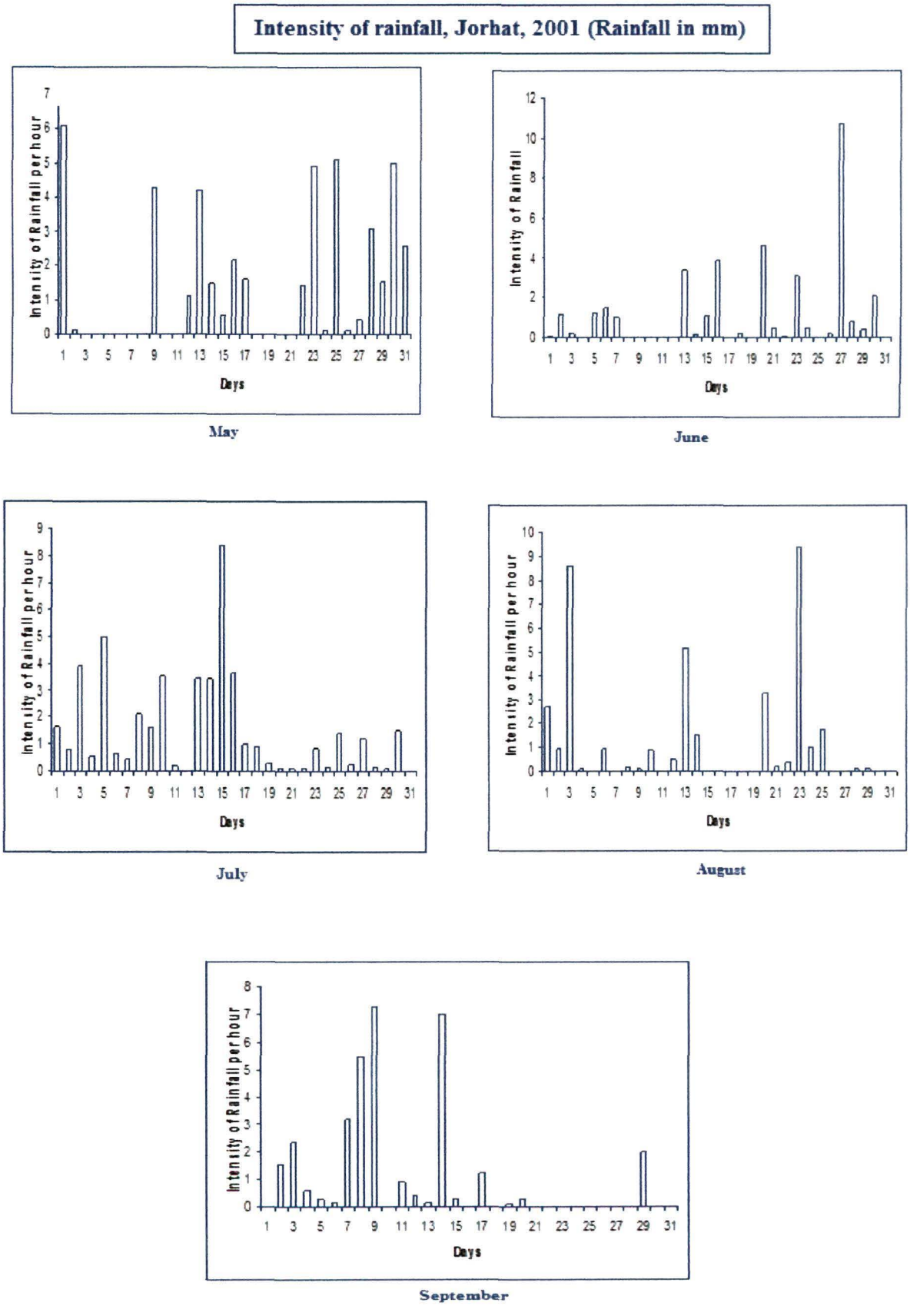
Table-33: Intensity of Rainfall per hour during Monsoon Season, 2001

Day	May	June	July	August	September
1	6.1	0.1	1.66	2.7	0
2	0.11	1.15	0.83	0.98	1.55
3	0	0.2	3.89	8.6	2.35
4	0	0	0.55	0.13	0.6
5	0	1.24	5	0	0.26
6	0	1.47	0.66	0.93	0.15
7	0	1	0.46	0	3.2
8	0	0	2.12	0.16	5.5
9	4.3	0	1.6	0.1	7.3
10	0	0	3.56	0.92	0
11	0	0	0.2	0	0.9
12	1.1	0	0	0.5	0.4
13	4.2	3.4	3.43	5.16	0.12
14	1.5	0.15	3.44	1.53	7.02
15	0.55	1.1	8.38	0	0.25
16	2.15	3.85	3.62	0	0
17	1.6	0	1.03	0	1.2
18	0	0.2	0.89	0	0
19	0	0	0.3	0	0.1
20	0	4.6	0.1	3.25	0.25
21	0	0.5	0.1	0.2	0
22	1.4	0.1	0.1	0.4	0
23	4.9	3.13	0.88	9.36	0
24	0.1	0.5	0.15	1.01	0
25	5.1	0	1.43	1.73	0
26	0.1	0.21	0.27	0	0
27	0.45	10.7	1.22	0	0
28	3.06	0.83	0.17	0.13	0
29	1.53	0.4	0.1	0.1	2
30	5	2.06	1.5	0	0
31	2.55	0.83	0	0	0

* Computed from the data, Indian Meteorological Centre, Guwahati.
Fig- 14

understood. The characteristic features of weather and climate of Jorhat is more or less similar to the weather and climate of the state as a whole. However, Jorhat has its own distinct microclimate that has been influenced by its unique physiographic conditions and location. The town and its environs are dominated by hilly areas to

Fig-14


Intensity of rainfall, Jorhat, 2001 (Rainfall in mm)
Intensity of Rainfall per hour
Days
May
Intensity of Rainfall
Days
June
Intensity of Rainfall per hour
Days
July
Intensity of Rainfall per hour
Days
August
Intensity of Rainfall per hour
Days
September

some extent, 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 has been included in the category of sub-tropical climate.[5]

Meteorologist, scientist and researchers of allied field analyses (with the available data) different elements of weather and climate as well as on its impact on the town 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 1967-1971 and 1978). The result of this estimation has often brought confused results[6]. The consequent attempt has been made with triennium data of rainfall on Guwahati to solve the water logging problem inside the city[7]. In this study , rainfall data for each hour has been collected from the rainfall records of Indian Meteorological Department, Guwahati. The recent data for six years 2000-2006 have been used, because it was observed that the town was inundated frequently since last decades. Average hourly variation of rainfall during monsoon period has been calculated using the following formula-

$R = {}^{r}/n$

Where, R= Average rainfall per hour

r= $\sum$ of total rainfall of the hour of the month and,

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

Using this formula, average rainfall for each hour, for the individual monsoon months May to September and for the season are calculated and presented in the table-34.

Table-34: Average Rainfall for each hour for the Monsoon Season (2000-2006)

May	June	July	Aug	Sept	Seasons
	3.16	2.30	2.94	2.54	2.26
2.77	3.76	3.60	2.73	2.20	3.93
3.71	3.02	2.66	2.66	2.90	2.23
2.79	3.46	2.68	3.11	1.77	2.55
3.88	2.34	2.62	3.11	2.54	2.65
2.67	3.46	2.66	3.50	2.28	2.34
2.76	3.02	2.68	3.00	3.00	2.57
2.49	3.46	2.66	3.00	2.60	2.00
2.76	3.63	2.82	2.79	2.28	3.02
2.79	2.24	2.19	2.66	2.78	2.23
2.72	3.03	3.07	2.89	2.00	3.13
2.03	3.02	2.62	2.66	2.44	2.44
2.77	2.21	2.70	2.79	2.54	2.63
2.62	2.90	2.00	2.66	2.54	2.82
2.74	2.34	2.62	2.79	2.78	2.23
2.80	3.03	2.84	2.66	2.23	2.35
2.80	2.03	3.18	3.11	3.33	4.21
2.74	3.16	2.68	2.79	2.23	2.26
2.80	3.03	2.70	2.66	2.524	3.42
2.62	2.16	2.84	3.11	3.75	2.23
2.67	3.01	2.66	2.66	2.11	3.52
2.68	2.42	2.68	3.11	1.77	2.26
3.90	4.03	2.70	2.94	4.09	3.93
2.70	2.16	2.70	2.66	2.04	2.24

Source: Indian Meteorological Department, Guwahati

The average rainfall per hour for each monsoon months and for the season has been plotted is the figure-15. The graphs are not smooth and show many primary and secondary peaks. To make the curve smooth, three point moving averages has been used (table-35). Yet some of the smooth curves have shown oscillatory in character. In order to adopt a pragmatic approach, standard deviation and co-efficient of variation of mean hourly rainfall data have been calculated (table- 36). These are calculated on the basis of the following formula-

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

Where, σ = Standard Deviation

x = Hourly rainfall

x = Mean hourly rainfall

n = Number of observation

ii) $Cov = \frac{\acute{o}}{\bar{x}} \times 100$

Where, Cov = Co-efficient of variation of mean hourly rainfall

σ = Standard deviation, $\bar{x}$ = Mean hourly rainfall

Table-35: Three Point Moving Averages of Rainfall per hour for the Monsoon Season 2000-2006 (rain in mm.)

Three Point Average of the Hours	May	June	July	Aug	Sep	Seasonal
1,2,3	3.00	3.31	2.85	2.78	2.88	2.80
2,3,4	3.09	3.41	2.98	2.84	2.62	2.90
3,4,5	3.46	2.94	2.65	2.96	2.73	2.48
4,5,6	3.11	3.08	2.65	2.24	2.19	2.51
5,6,7	3.10	2.94	2.65	3.20	2.60	2.52
6,7,8	2.64	3.31	2.67	3.16	2.62	3.31
7,8,9	2.67	3.37	2.72	2.93	2.60	2.53
8,9,10	2.68	3.17	2.54	2.82	2.62	2.33
9,10,11	2.06	3.03	2.69	2.78	2.35	3.09
10,11,12	2.51	2.82	2.63	2.74	2.40	2.60
11,12,13	2.52	2.75	2.79	2.78	2.32	2.73
12,13,14	2.47	2.71	2.44	2.76	2.76	2.63
13,14,15	2.77	2.48	2.44	2.75	2.62	2.56
14,15,16	2.72	2.75	2.48	2.70	2.51	2.47
15,16,17	2.78	2.46	2.88	2.85	2.78	2.93
16,17,18	2.78	2.74	2.90	2.85	2.59	2.94
17,18,19	2.78	2.74	2.85	2.85	2.70	3.29
18,19,20	2.72	2.78	2.74	2.85	2.84	2.64
19,20,21	2.69	2.73	2.73	2.81	2.91	3.05
20,21,22	2.66	2.53	2.73	2.81	2.97	2.67
21,22,23	3.08	3.15	2.68	2.90	2.77	3.00
22,23,24	3.09	2.87	2.69	2.90	2.63	2.80

Source: Computed from the table, Average Rainfall per hour for the monsoon season

Results: The average rainfall of five monsoon months that is May to September shows a distinct variation pattern (fig-15a and fig-15b). The average rainfall is lowest in September, while it is highest in June. The co-efficient of variation of the mean hourly rainfall is highest in June (77.61 percent) as compared to the lowest in August (7.99 percent).

Table-36: Mean, Standard Deviation and Co-efficient of Variation of Rainfall per hour per rainy day in the Months of May to September during, 2000-2006.

Months	Average Hourly Rainfall in mm	Standard Deviation of $\overline{X}$ (in mm)	Co- efficient of variation of $\overline{X}$ in percent
May	2.82	0.86	30.49
June	2.96	2.12	77.61
July	2.69	0.58	21.56
August	2.88	0.23	7.99
September	2.59	2.01	71.62
Seasonal	2.72	1.61	59.19

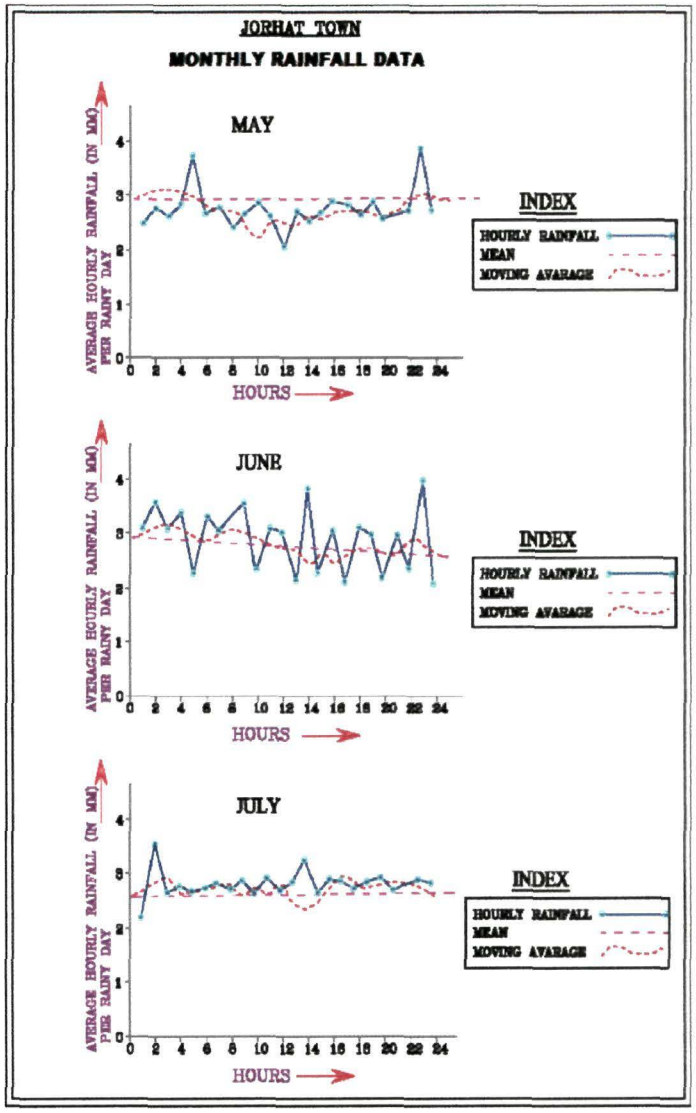
Source:Computed by the Researcher

The month of May curve indicates few peaks out of which two are greater than the mean rainfall of 24 hours. May, June and July month's curves shows prominent peaks. The characteristic feature of high peak of May 2300 hour Indian Standard Time (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 peak 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 average rainfall per hour above mean rainfall occur in eight occasions. Because of its structure (of relief), the surface run off flowing down from Naga hills in the south east, gushes into the town environs causing havoc and hazards during the peak hour of rains.

The coastal regions like Goa, Mumbai, Cochin and Trivandrum have morning maxima[8]. On the other hand, inland stations like Nagpur[9] and hill stations like Mahabaleshwar and Kodaikanal[10] have reported an afternoon rainfall.

Cherrapunjee in Meghalaya which has very heavy rainfall indicates night and early morning maxima[11]. At Jorhat, diurnal variation of rainfall varies for each of the monsoon months, earlier results shows that the diurnal variation of rainfall at Jorhat was less erratic than that of Goa, Mumbai, Bengaluru and Trivandrum. Even country's capital New Delhi has experienced water logging in the streets with an hour of heavy down pours (22nd September, 1986). This is due to nearly hundred percent roof and pavement in and around the town where runoff is higher. The diurnal variations of rainfall in micro regions are obviously different from macro regions. Hence, diurnal variation of rainfall observed in micro region is dependent on its local physiographic conditions. However, the workers engaged in this field suggested rainfall variation is due to the surface heating and associated local atmospheric circulation. Sometimes the rainfall is also caused by cyclonic storms of depression where in the diurnal variation is comparatively small[12].

Fig-15a



The prevalence of anabatic winds and the associated thunderstorms cause rainfall during daytime in monsoon region[13]. The midnight (2200-2300 hour IST) maxima observed in the month of May to June, perhaps due to delayed ground radiation and convection (the ceiling effect of cloud delays rapid radiation).

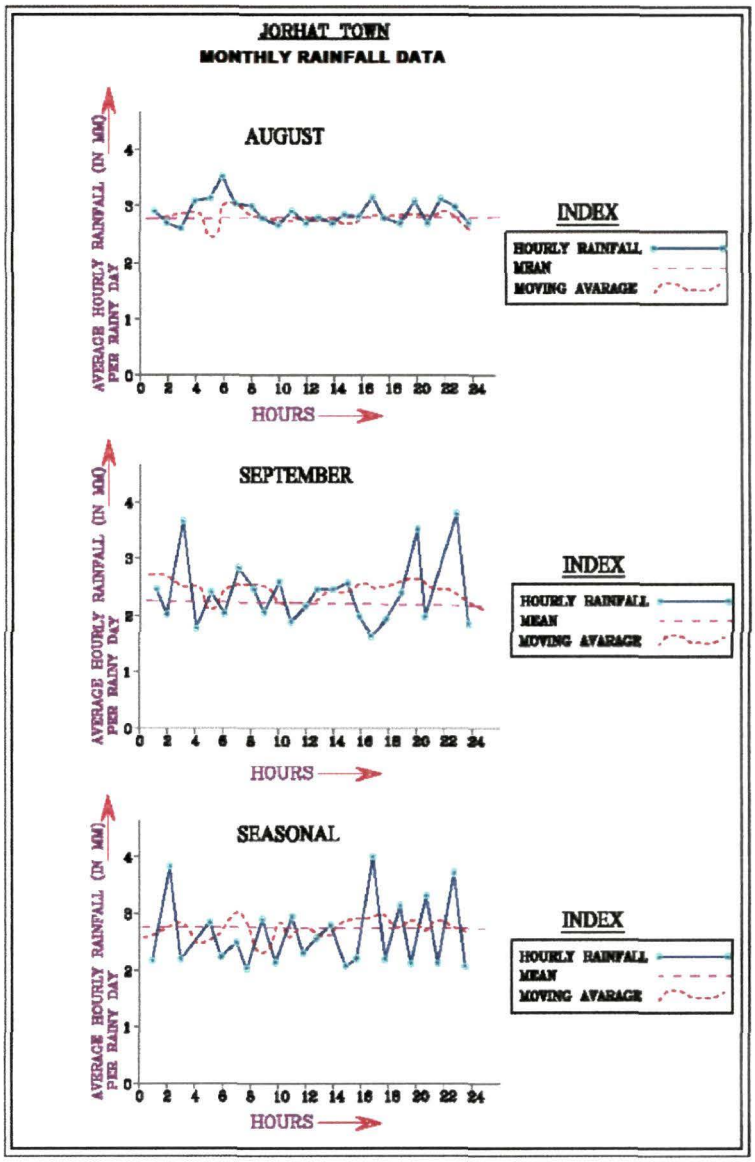


Fig 15b

In June, maximum 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 thundershowers from 1200 hour to 1700 hour in the month of June.

In the month of July, occurrence of rainfall shift beyond 1700 hours to late night (0200 hours IST). The ground radiation is delayed progressively in this month. Therefore, the thermal peak is recorded at afternoon and convectional 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 showers which continues till morning.

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, this produces instability in the atmosphere, which leads to katabatic winds during the night, and results in rainfall maxima in the evening and night of August. September is also a wet month for both Jorhat as well as for entire north east India. During this month, insolation is high from 1400 hour to 1600 hour IST. This is normally due to delayed convection processes and rainfall at night.The average hourly rainfall per rainy day is maximum and becomes incessant in the month of June and minimum in September (table-36). The co-efficient of variation of average hourly rainfall is maximum in June. The curve (fig -15a and fig-15b) clearly depicts that most of the rainfall occurs in the afternoon and during the night whereas it is less from 0400 hour to 1200 hour IST.

From the above analysis, it is apparent that Jorhat experiences about eight peak hours of high intensity of rainfall periods in one monsoon season. At times, surface runoff together with silt deposits due to erosion from surrounding high slopes that inundates the low-lying areas of the town.Though there are many peak hours but in the month of May only one peak rainfall maxima (2300 hour IST) is significant. As the monsoon begins in May, the secondary peak hour rainfall is normally absorbed by the soil, which reaches the saturated point. The other peaks (primary and secondary maxima) from the month of June to September is a sensitive period with full of

potential of flooding in the town through runoff water. The intensity of hourly rainfall is maximum in June and is always alarming as it exposed the inherent drawbacks of the drainage system of Jorhat. Rainfall occurrence and intensity is a natural phenomenon, which shows the impact on environmental degradation. It has enhanced waterlogging hazards over the last decades. This problem can be solved by restoring the natural drainage to its original extent and adding the artificial drainage system to it so that this 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 drainage channels and transport system.

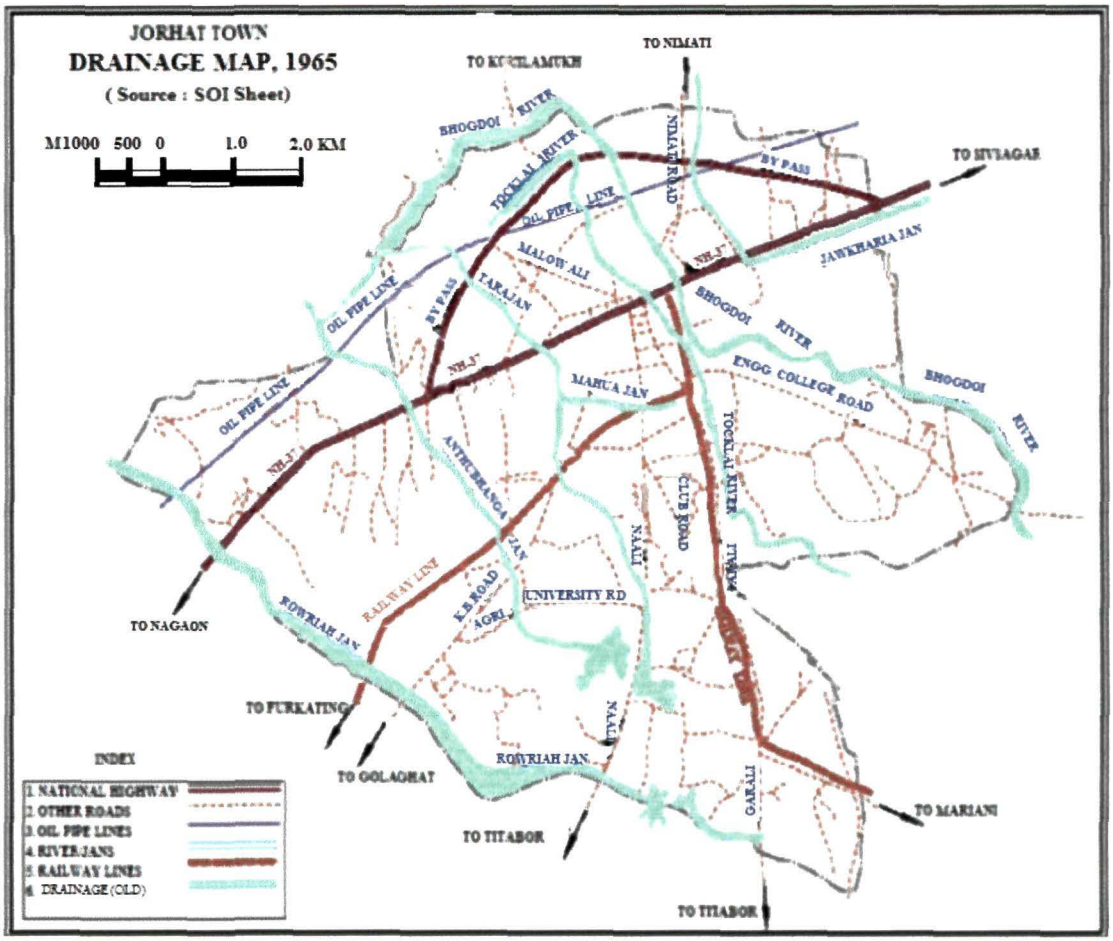
This is an initial attempt to study the problems of water logging in Jorhat town and its immediate environs that forms the part of Jorhat municipal board. In fact, the analysis includes with a question that is, whether the proportion between the drainage density and the inhabited area of the town is adequate and its impact on providing adequate urban facilities to the inhabitants of the town.

V.10. Drainage Change Analysis

Drainage is one of the clearest indexes of geomorphic development and process. The drainage pattern means the 'form' (geometrical form) of the drainage system and the spatial arrangement of streams in a particular locality or region. The location, number and flow directions of different streams of a particular region depends on the nature of slopes, structure control, tectonic factors, climatic conditions,

characteristics etc. since there are much variation in the environmental conditions of different regions. There are also spatial variations in the drainage pattern. The

Map-10

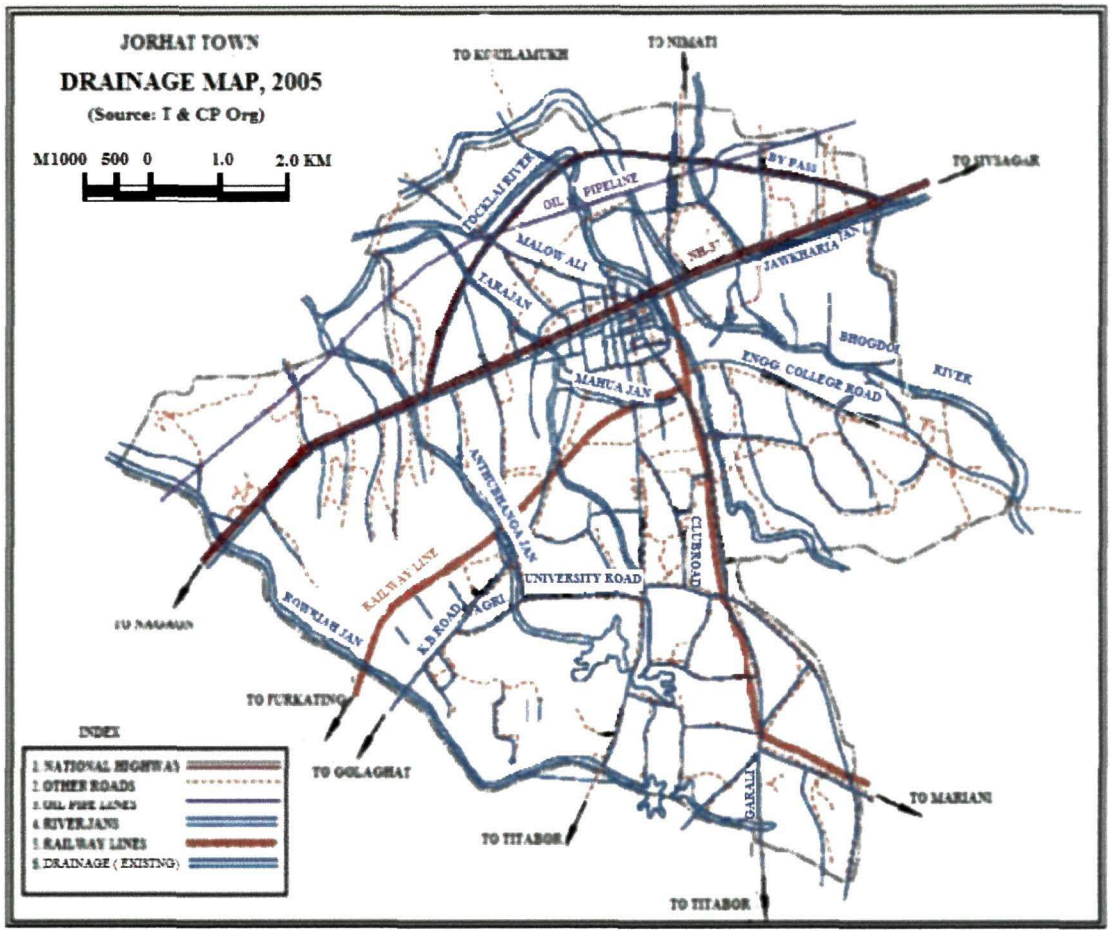


Source: Survey of India Toposheet,1965

drainage change over a long period can give us a better idea of surface flow. More number of drainage can help to drain out accumulated water at a rapid pace. To study the drainage change, both old and existing drainage maps of Jorhat have been prepared. The old drainage map was collected from the Survey of India toposheets of 1:50000 scales surveyed in 1965 (map-10).

The new drainage map is collected from Town and Country Planning Department, Jorhat, 2005 (map-11). Drastic changes have been observed between these two maps prepared since the time gap was 40 years.

Map-11

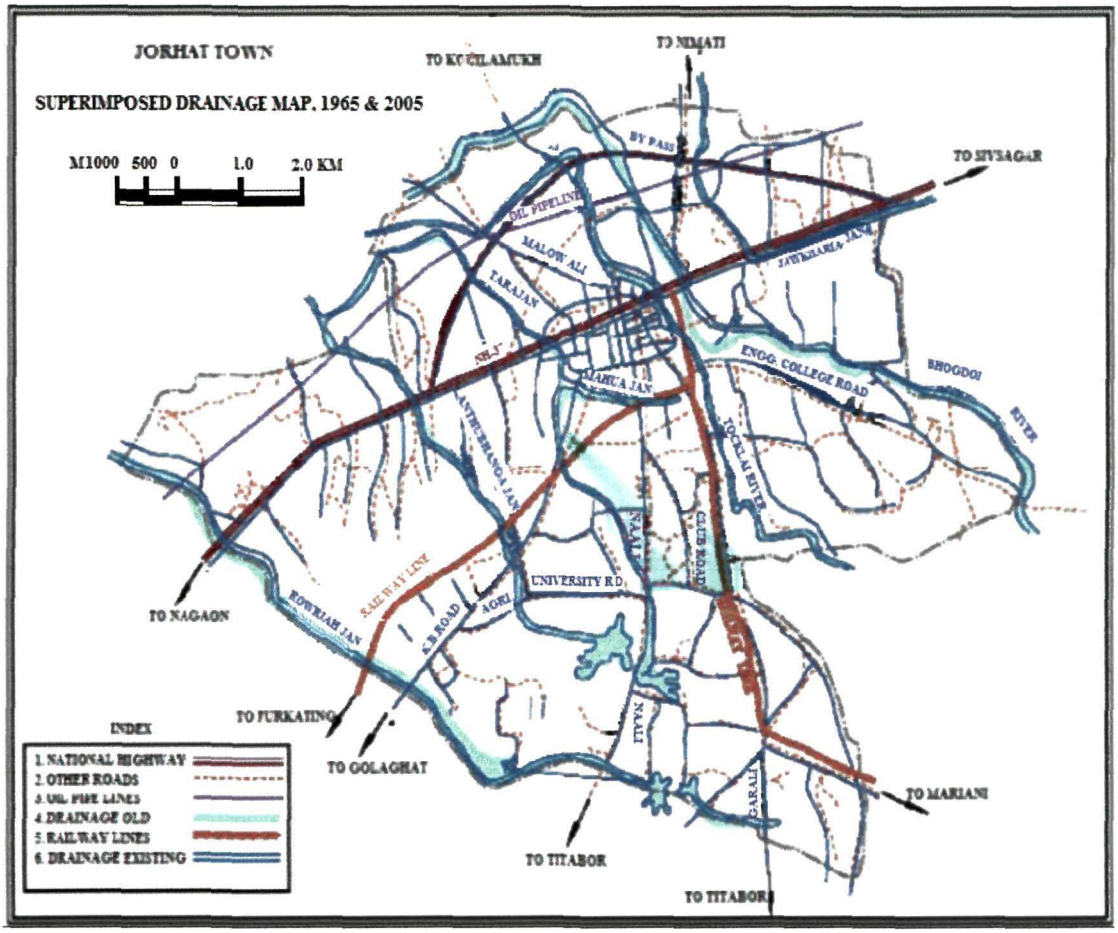


Source: Town and Country Planning Department,Jorhat

More drainage periphery has been found after a long period including both natural and artificial drains, which depicts a fair surface flow system. But in reality it is not so due to the increasing population and settlements. More areas are now occupied by settlements due to which many existing drains are not working properly. Residential and commercial areas have increased from 177.49 hectares and 22.99 hectares in 1963 to 197.57 hectares and 45.79 hectares in 2005 respectively (table-37).

To detect the changes during this long period of time both old and existing drainage maps are found out by superimposing these maps (map-12). Before the construction

Map-12



Source: Prepared by the Researcher

of the national highway in the northern side of the town, the excessive water of the town had a direct flow to the Malow area (RL 82.06 meter), the northwestern side of the town. But after the construction of this highway, water got blocked and began to accumulate towards the south. Moreover, earth filling of low-lying areas also affected the normal outflow of the drains. Though drainage network has increased at a fairly high rate during these periods, but is not effective because large areas are occupied.

The following changes of drainage have been observed during these long intervals of times in Jorhat town:

a) The periphery of the town limit became bigger than the drainage network. The channels have become inadequate to carry the discharges to its maximum as the runoff increased with the increase of settlement.

b) Human encroachment became a common feature on the natural streams. Most streams are not in their original shape and deviated to either of its banks.

c) Depth of Anthubhangajan and Jawkhariajan have been increased by linking them with Bhogdoi river and connecting water logged areas of the town with these natural streams to carry away the water.

d) All major waterlogged areas of the town have been connected to Mahuajan, Tarajan and Tocklai river then to river Bhogdoi for fast discharge of water.

e) Major portion of the bed of Tarajan channel has been converted to concrete cast by maintaining the natural slope of the area.

f) Mahuajan is converted to RCC which is flowing through the heart of the town and being connected to the downstream of Tarajan.

g) The shape of river Bhogdoi is deviated towards east due to sprawling of urban growth towards western side of the town.

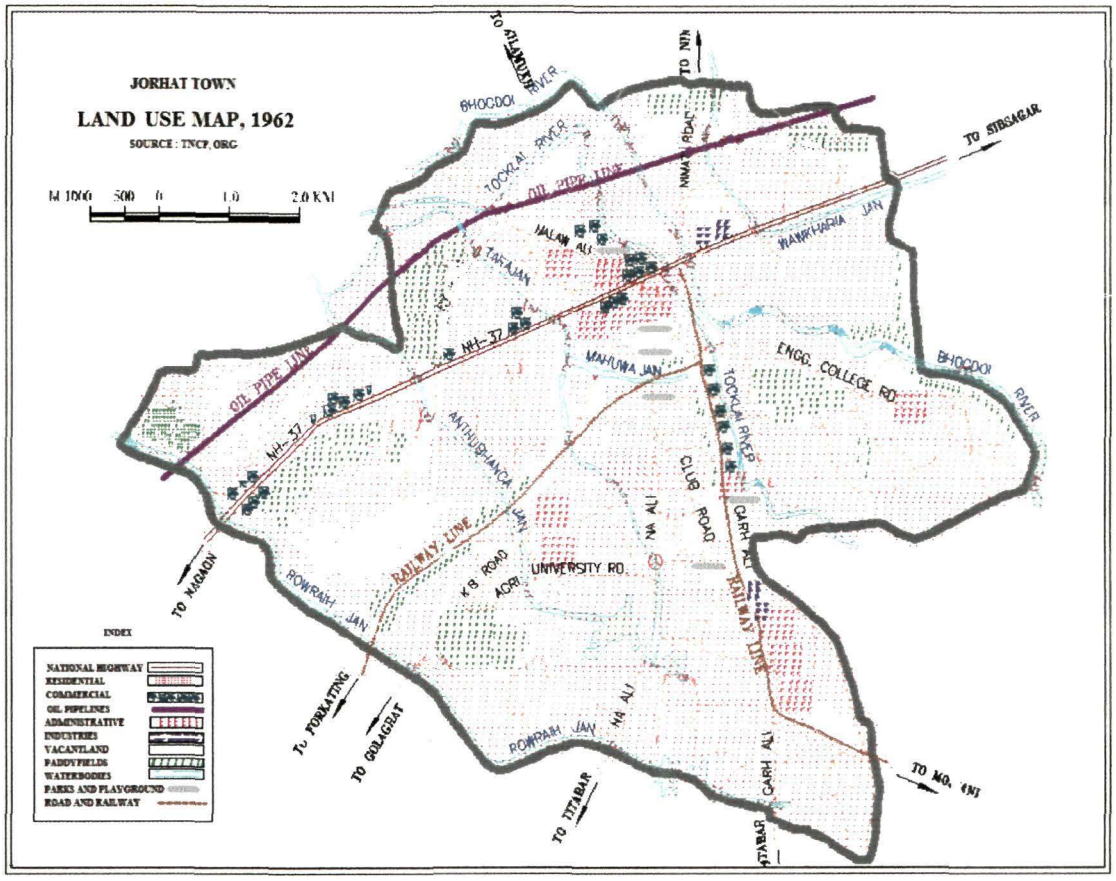
h) The existing natural drains have become narrower and shallower due to human settlements, which became a haphazard growth towards the east of the town.

i) Drainage network is not increasing proportionately with the growth of urban areas thus decreasing the surface water flow capacity and creating more water logging areas.

V.11. Land use Analysis

Land is a part of physical environment and there is a marked variation in the physical environment, type of economy, mode of production, types and levels

Map-13



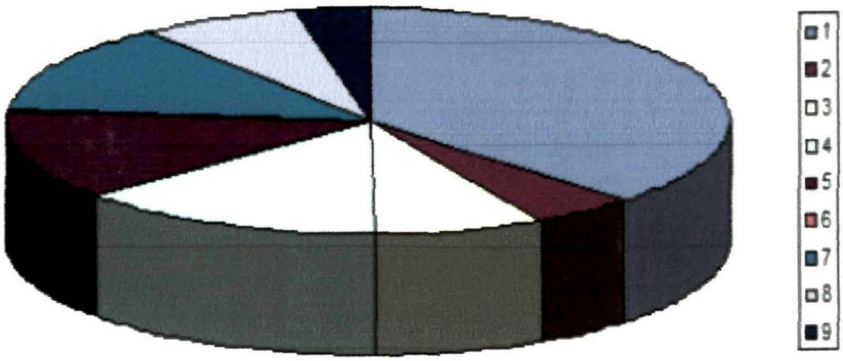
Source: Town and Country Planning Department,Jorhat

of technology, society, culture etc. from place to place. The change in technology, society, economy and culture over time changes the concept of land use and this is strongly linked with the advances of human civilization. Though changes occur in physical environment, yet it is a very slow process and in fact, hardly it has any impact on the change in land use. However, in a culturally developed urban area, land use changes are very fast. Land use of a place shows the area under different uses of

activities in different zones. To study water logging of an area land use study is indispensable. For example, an increase in residential and commercial area increases covered* area and decreases vacant land, thus making the area more prone to water logging. (*coverage is the percentage ratio of the plinth area of the main and accessory buildings to the total area of the plot).

Fig-16

BASE LANDUSE, 1962



TOWN AREA
TOTAL AREA = 1240 ACRES (1.90 SQ.MILE)
TOTAL DEVELOPED AREA = 769 ACRES (1.20 SQ MILE)

ANALYSIS OF LANDUSE

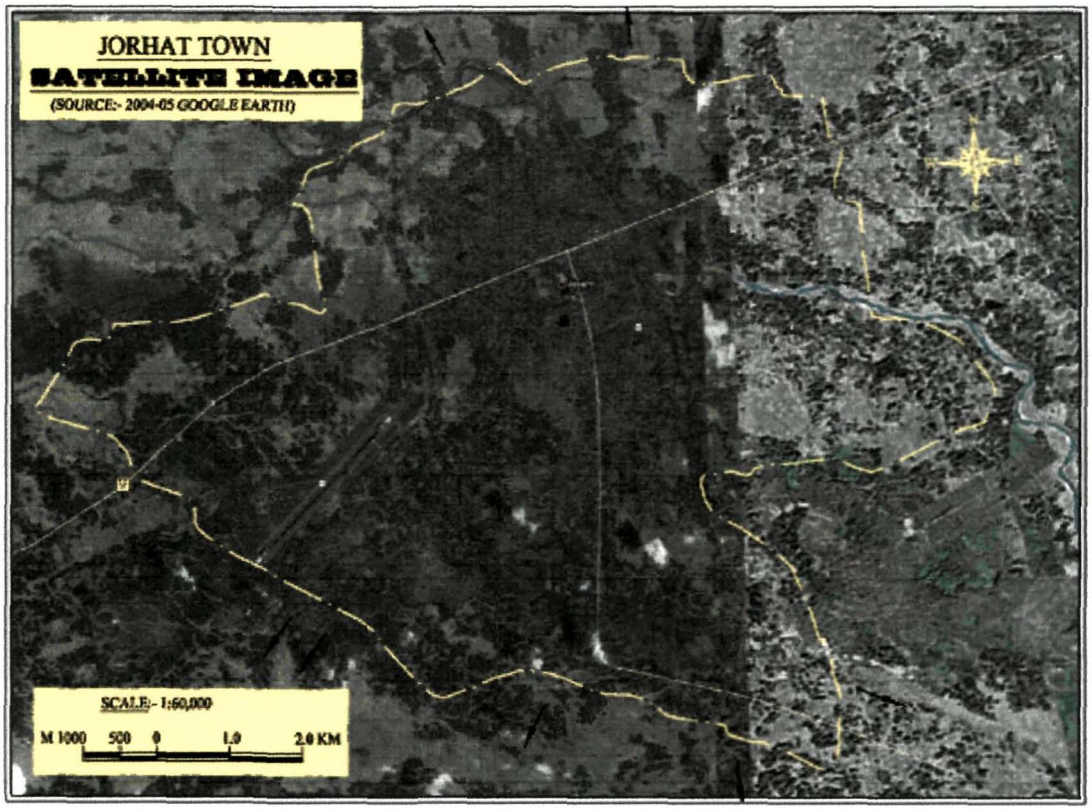
	LANDUSE	AREA		% OF	
		HECTARE	ACRE	DEV. AREA	TOTAL AREA
1.	RESINDENTIAL	177.49	438.58	55.67	36.14
2.	COMMERCIAL	22.00	55.82	7.26	4.50
3.	ADMINISTRATIVE	36.23	83.50	11.32	7.86
4.	ROADS & RAILWAYS	55.97	155.03	20.55	13.03
5.	PADDY FIELDS	51.07	150.92	-	12.10
6.	INDUSTRIES	0.74	184	0.23	0.14
7.	VACANT LAND	0.74	220.79	-	17.88
8.	WATER BODIES	87.35	87.97	-	7.05
9.	PARKS & PLAYGROUND	15.39	39.04	4.80	3.10

Land use analysis is done on the basis of comparison of land use activities between past and present year. A land use survey for the Jorhat master plan area was conducted in 1962, which revealed that the town is growing in a haphazard manner

with considerable ribbon development along the major roads. This year has been taken as the base year and shown in map-13. Figure-16 shows the land use under various classifications of the year 1962.

Existing land use map has been prepared from Google Earth image. After downloading, the images are combined using image processing software and classified into different layers (for example, paddy field, habitation, built up areas, water body etc.). After classification, various land uses are calculated and compared with the land use of 1962 (map-14 and fig-17).

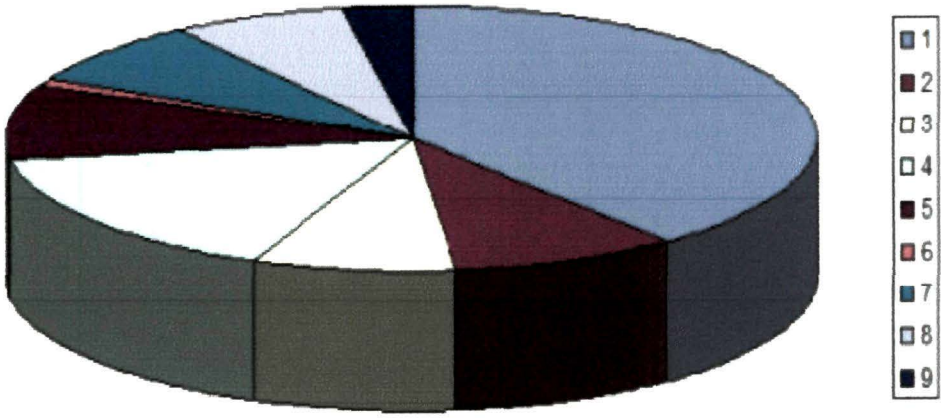
Map -14



Source:Google Earth Image,2004-05

Fig-17

EXISTING LANDUSE, 2005



TOWN AREA
TOTAL AREA = 1248 ACRES (1.80 SQ.MILE)
TOTAL DEVELOPED AREA = 945 ACRES (1.45 SQ MILE)

ANALYSIS OF LANDUSE					
	LANDUSE	AREA		% OF	
		HECTARE	ACRE	DEV. AREA	TOTAL AREA
1.	RESINDENTIAL	197.57	488.20	61.97	39.14
2.	COMMERCIAL	45.79	113.15	14.36	9.07
3.	ADMINISTRATIVE	41.37	102.23	12.98	8.19
4.	ROADS & RAILWAYS	81.78	202.08	25.65	16.20
5.	PADDY FIELDS	45.66	113.37	-	9.09
6.	INDUSTRIES	3.87	9.56	1.21	0.77
7.	VACANT LAND	39.88	85.54	-	7.90
8.	WATER BODIES	34.60	85.50	-	6.85
9.	PARKS & PLAYGROUND	14.09	34.82	4.42	2.79

The total master plan area of Jorhat is about 7257.65 hectares out of which the developed area is about 2313.16 hectares forming about 31.9 percent of the total plan area. Municipal area covers an area of 504.85 hectares, which forms about 7 percent of total planning area. Within the municipal area, the major land use is for

residential purposes constituting about 35 percent whereas within the master plan area agriculture occupies the largest proportion of land forming about 39 percent of the total existing land use.

Table-37: Existing Land use of Jorhat Master Plan area

Land use	Jorhat Municipal Area			Jorhat Master Plan Area (including Municipal Area)		
	Area in Hectare	Percentage of Total Municipal Area	Percentage of total Developed Area	Area in Hectare	Percentage of Total Planning Area	Percentage of Total Developed Area
Residential	197.57	35.14	55.67	948.16	13.07	40.99
Commercial	45.79	4.50	7.26	54.01	0.75	2.34
Industrial	3.87	0.14	0.23	38.20	0.52	1.66
Public Semi-public	41.37	7.00	11.30	959.68	13.22	41.48
Roads and Railways	81.78	13.03	20.68	275.21	3.79	11.90
Parks & Playgrounds	14.09	13.10	4.00	37.91	0.52	1.63
Agricultural	45.88	12.10	-	2840.08	39.13	-
Tea Estates	-	-	-	402.32	5.54	-
Vacant & un-developed	39.88	17.88	-	1496.86	20.63	-
Water bodies	34.6	7.50	-	204.87	2.83	-
Total area	504.85	100.00	100.00	7257.65	100.00	100.00
Total developed area	310.90	-	-	2313.13	31.88	-

Source: Google Earth Image, 2004-2005

The percentage of vacant and undeveloped land in both municipal and planning area offers a considerable scope for the expansion of the town, though they do not vary much in quantity. Commercial land use occupies about 54.01 hectares or 2.34 percent of the total developed area. The Chowk Bazar and the business establishments along Assam Trunk Road and Gar-Ali are the central business area of Jorhat town. The Chowk Bazar is extremely congested and there is hardly any space for future expansion. Besides, finding additional space for its expansion it is also necessary to reserve suitable sites for developing several local markets in the master plan area.

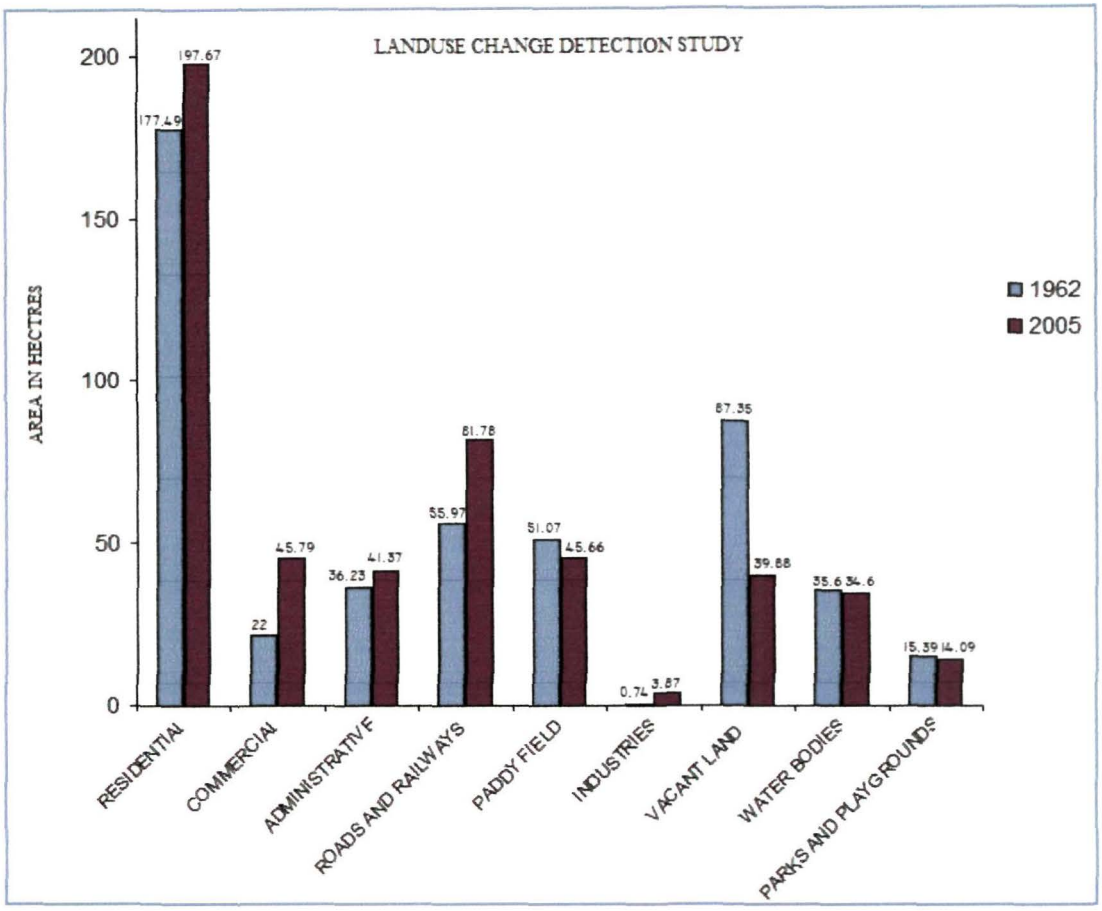
The industrial land use occupies about 38.20 hectares (1.66 percent) of the total developed area. Predominant industries in Jorhat are mostly service oriented and cater

to the needs of the neighboring tea gardens. The divisional workshop of Assam State Transport, cement tile manufacturing unit and a few engineering workshops are the only major establishments. Other smaller establishments are scattered all over Jorhat master plan area in a haphazard manner. The industrial estate constructed near Cinnamara can cater to the needs of development of small-scale industries in this area.

The public and semi-public uses, which include educational institutions, government offices etc. and occupying about 959.68 hectares (11.40 percent) of the total developed area (table-37). The Regional Research Laboratory, the Assam Agricultural University, the Prince of Wales Institute of Technology and the Engineering College form the major percentage of educational land uses. Similarly, Mission Hospital and the District Jail occupy a large area. Besides these, there are many state and central government offices located in various parts of the town. Parks and playgrounds occupy about 948.16 hectares out of which about 22 hectares belong to the planter's club, which is for the exclusive use of its members. There is only one playground for the entire population of the area. Roads and railways occupy about 275.21 hectares of 11.90 percent of the total developed land; water bodies occupy about 204.87 hectares.

Between 1962 and 2005, major land use changes have taken place both in residential and commercial areas in Jorhat municipal area (fig-18). The vacant land decreased from 87.35 hectares to 39.88 hectares. In case of roads and railways, the land area has increased from 55.95 hectares in 1962 to 81.78 hectares in 2005. The parks and playgrounds are decreasing from 15.39 hectares to 14.09 hectares. Commercial and residential lands have increased to 22.80 and 20.08 hectares

Fig. - 18



respectively. Vacant land and water bodies are also showing decreased. All these land use changes are mainly due to increasing of population and settlements.

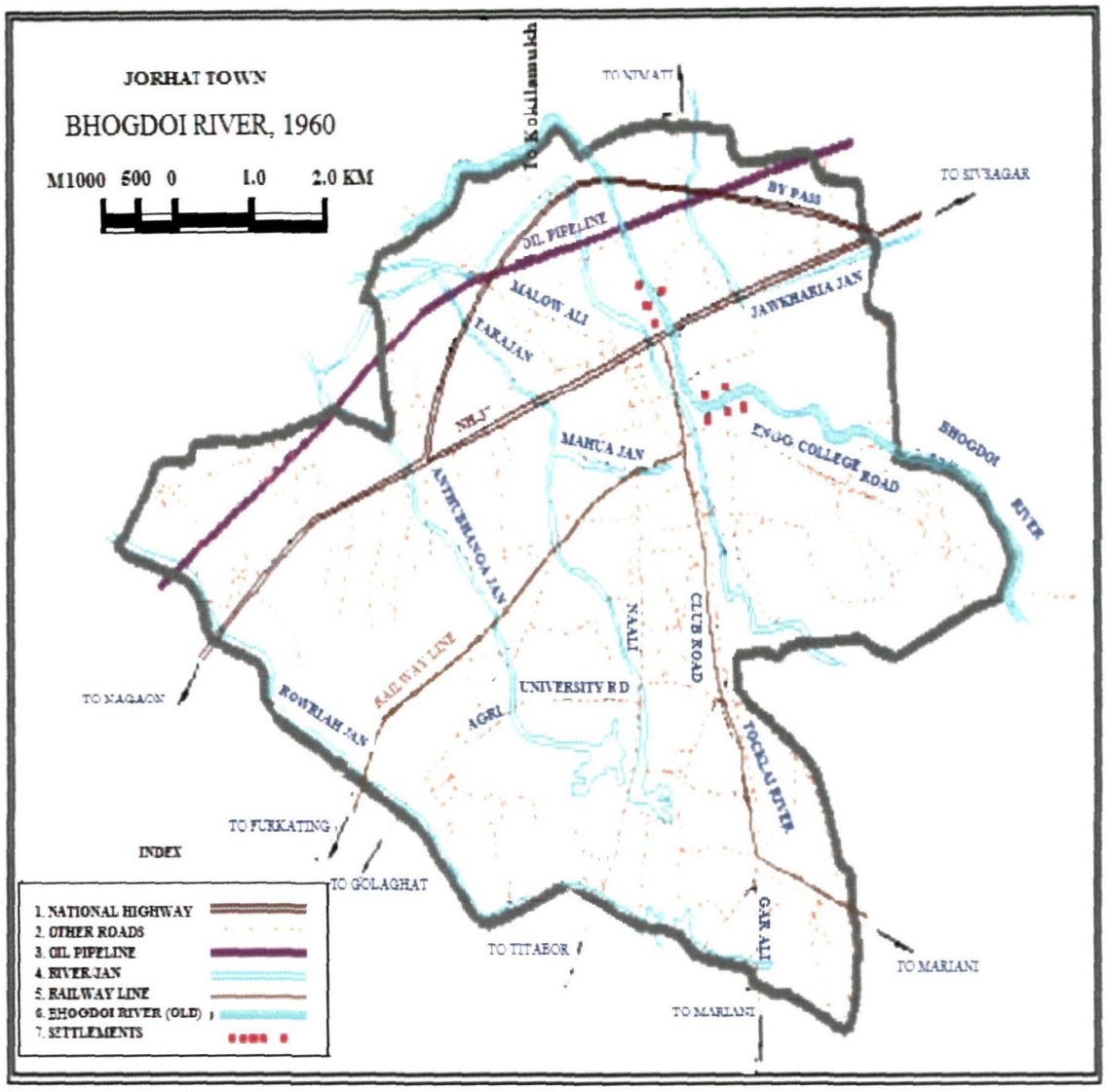
It is observed that covered areas have increased at a faster rate, which ultimately reduced the capacity of surface flow. As a result, surface water accumulates more and rushes to depressed areas to make water logging.

V.12. Bhogdoi River Course Analysis

The Bhogdoi river course as well as the sprawling urban growth of the town has been studied in two different periods. The map of the Bhogdoi river of 2005 has been taken to represent the present landscape. Land use map of 1960's of town and country planning department has been considered as base year to detect the changes.

Natural flow of the river water was not hampered in 1960 since population was very sparse at that time (map-15). Population increased at a rapid rate within the periphery

Map no-15

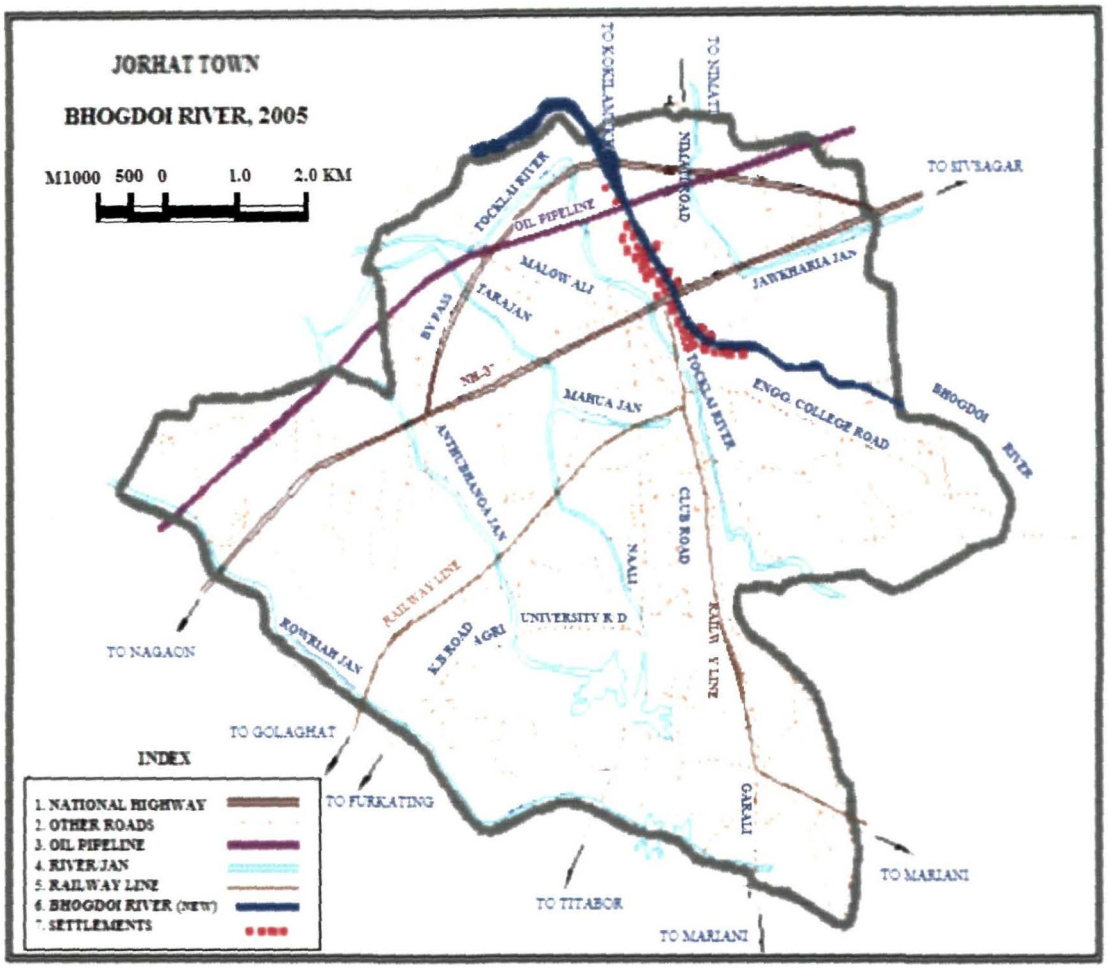


Source: Town and Country Planning Department,Jorhat

of the town due to infrastructural facilities and growth of urban centres in the western side of the river. Urban growth is a dynamic process. However, growth takes place not only in a definite time setting but also in a spatial or geographical setting. Urban growth involves the growth of towns and cities that changes the socio-economic and socio-cultural variables and land use. The explosive increase in population and the

sprawling urban growth may yield many socio-economic and political problems. Jorhat town has been changing both physically and culturally in the last three decades. Gradually more settlements have developed on the western bank of Bhogdoi river (map-16). The changes have been detected by superimposing the existing and the old Bhogdoi River (map-17).

Map-16

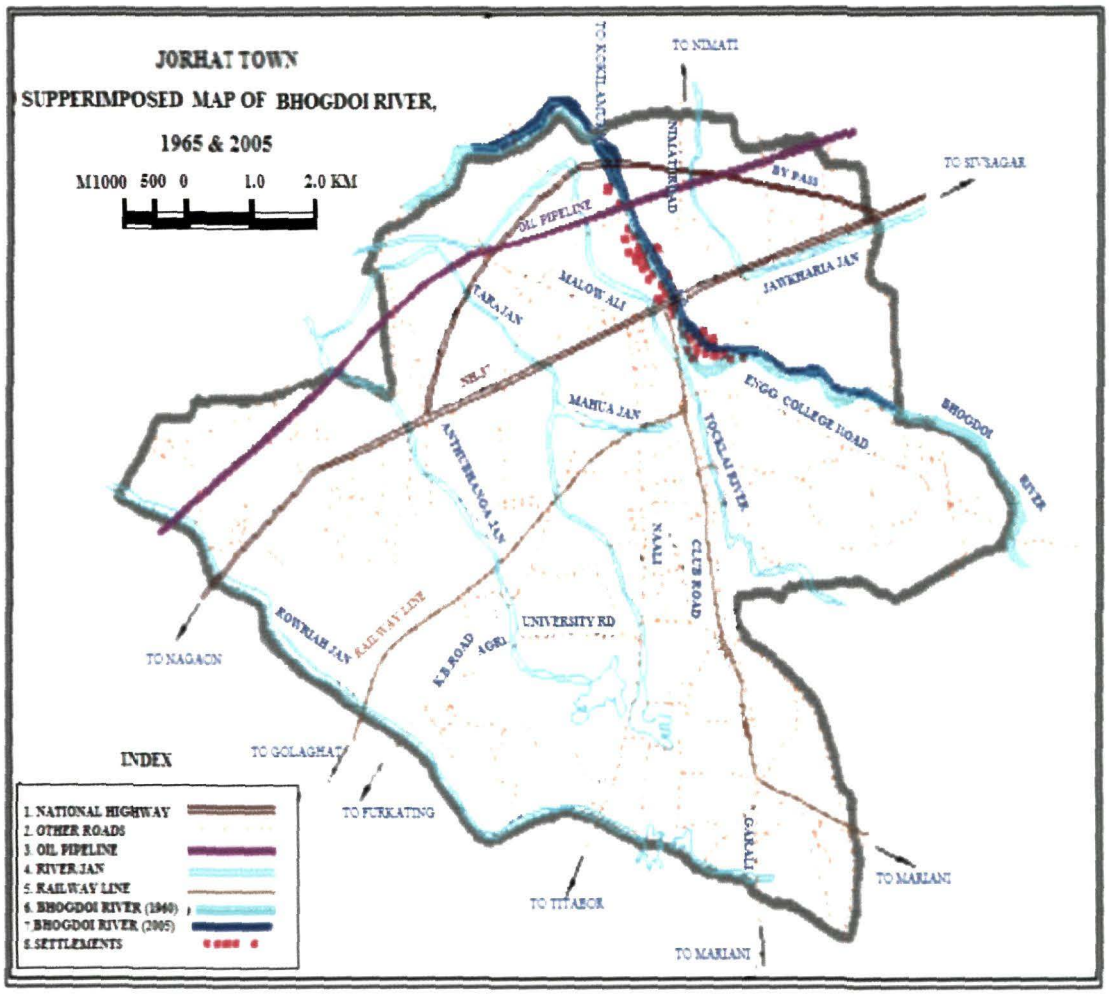


Source:Town and Country Planning Department,Jorhat

River Bhogdoi is deviating towards its eastern side due to increasing settlements in the west. The overall urban growth of this town is sprawling towards western and southern side. The reason behind this sprawl is mainly, the presence of extensive plain land with large transport networks and establishments of many educational

institutions. Increasing settlement is towards low-lying lands. As these low-lying areas are being filled up, on the other parts the water logged are increasing. The waterlogged areas of Fancy Ali, Garmur area, Sweeper basti, Malow Ali etc. are the excellent examples of this type.

Map no-17



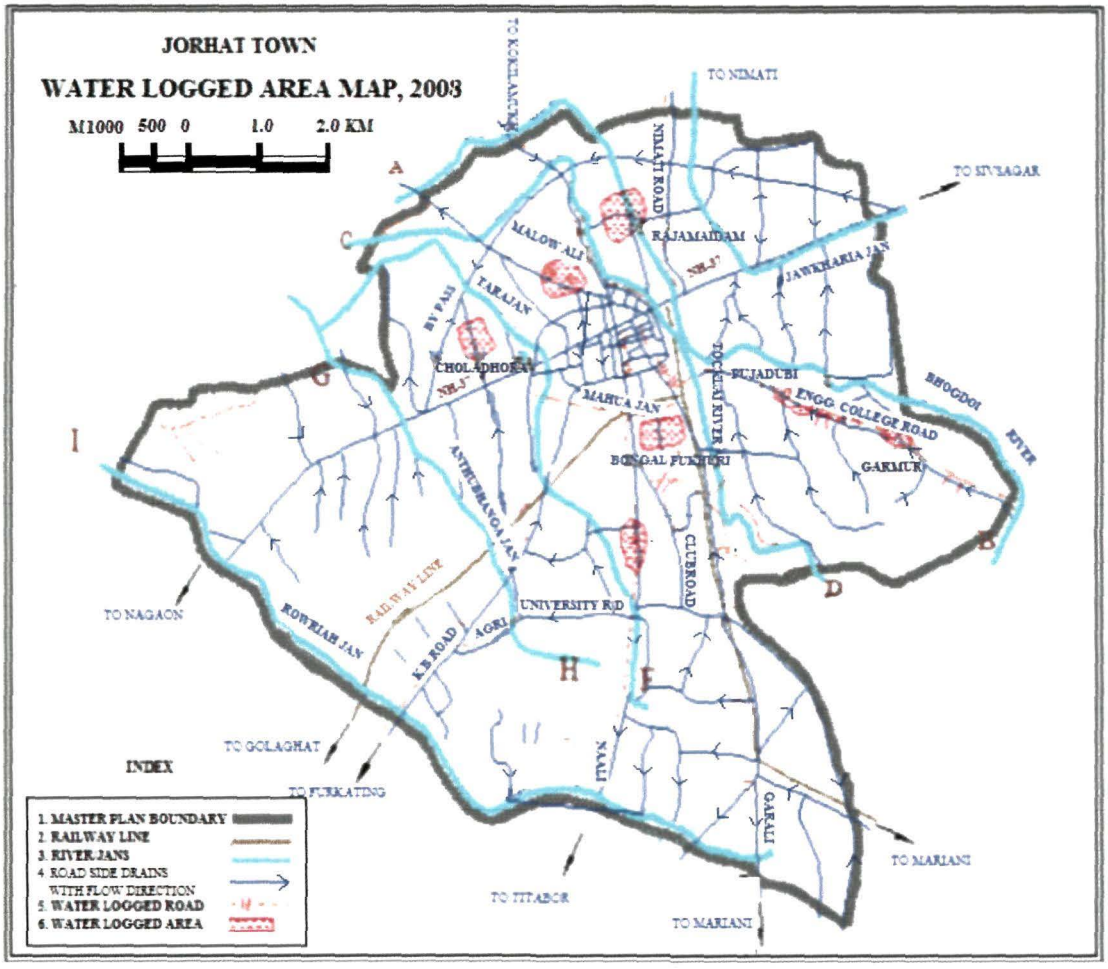
Source: Prepared by the Researcher

V. 13. Permanent waterlogged areas of Jorhat town

The natural drainage of Jorhat has been discussed in this chapter. In order to elaborate the drainage links in map no-18. Here AB is the main natural channel

known as Bhogdoi river. Numerically, there are many drains in the town area. From the map-18, it is very clear that river Bhogdoi is the main natural channel which absorbs many artificial drain loads of the town. As shown in the map, the drain CD extends from Sensua gaon near Bhogdoi and passes through the main commercial areas of the town. It carries all the industrial waste along with rainwater from Cinnamara, Rajabari, Garmur, Fanci Ali area.

Map-18



Source: Prepared by the researcher

The drain EF extends from Sarucharai Gharphalia gaon to Chaodang gaon and it runs along the western side of Jorhat–Furkating railway line. The drain GH extends from

Naochalia and crosses Jorhat–Furkating railway line subsequently flows towards south eastern part of the town. IJ extends from Karanga area and crosses Assam Agricultural University, Rowriah air field and Regional Research Laboratory areas. There is no other outlet system of these various establishments of the town connecting the main channels. The drain KL runs along the Dohabara, Atilagaon and northern side of the railway line, crosses Na-Ali. The area Sonali Jayanti on the north west side of the map lies significantly below 79 metres contour (which is much below the danger level of 98.00m). This area specifically is subjected to continuous earth filling for new construction of residential buildings. The drain from Bohatia to Naosholia is narrower. As a result the area is discharged in the form of sheet flow into the drain towards north of Assam Trunk road. The last consecutive two years observation on Bhogdoi shows that Rajamaidan Road. Jagannath Barooah road and adjoining areas get water logged. The Gopalchandra Bordoloi School use to suffer from such disasters every year (Plate-16).

Plate 16

The above drains fall into the river Bhogdoi. The drains are not capable of flushing out the rainwater effectively for many reasons. These are,

a) Drains do not follow the natural slope.

b) Drains are constructed without taking into account of the volume of flush.

c) The gradients of the drains are low.

d) Adequate manholes are not provided etc.

Inlet holes are either smaller or constructed not at proper level of the road. The worst affected areas are Bangalpukhuri, Malow-Ali and the Circuit House road, Club Road etc. (plate-17 and plate-18).

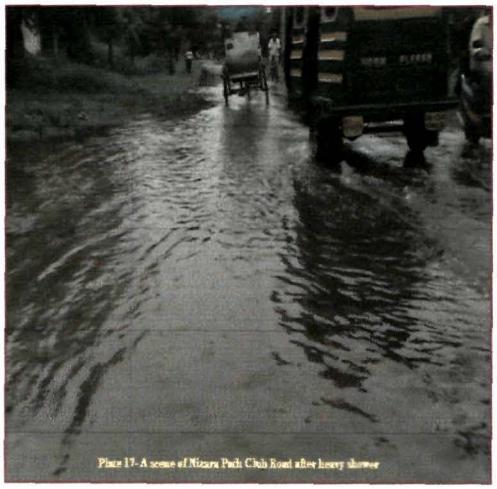


Plate 17-A scene of Mizara Path Club Road after heavy shower

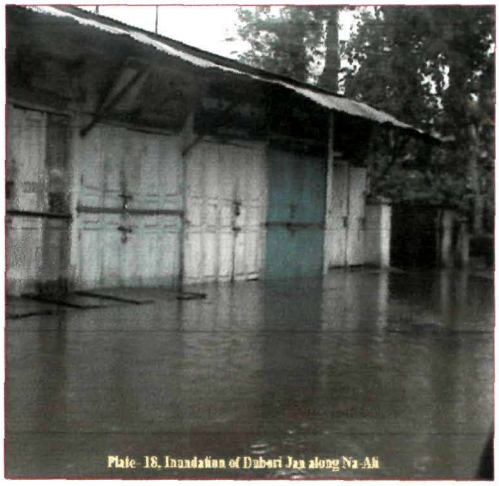


Plate- 18. Inundation of Duberi Jan along Na-Ali

After a continous observation for consecutive rainy seasons, five permanent waterlogged areas have been identified. The maximum duration of water logging in these areas are 72 hours. In some major water logged areas, the depth rises up to 3.9 feet (table-38). On the north side of the town, both Malow Ali and Rajamaidam are two major water logged areas on the bank of Tocklai river. Another major area is Pujadubi, which is in the southeastern part of the town and on the bank of the river Bhogdoi. On the south and the northwestern part, Bongalpukhuri and Choladhara are

V.14. Study of Water logged areas by sequential increase: To make the study more comprehensive, comparative last five years (2003–2007) on some permanent water logged areas have been studied by identifying the locations. The study shows

Table-38: Duration and depth of water logged areas during Monsoon (2003–2007)

Sl No	Name of Water logged areas	Direction	Location Major/ Minor	Jan/River Nearer to those river	Depth of Water logging (in feet)				Duration Of Water logging (in Hours)			
					April	May	June	July	April	May	June	July
1	Malow ali	North	Major	Tocklai	1	2.3	3	2.3	12.38	63.25	72.1	71.09
2	Rajamaidam	North	Major	Tocklai	0.6	1.2	2.1	1.9	13.4	59.43	69.2	68.03
3	Bongal pukhuri	South	Minor	Mohuajan	0.40	2.1	2.2	1.8	12.0	48.32	52.4	52.98
4	Choladhara	North West	Minor	Tarajan	0.45	1.9	2.1	2.0	12.1	39.48	59.3	58.39
5	Pujadubi	South East	Major	Bhogdoi	1	2.8	3.9	3.0	13.8	60.0	71.5	70.1

Source: Field Survey by the researcher

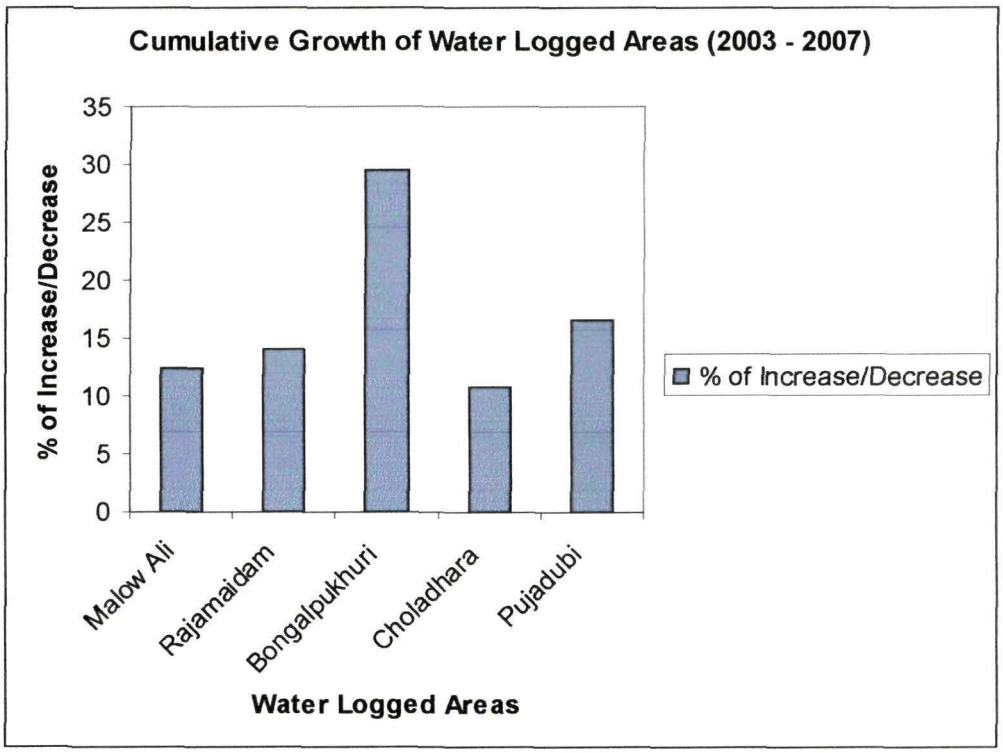
that percentage growths of the identified locations are found to be increasing (table-39). These growth percentages have been found out by using the following formula:

$$\frac{\text{Growth of the present year} - \text{Growth of the previous year}}{\text{Growth of the previous year}} \times 100$$

After getting the comparative value for all the locations, cumulative growth rate percentage of increase and decrease have been found out by using the same formula. It is observed that among all these areas, Bongalpukhuri was found with the highest cumulative growth with 29.55 percent (Fig-19). Frequent earth filling on low lying lands including swampy areas for construction of buildings are the main reason for this highest growth. Pujadubi has a growth of 16.57 percent next to Bongalpukhuri, which is caused by the rapid growth of slums. Pujadubi is situated on the immediate bank of the river Bhogdoi. Silt deposition on the river bed increasing every year and make Bhogdoi incapable of carrying its loads. Because of this reason during rainy days, the river inundates this area regularly. Rajamaidam shows 14.02

percent growth. Construction of new buildings without proper drainage outlets, filling up of swampy areas etc. are some causes for which this growth is increasing.

Fig-19



Moreover, the wall of the City Maternity Home at Rajamaidam area is standing as a barrier to the river Tocklai and thereby affecting the area more. Malow Ali faced an increasing growth for many years till 2006. But, now the problem is somewhat minimized due to the construction of some new road side drains. Between 2006 and 2007 the area shows a decreasing growth from 1.4 sq. km. to 2.89 sq. km. During 2003–2007 the volume of water in the water logged areas have increased. The five permanent water logged areas are spread all over the town; three are major while two are minor. These are Malow Ali, Rajamaidam, Bongalpukhuri, Choladhara and

Table-39: Increase and decrease percentage of permanent water logged areas in Jorhat Town (2003 –2007)

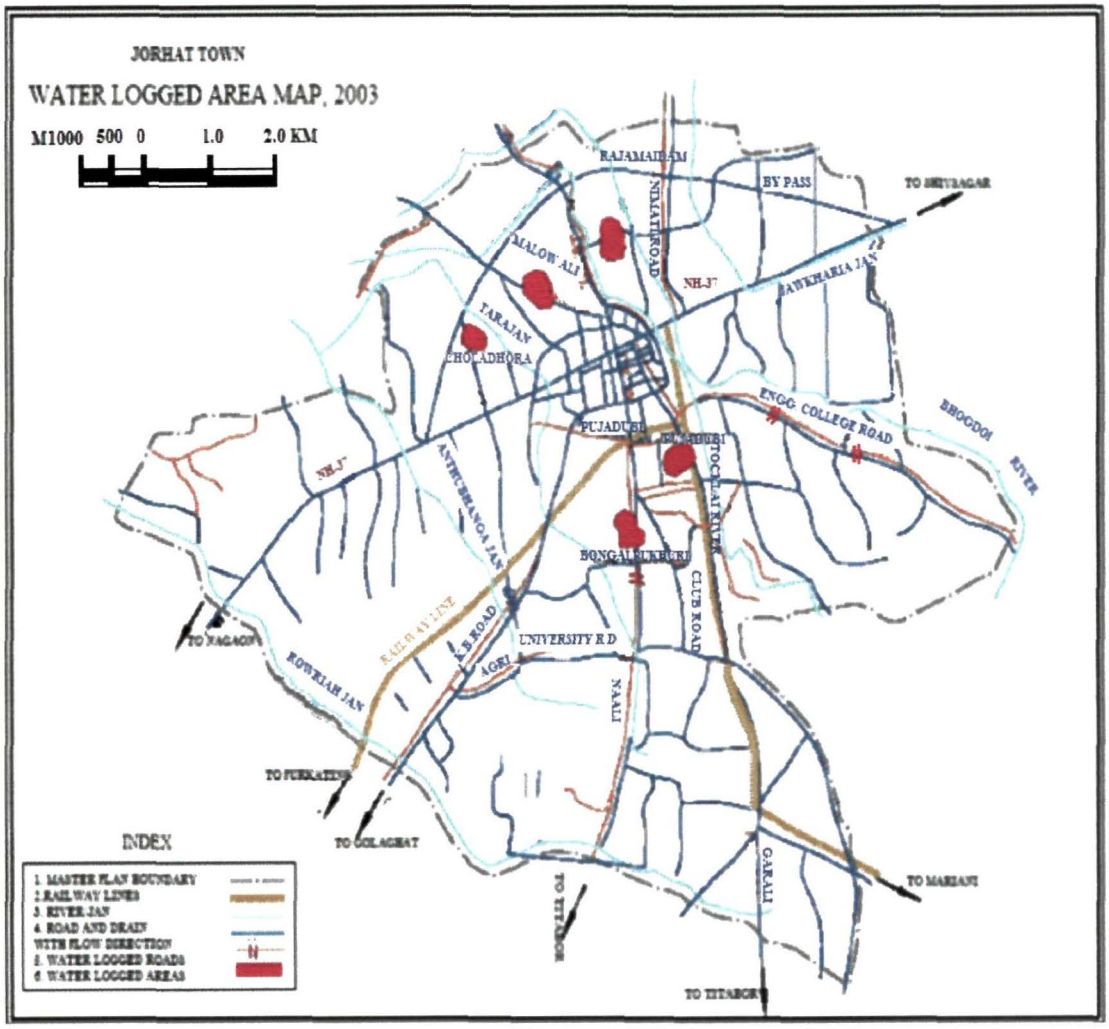
Location	Year	Water logged area (in Sq. Km.)	percentage of Increase/Decrease	Total (2003 – 2007) water logged area percentage of Increase/Decrease
Malow Ali	2003	0.45	–	
	2004	0.65	44.44	
	2005	0.75	15.38	
	2006	1.4	86.87	
	2007	0.89	– 36.43	
				12.42%
Rajamaidam	2003	0.64	–	
	2004	0.68	6.25	
	2005	0.73	7.35	
	2006	0.82	12.83	
	2007	0.98	19.51	
Total		3.71	4.23	14.02%
Pujadubi	2003	0.93	–	
	2004	0.95	2.15	
	2005	0.98	3.16	
	2006	1.33	35.71	
	2007	1.76	32.33	
Total		16.72	19.49	16.57%
Bongalpukhuri	2003	0.48	–	
	2004	0.55	14.58	
	2005	0.82	49.09	
	2006	0.83	1.22	
	2007	0.91	9.64	
Total		4.23	5.48	29.55%
Choladhara	2003	0.80	–	
	2004	0.88	10.0	
	2005	0.95	7.95	
	2006	1.10	15.79	
	2007	1.53	39.09	
Total		5.48	6.07	10.77%

Source: Computed by the researcher.

Pujadubi area (table-38 and map-18). Maps of waterlogged areas have been prepared by using GIS tools. In the year 2003, major waterlogged areas of Malow Ali, Rajamaidam and Pujadubi had an extension of 0.45sq.kms, 0.65sq.kms and 0.93sq.kms respectively (map-19). On the other hand, minor water logged areas of

Bongalpukhuri had an extension of 0.48 sq.kms, while Choladhara occupied an area of 0.80sq.kms.

Map-19

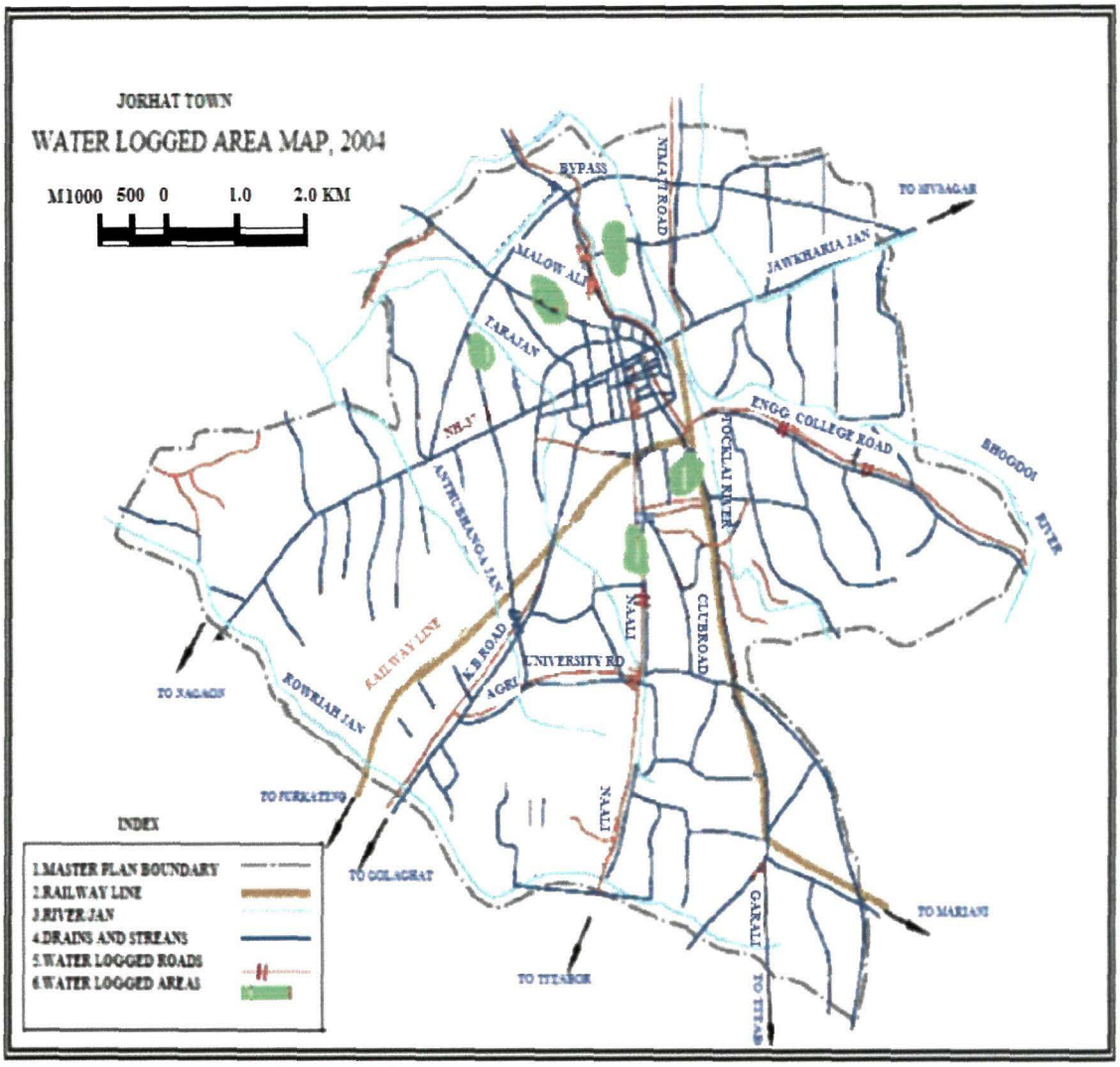


Source: Prepared by the researcher

In 2004 water logged area growth was insignificant compared to 2003 (map-20). The Malow Ali area increased to 0.20 sq. kms than before. Bongalpukhuri and Pujadubi show a growth of 0.07 sq. kms. and .02 sq. kms. respectively. Both Choladhara and Rajamaidam show increase of 0.08 sq. kms. Gradual increase of population pressure over Malow Ali contributes in the expansion of waterlogged

areas. The earth filling on low-lying and cultivated land, increase of population, encroachment on Duborijan channel creates clogging in the town.

Map-20

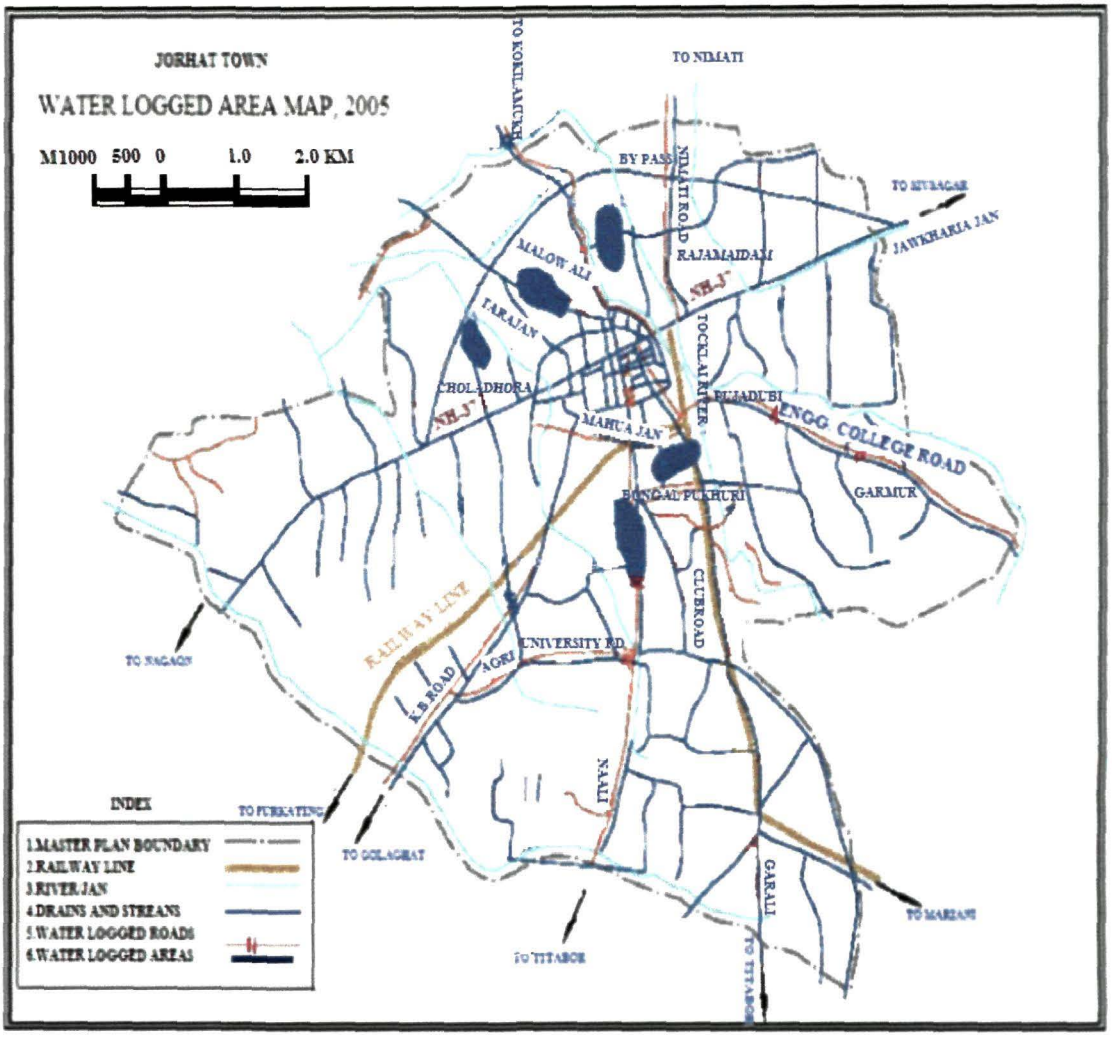


Source:Prepared by the researcher,

Among the permanent water logged areas in the town, size and extension of Bongalpukhuri area was the highest (0.27 sq. kms.) in the year 2005. Malow Ali, Rajamaidam, Choladhara and Pujadubi increased to 0.10 sq. kms., 0.05 sq. kms., 0.07 sq. kms. and 0.03 sq. kms. respectively (map-21). Bongalpuhuri is facing acute urban

infrastructural problems like inadequate drainage, sewage disposal etc. due to its fast growing township leading to water logging.

Map-21

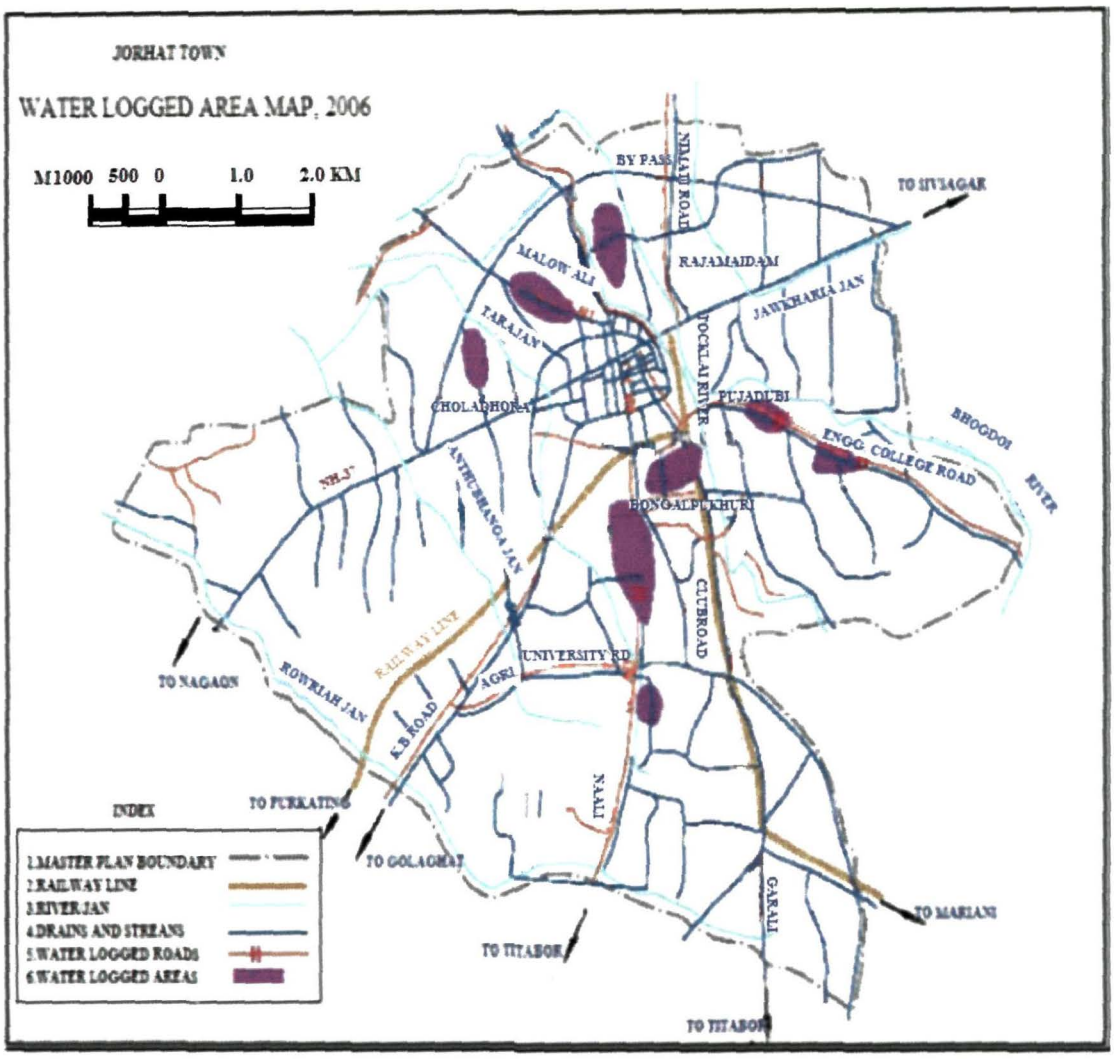


Source: Prepared by the researcher

The year 2006 experienced heavy rainfall. Most of the areas in the town were inundated. Within this period of 2003 to 2006, few more waterlogged areas were formed. The main reason behind this was due to increasing building constructions without proper drainage facilities. During this year Malow Ali expanded to 0.55 sq.

kms, while Bongalpukhuri's growth was 0.01 sq. kms (Map-22). Likewise, in 2007 also, water logged areas of both Pujadubi and Choladhara expanded to 0.43 sq. kms

Map-22

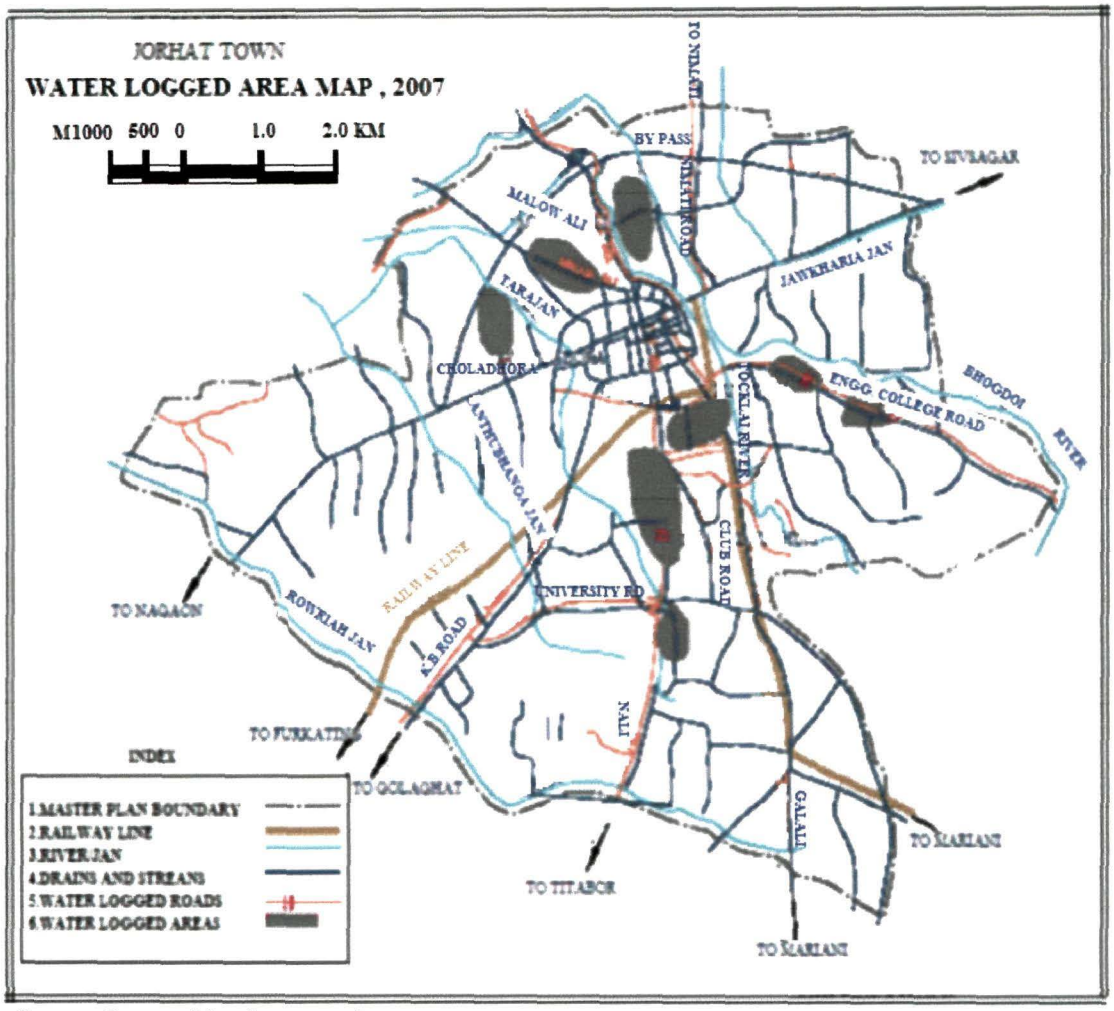


Source: Prepared by the researcher

each. Construction of new roadside drains were seen at Malow Ali area and thereby a little development and comparatively less water logging. Bongalpukhuri expanded to 0.08 sq. kms while Rajamaidam 0.16 sq. kms.(map-23).

To analyse systematically, all the maps of waterlogged areas of 2003-2007 have been superimposed to detect the increasing areas (map-24). In case of Malow Ali

Map-23



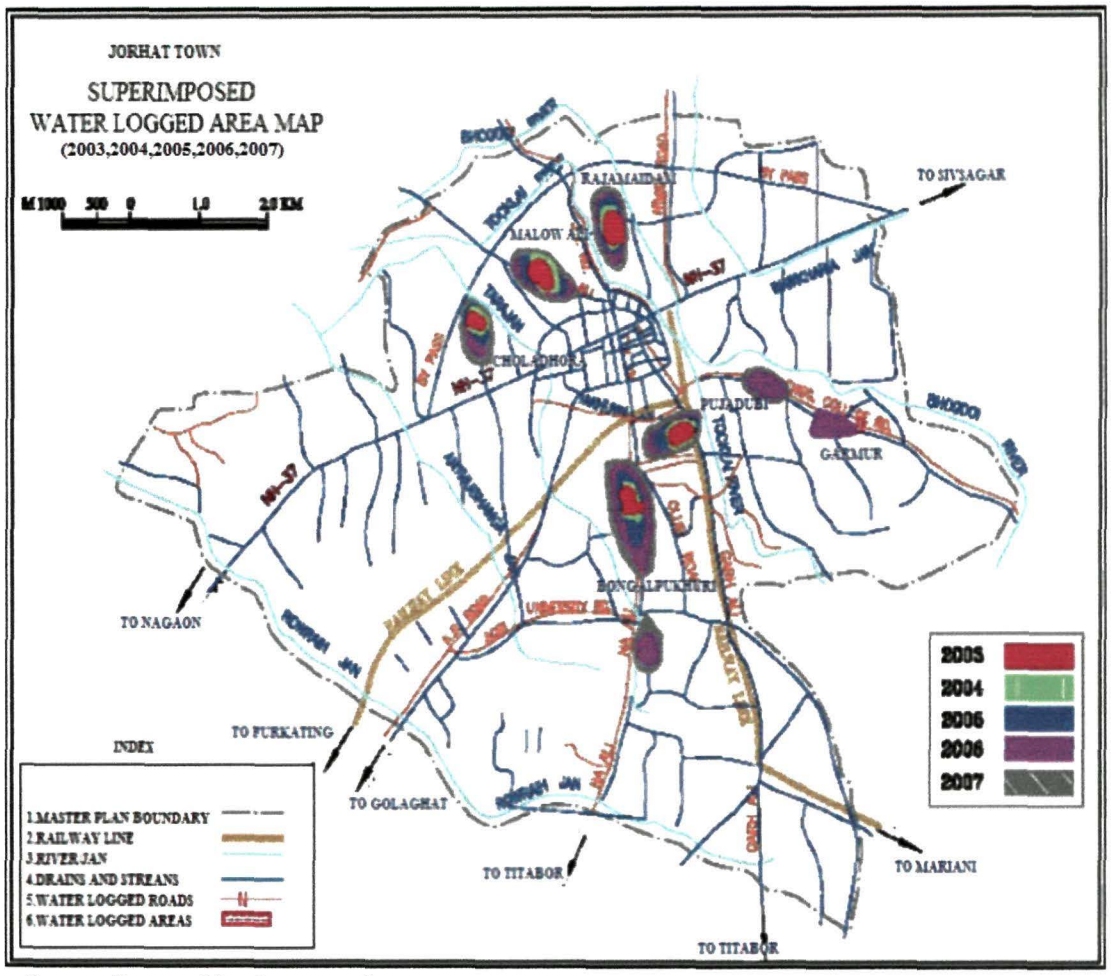
Source: Prepared by the researcher

within the period 2003-2004, the growth percentage of the volume of water was 44.44 percent. It increased from 0.75 sq.kms in 2005 to 1.4 sq .kms in 2006.

But, there is an decreasing trend in the last few years due to the improvement of existing drainage network of Tarajan channel. However, the encroachment of extensive lowlands, construction of buildings without proper drainage planning etc.

are causing water logging in Malow Ali area. Likewise waterlogged areas of Rajamaidam have also increased. The extended area was from 0.82 sq. kms. in 2005

Map-24



Source: Prepared by the researcher

to 0.98 sq.kms. in 2006 with a growth percentage of 19.51. In 2005, the volume of waterlogged areas increased by 0.27sq.kms at Bongalpukhuri area which is the highest rates of increase within this period. This was due to the migrants' population occupying large paddy fields in the western sides, construction of new buildings on low-lying areas and increasing covered area etc. Moreover, illegal encroachments on the Duborijan and Mahuajan, use of Duborijan as a garbage dumping site by the residents and shopkeepers of the area increased *jans* problem.

In Choladhara, there was no any expansion of waterlogged area during 2003-2005. But, in 2006 it was very high (0.37sq.kms, from 2005) due to encroachment on the road side drains, construction of many commercial as well as residential buildings etc. The oil pipeline, which is passing through the town across the Tarajan channel, is another reason for which the residents of Tarajan area face the problem of water logging. Percentage increase in volume of waterlogged area was 3.16 and 35.71 in the year 2005 and 2006 respectively. The extension of Pujadubi was 1.33 sq. kms in 2006 and increased to 1.76 sq. kms. in 2007. The encroachment on Tocklai and Bhogdoi river, haphazard growth of the slums along the rivers, closely spacing embankments along Bhogdoi, non-clearance of the water hyacinth plants that creates blockade to the free flow of Tocklai etc. are some of the major causes of water logging in Jorhat town.

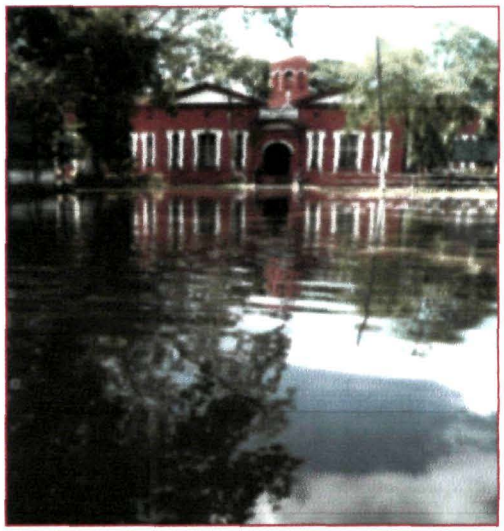
V.15. Study of water logged areas in two different seasons through photographs

Different photographs of both rainy and non-rainy seasons of respective water logged areas have been taken during the survey period. These pictures give two different views of the same localities to understand the problem better.

Deputy Commissioner's Office, Jorhat

Date: 16/01/2007

DURING DRY SEASON
(OCTOBER TO MARCH)



Date: 20/07/2006

DURING RAINY SEASON
(APRIL TO SEPTEMBER)

Circuit House, K. B. Road, Jorhat

Date: 16/01/2007

DURING DRY SEASON
(OCTOBER TO MARCH)

Date: 20/07/2006

DURING RAINY SEASON
(APRIL TO SEPTEMBER)

Gandhi Park, K. B. Road, Jorhat

Date: 16/01/2007

DURING DRY SEASON
(OCTOBER TO MARCH)

Date: 20/07/2006

DURING RAINY SEASON
(APRIL TO SEPTEMBER)

Govt. Boys' School, Jorhat

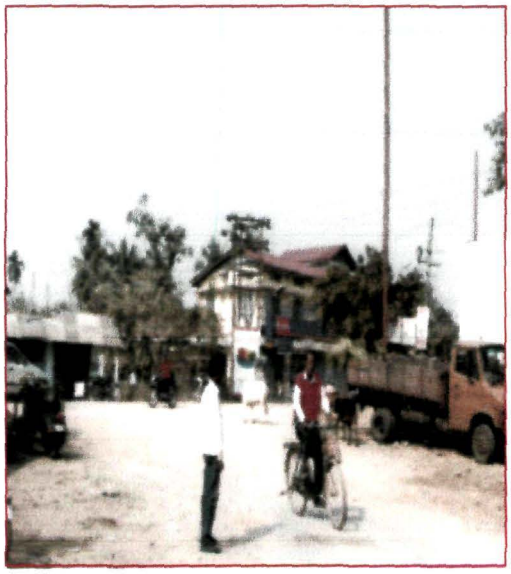
Date: 16/01/2007

DURING DRY SEASON
(OCTOBER TO MARCH)

Date: 20/07/2006

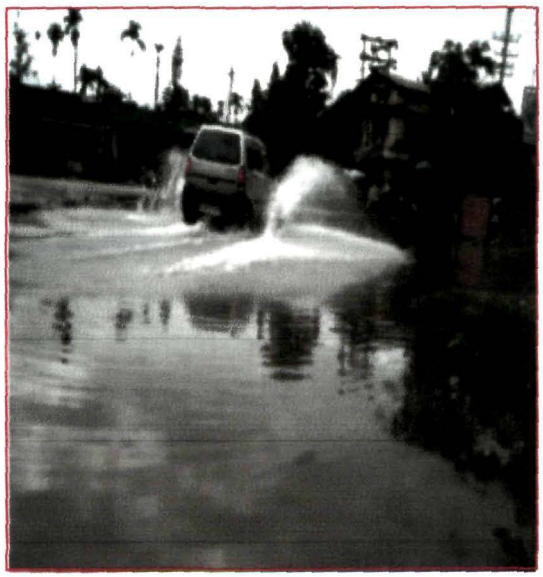
DURING RAINY SEASON
(APRIL TO SEPTEMBER)

Club Road, Bongalpukhuri, Jorhat



Date: 16/01/2007

DURING DRY SEASON
(OCTOBER TO MARCH)



Date: 20/07/2006

DURING RAINY SEASON
(APRIL TO SEPTEMBER)

V. 16.Towards Solution of Drainage and Water Logging Problem of Jorhat

The characteristics features of the natural drainage of Greater Jorhat (chapter II) and the internal link inside the congested city (chapter IV) have been discussed elaborately. In addition to other attributes like average slope, rainfall, water discharge and water level have also been analyzed (chapter V).

Further analysis is necessary to study the river Bhogdoi, which lay on the northeastern side of the Greater Jorhat. This is because since it has direct link with town's flood and drainage problem. In the light of the problem, the Brahmaputra Flood Control Board took up investigation work in the year 1977 to controll flood and drainage problems of Jorhat town and its suburbs. Part of the scheme is being executed in phases. Jorhat town is fast growing with its development along the major roads. There are only 30 percent *pucca* drains in the municipal area and rests are *kutcha*. Except for the natural channel due consideration has been given to provide covered drainage on both sides of the wider roads and a single side where road is narrow. Because of the geographical condition, the rainfall, humidity and climate are quite different from the rest of the country and therefore due consideration has been taken to adopt the system to match the prevailing system in Assam. It is considered that NP_3/NP_4 Hume pipes of equivalent section will be provided in the main road crossings to handle flooding menace.

References

1. Strahler,A.N. 1971: *"Physical Geography"*, Wiley Eastern Private Limited, New Delhi, P.39.
2. Monkhouse, F.J and Wilkinson H.R, 1967: *"Maps and diagrams"*. Methuen and Co.Ltd, London P.101.
3. Ibid.
4. Leet,L.D. et. all 1982: *"Physical Geology"*, Prentice Hall, Englewood cliffs. New Jersey, p.259.
4. Borthakur, M: "Weather and Climate of Assam". Extension lecturer, North East Indian Geographical Society., Series,2.
5. Kalita, S. and Sharma, S.K. 1982: "Diurnal variation of Monsoon Rainfall of an Inland station in the Brahmaputra Valley", current Science I, vol, 51, no.18.
6. Sharma, S. 1986: "Cartographic Representation of Water logging areas in the Guwahati city and its development planning" proc. Symp. Land use mapping NATMO p.32.
7. Ananthakrishnan, R. and others, 1979: Proc. Indian Acad. Sci. A. 88 p. 177.
8. Mulky, G. R. 1958: Indian, J.Met, Geophy vol. 9 p.403.
9. Prasad, B. 1970: Indian J Met, Geophys. Vol 21, p. 443.
10. Ibid, 1974: Indian J. Met. Geophys. Vol. 25, p.245.
11. Foster, E.E. 1949: *"Rainfall and runoff"*, the Macmillan Company, New York, p-121.
12. Sharma, S. and Gopalakrishnan, R: "Impact of hourly Rainfall on Guwahati City (Assam)", 12th Annual Conference of North East India Geographical Society, Jorhat, December, 28-29, 1987.

CHAPTER VI

Summery and Conclusion

Jorhat town grows like an organic entity. Each aspect of growth is related to each other. Only a comprehensive, balanced growth plan can ensure future of this town. The study investigates the problems associated with the water logging, particularly drainage system of Jorhat town. Though the water logging and related problems could be investigated through different angles, here in this study the analysis is from a geographical perspective. The problem of research and its goal and significance are outlined with attributes like physical, economic and socio–cultural environment of the study area. The study is based on wide range of primary data collected through personal field investigation and through questionnaires and reports of various government departments and academic institutions. These data are processed, tabulated and analyzed with the help of computer assisted software and interpreted. Further, satellite imagery, topographical maps of 1:50,000 scale and other departmental maps were used to investigate the problem associated with water logging in Jorhat town.

The rapid growth of population and consequential growth of residential units and related infrastructures like building construction activities, filling up of the wet lands and low lying areas and encroachments along the side of the existing drainage channels have reduced the hydraulic capacity of drains. Ultimately this resulted in a situation where even a downpour of half an hour plunges many areas of the town into flood like situation. Clogging of drains due to heavy silt brought down from adjacent high areas has aggravated the seasonal hazards of water logging in Jorhat town.

From the analysis of the various data collected for understanding the past and the present water logging scenario, the following facts have been found out:

- The bed level of river Bhogdoi that passes through the town is higher than the bed level of the other streams and drains making it difficult to drain out the storm water directly to the river Bhogdoi. During high flood there is reverse flow from Bhogdoi through other drains and thus inundates the town and making most part of the town water logged.
- Topography of Jorhat town is almost plain. Average slope of Greater Jorhat area gradually falls towards southeast to northwest. The general shape of the town is like a parabola. There is no other blockade or abrupt high lands in the town to hamper the natural flow. Malow Ali (northwestern side of the town) is the area where all the surface water of the town accumulates. The relief level of Malow Ali is 86 meters while the DC Court site (the centre of the town) is about 96 meters. So, it is apparent that there is no shortage of gradient to drain out the water of the town.
- Construction of buildings and roads over the man made drains are responsible for bottlenecking the drainage. Indiscriminate filling up of low-lying areas are also responsible for sheet wash along the Bhogdoi river. During heavy rain, enormous loose soils and silts are deposited in the channels rapidly. The filled up areas posses low seepage capacity because of compactness and saturate at a faster rate and therefore do not allow flow of floodwater.
- Most of the original and natural water reservoirs are filled up for residential, official, industrial and institutional purposes. Consequently, the rainwater spread over the built up areas thus causes flash floods.

- Due to prolonged silting, gradation and encroachments upon the banks of river Bhogdoi, the load discharge capacity of the river have reduced specially in the National Highway Bridge at Assam Trunk road site. The riverbed is becoming shallow and as a result, during flood season, the river crosses danger mark (89 meter) within 12 hours of precipitation. The average bed level is approximately 2 meters higher than that of Jorhat town, which fails to carry off the normal discharges. At the time of high water level of Bhogdoi, the water back flows into the town through the other streams.
- The oil pipeline of Oil India Limited goes through the Jorhat town and crosses the Tarajan perpendicularly. It was put at such a height that it is standing like a barrier to the discharges of the channel. Garbage coming through the channels use to be stuck at this point and the accumulated garbage formed a dome shaped barrier and water gets stagnant at this point. During rainy days, the channel easily overflows which in turn inundates the southwestern side of the town.
- Beyond the bypass, across Malow Ali, there is a box culvert. It was put three meters above the normal height of the town. The culvert was constructed for discharging the waters of the diversified Tocklai, but in reality water comes to this spot and rushes back in turn it creates water logging in the adjacent areas.
- The construction of Jorhat Medical College at Jail Road site has created new water logged areas in Senchowagaon, Cheunigaon and Sonarigaon due to obstruction of the channel Duborijan that carries the waters from Na-Ali, Bongalpukhuri and Lichubari area. Before the construction of the college, the main channel of Duborijan was within the college campus. The *jan* is now filled up completely and the water of

this channel accumulates at the south side of the college campus thus creates water havoc in the Jail Road -Sonari gaon path.

- The erosion on the banks of river Bhogdoi is very severe due to close spacing of embankment system. Canalization of the river at some vulnerable reaches was taken to develop the banks and deepening of the channel to reduce the increasing flood and to tackle the erosion problem. These works were in the form of bank bars and dampeners that stopped direct erosive attack on the river, but the bed was not deep enough to stop the flood levels.
- During dry days, these drains become stagnant and decomposed garbage thrown on drains clogging the water flow, also lack of proper gradient of the town.
- In Rajamaidam area, several unauthorized RCC buildings have blocked the main stream Tocklai. In Milan Nagar area, the wall of City Maternity Home on its midway has obstructed Tocklai, which carries a major part of water from the entire area. Likewise, many unauthorized structures have reduced its size to a narrow strip.
- The outgrowth of the water hyacinth plant on the Tocklai river near its upper reaches and Tarajan channel near Sarucharai area hinders the natural flow of water.
- Among 250 households surveyed, 69 percent throw their garbage in open drains, 10 percent throw at the roadside, whereas about 21 percent households have garbage removal system supplied by municipal board.
- The channel banks are encroached illegally by the people mainly in the town area where construction of permanent structures are carried out. Large quantities of debris and waste materials are being collected at the bottoms thus blocking the water flow.

- Proper maintenance of the drainage is not done. The debris and waste materials on the bed of the channels also resulting to drainage problem. Thus, the town is facing excessive water logging and drainage congestion.
- Every year during Bijaya Dashami, the day of immersion of idols held after the Durga puja where more than 150 groups of idols are thrown into the river Bhogdoi. These idols are made of clay, hay and other metals. This contributes a major part of sedimentation in the river making the riverbed higher.
- Open *jans* are carrying the commercial as well as industrial garbage and waste of the town. The major amount of garbage waste in Tocklai comes from the fish market that situated on the western bank of the river. The organic wastage generated by the market is being dumped in the drain area. There are many dumping spots located on the banks of Tocklai river which regularly collects waste and garbage. Besides polluting the environment, the landscape is unthinkably marred by expanding heaps of garbage.
- As a result of increasing settlements, the number of paddy fields and vacant lands are decreasing at a faster rate. Jorhat town is fast growing with its star type settlements along the main roads. There are only 30 percent *pucca* drains in the municipal area and the rests are *kutchha*. In the peripheral areas also along the bypass, the extensive paddy fields are occupied by settlers because of which urban crisis like slum growth, ecological imbalance etc. are increasing.
- Out of the five slum areas in the town, sweeper colony occupies single roomed houses of about 72 percent while Dhakkai Patty occupies single roomed houses of about 85.94 percent, which are blocking many drains.

- Removal of vegetation cover, cutting of lands, unplanned construction of buildings and roads, release of industrial waste into the drainage channel, stagnation of filthy water in the intermittently unfilled depressions becomes the breeding place of mosquitoes. All these have created serious problems of environmental pollutions endangering the health of civic life in the town.
- The present drainage networks 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. New residential areas are almost devoid of proper drains, which create rapid water accumulation and frequent floods.
- Drains are very narrow and they are not capable of carrying the huge quantity of water that pours from different parts of the town during heavy rains. The drains constructed in the town do not end at the ultimate discharge points, which are capable of holding this huge quantity of water.
- Encroachment over the low lying areas of Rajamaidam, Bongalpukhuri, Malow Ali by new settlers on the either side of the natural drains have blocked the natural flow of flood water to drain.
- The contamination of river water due to foul water of the built up areas of Jorhat harboured number coliform bacteria causes water borne infectious diseases. Some of the diseases (tuberculosis, lung cancer, asthma, eye disease) are caused by micro mini particles of smoke released from the industries.
- Jorhat experiences about eight peaks of high intensity rainfall during monsoon season. As the monsoon begins in the months of May, the secondary peak hour rainfall does not result into flood as rainfall is absorbed by the soil into the

saturated point. The other peaks (primary and secondary maxima) from June to September is a sensitive period with full potential of flooding in the town through runoff water. The intensity of mean hourly rainfall is maximum in June. Significantly, co-efficient of variation shows very high in June (77.61percent). Hence, this month is always alarming as it exposed the inherent drawbacks of Jorhat's drainage system.

All these above factors causes water logging and making serious threats to the town. Frequent water logged areas are Malow Ali, Rajamaidam, Bongapukhuri, Pujadubi and Choladhara area. There are many areas where water logging is observed occasionally. These areas are Bansbari, Dohabara area, Atila gaon, Naoboisa and Digambar Chowk etc. The study reveals the necessity of pre treatment of water logging of the town before allowing them to create severe problems. A detail master plan needs to be prepared for it. On the basis of aforesaid study, several implications of general and specific nature arises which require consideration from academicians, policy makers and administrators.

Following are some of the suggestions to improve waterlogging problems in Jorhat town:

- The drains need to be cleaned at regular intervals, which will help effective water flow easier, the beds of the drains should be of concrete cast.
- Streams like Rowriahjan, Mohuajan, Anthubhangajan and Tocklai river need to be cleaned from time to time and their misuse and encroachment be strictly dealt with. It would be necessary to connect the major drains to these streams.
- Mahuajan, Tarajan and Rowriahjan connected through open drains cannot accommodate entire water received during the peak discharge. There is also no practical use of Tocklai river due to its shallowness and narrowness. Hence all the

above mentioned *jans* need to be excavated to enable them to reserve the excess storm water.

- To absorb the city runoff, which comes through the existing drains, the low-lying areas of Tarajan that is, the northwestern part of the town needs to be excavated. The outgrowth of water hyacinth plant on Tarajan channel need to be removed.
- Deepening of Anthubhangajan, Rowriahjan, Jawkhoriajan, Tocklai and Tarajan linking them with Bhogdoi river and connecting the water logged areas of the town with these natural streams will reduce the problem.
- It is necessary to borrow the services of technical experts from different departments and institutions to suggest the size and lay out of drains based on the volume of water to carry during smart showers. Appropriate lay out of the entire drainage network is highly essential to discharge the entire town water to natural wet lands.
- Drain should be kept free from all obstructions by removing the excessive accumulation of silts. A deep drain may be constructed along the bypass to catch the additional silt loads from the Tocklai and the Bhogdoi river. Some additional silt traps (silt trap is a design which maintains silting velocity for selected particle size) may be constructed at important sites along the existing natural drains and clean it regularly.
- The earth cutting on the bank of the river and the *jan* should be stopped immediately. This will reduce the rate of siltation in the drains.
- Efforts should be made to convert the existing drains free from garbage. This will increase the water carrying capacity of the drains and the problem of water logging will be reduced. Service path on both sides of the drain should be kept for maintenance purpose.

- Garbages should never be kept bare making some compromise with people's standards, wheeled metal boxes of moderate size with back side covered three fourths at convenient points can be placed and the filled boxes can be carried by tractors during night hours replacing with another empty box. The garbage thus carried, instead of discharging at open places or low-lying areas or the wetlands, must be scientifically treated to produce manure or electricity.
- Non-degradable solid waste like plastics, polythene, rubber items and metallic products should not be thrown into drain water which acts as the hindrance of free flow of drain water. Coverage on the channels with nettings would prevent dumping of garbage.
- In case of refuse disposal, modern method of incineration can be adopted. The first of its kind may be located in the present site of garbage disposal near Tocklai river.
- The existing oil pipeline over the Tarajan channel should be relocated.
- On Malow Ali area along the bypass, the bed of the box type culvert should be lowered down at least by two meters from the existing level to get a straight slope for maximum discharge.
- On the right bank of the Bhogdoi river, there lies Bejijan channel. This channel drains substantial areas and was constructed in 1959 for 10 kms. To get free from water logging in the western side of Jorhat town, this channel requires re-sectioning and re-grading to effectively drain out the water.

- Rain water harvesting, particularly roof top harvesting should be encouraged, so that some amount of water could be kept there to reduce the intensity of water logging.
- The deposited silt on the bed of the river Bhogdoi during immersion of idols can be minimized by removing the debris immediately after the immersion.
- To prevent water logging on the Jail road - Sonari Gaon Road, construction of alternative outlets needed to drain out the accumulated water of Duborijan on the south side of the college campus.
- Some more new drains in the new residential areas of Bansbari, Bongalpukhuri, Jail road, Choladhara etc should be constructed along the natural slope of the area connecting them to the nearest natural river or streams to carry all the surface water.
- The existing drain should be expanded so that water flow is increased. In this context, an integrated master plan for the management of Bhogdoi river and other *Jans* will ensure the stability.
- In order to protect the area from the backflow of the river Bhogdoi, marginal bund on both banks from Immersionghat to upstream can be provided. Diversion of Tocklai to Bhogdoi near Immersionghat is necessary.

Diversion of Tocklai at down reach from the original outfall (near Jagannath Barooah road) towards downstream of Bhogdoi was linked with Tarajan. The main natural channels need to be cleaned and re-sectioned with widening the drainage on priority basis.

The findings as discussed above ensure a positive way to the original questions stated in chapter I about the complexity of the water logging related problems. As the

Jorhat town facing various water logging related problems, which are increasing day by day, the remedial measures have to be taken up without further delay. For this, an attempt has to be made by all concerned departments collectively. To get proper directions and planning to take necessary action, an acceptable model has to be evolved considering the present situation and the trend of changes at least in last few years. To do so a strong database is requiredwhich is not yet generated at any level. In this thesis, an attempt has been made to pinpoint certain facts based on data generated directly from the field. Though it is only a part of whole planning process of efficient drainage management in Jorhat, this study may help in understanding the vital waterlogging related issues in the town.

BIBLIOGRAPHY

- Alam, S.M. and Pokshishevsky V.V, (eds). 1976: "*Urbanisation in Developing Countries*"-Indo Soviet Collaborative Volume, Osmania University, Hyderabad.
- Adhikarti, S.S.1977: "Prediction of Stage Discharge, Relation for Alluvial Stream in North East India with Special Reference to Brahmaputra". Thesis, unpublished, Gauhati University.
- Alam, S. M. (1965): "*Hydrabad, Secunderbad-A study in Urban Geography*", Allied Publishers Pvt. Ltd., Hydrabad.
- Alam, S. M. (1972) and Khan: " *Metropolitan Hydrabad and it's region – A strategy for development*", Publishing house, Bombay, Anantha Krishnan R. Aralikathi and Pathan G.M. 1979 Proc. Indian Acad. Sci. A. 88.p.177 .
- Agarwala, A.N 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, P.P. 191-2002.
- Adhikarti, S.S.1977: "Prediction of Stage Discharge, Relation for Alluvial Stream in North East India with Special Reference to Brahmaputra". Thesis, unpublished, Gauhati University.
- Bhatt, S, 1986: *"Environmental laws and water resources Management*", Redient Publishers, New Delhi.
- Borah, J. 1985: "Spatial Structure of Urban Influence in the Neighbouring Areas of Gauhati City", Inter India Publication, New Delhi.
- Baruah,K.L,1933: "*Early History of Kamrupa*", Author – K.L. Baruah, Shillong.
- Bose, A. 1978 : "*India's Urbanisation (1901-2001")*, Tata McGraw-Hill Publishing Company Limited, New Delhi.
- Borthakur, M: "Weather and Climate of Assam", North East Indian Geographical Society, Extension Lecture, Series No. 2.
- Barooah, Anandaram, (1971): "*Ancient geography of India*", Ghy, p – 68.
- Burton, J. et.al, 1978: *"The environmental Hazards*", Oxford University Press, New York.
- Burton, I. et. al, 1969: "Flood Damage Reduction in Canada" in Nelson J.G. and Chambers M.J. (eds) "*Water*", Methuen, Toronto, pp 77-108
- Bowen, A. J. and Inman D.L. 1966: "Budget of Point Argnello", California, and C.E.R.C. Tech. Memo.19.
- Biswas, A.K. 1970 : "*History of Hydrology*", North Holland, Amsterdam, London.
- Bernard, Merril, 1938: "Modified Rational Method of Estimating Flood flows", Appendix, A. in low Dams, National Resource Committee, Washington.
- Banu, Z. 1999: Environmental Degradation and its impact on Human Health, A Study of Chennai, journal of Dravidic Studies, p-57.

- Biswas, Sujata and others, 1999: "Morphometric Analysis of Drainage Basin, A Remote sensing and G.I.S. Approach", Journal of Indian Society of Remote Sensing.
- Borthakur, 1968: "Drainage and Flood in Upper Assam", Proc. Pre-congress, Symposium and Field Study, etc. 21st International Geog. Congress India, held in the Deptt. of Geog, G.U.
- Borthakur, D.N. 1988: "Flood Control and Agriculture Production". Keynote address in the seminar on "Flood production for Dibrugarh and Suburbs." Organised by Dibrugarh University.
- Bora, A.K., 1990: "Jia Bharoli River of Assam, A study in Fluvial Geomorphology" An unpublished PhD. Thesis, Gauhati University.
- Borah, J. 1985: "Spatial Structure of Urban influence in the neighbouring areas of Guwahati city", Inter India Publications, New Delhi.
- Bose, A. 1978: *"India's Urbanization (1901-2000)"*, Tata McGraw-Hill Publishing Co. Ltd. New Delhi.
- Bacpin, C.W, 1966: "Central Places in Southern Germany", Englewood Cliffs, N.J. translation of W. Christeller's (1933) *Die Zentralen Orte* in Suddentschland.
- Beckinsole, and Huston, J.M. 1970: *"Urbanization and its Problem"*, Basil Blackwell, Oxford.
- Bhardwaj, R.K. 1974: *"Urban Development in India"*, National Publishing House, New Delhi.
- Bhat, L.S. 1980: *"Impact of a Metropolitan City on the surrounding region-A study of South Kalaba, Maharastra"*, Concept Publishing Company, New Delhi.
- Bosh, Ashis 1973 : *"Studies in India's Urbanization 1901-1971"*, Tata McGraw-Hill, New Delhi .
- Bourne,L.S.and others, 1984 "Urbanization and Settlement system, International perspective, Oxford University Press, "The Growth of the City in Park, R.F.
- Bhattacharyya, N.N: "Gauhati, A Study in Urban Morphology", PhD. Thesis, Unpublished, 1977.
- Burgers, E. W 1925: "The Growth of the City", in R. E. Park, E. N. Burger, R. D. McKenzie's, *"The City"*, University of Chicago press.
- Boudevill,J.R.1966:*"Problems of Regional Economic,Edinburgh"*, Edinburgh University Press.
- Brain, B. 1961: "Some Relations of Urbanisations and Basic Patterns of Economic Development", in Norton Ginsburg, *"Atlas of Economic Development"*, Chicago.
- Cater, H. 1982: *"The study of Urban Geography"*, Arnold Heinemann, New Delhi.
- Chase,S and Ferrull, 1957: "Oxygen Demand Exerted by Leaves Stored under Water", J. New, Engl, Wat. Works, Ass 71, pp.307 -312.
- Chittranjan, P. 1978: "Urbanization in N.E. Region of India", M. Phil Thesis (Unpublished) Submitted to N.E.H.U.

- Coppock, J.T. and Prince,H.C, 1964: "*The Geography of Greater London*", Feber London.
- Chow, V.T. 1962: "*Hydrologic Determination of Waterway areas for the Design of Drainage, structures in small drainage Basins*" University of Illinois, Eng., Expt. Sta.Bull. P.462.
- Chow, V.T. 1969: "*Handbook of Applied Hydrology*", Mc Grow-Hill, New York.
- Coats, D.R. 1971: "Environmental Geomorphology and Landscape Conservation", Vols I, II, and III Hutchinson and Ross. Inc. Stroudsburg, Pennsylvania.
- Chow, T.V. 1956: "Hydrologic and studies of flood", the U.S. International Assoc. of Science. Publications, 42.PP.134-170 .
- Christeller, W.1966: "*Central Place in Southern Germany*" , (Translated from *Die Zentralen Centre* in Suddentschland) Eaglewood. Cliffs. Prentice Hall. Inc. New Jersey.
- Census of India, 2001, Assam .
- Changkakoti, G.C. and Deka, A.K: "Development of Drainage of the City of Gauhati", Seminar paper, The Institute of Engineers (India), Gauhati, September 14 – 16, 1982.
- Dickinson, R.E. 1967: "*City Rg, in Western Europe*", Routledge and Kegan Paul. Ltd. London.
- Dhar, O.M. 1962: "Rainfall and floods in Yamuna Catchment." Indian Journal of Meteorology and Geophysics.
- Dury, G.H. 1961: "Bankful Discharge. An example of Statistical Relationships". Int. Assoc. sci, hydrol, 6th year U.S. Geol. Ser-V.3 PP.48-55.
- Dury, G.H.1969: "Perspective on Processes" Assoc, Amer, Geographical Resource Paper-3.
- Das, B.K., 1982: "Strom Drainage and Sewerage Designs in High Rainfall Intensity urban areas", Seminar Proceeding, The Institute of Engineers (India) Assam State Center, Sept 14-16.
- "Design and Construction of Sanitary and Storm Sewers", 1960, American society of Civil Engineers and Practice, No 37 or water pollution control Federation Mannual of Practice no.9.
- District Gazetter of Sibsagar (Shillong, 1976) p. 33 .
- Chatterjee, S. K : "*The Places of Assam in the History and Civilization of India*" (Ghy, 1970) p.9 – 10.
- Dickinson, R.E. 1969: "*The Makers of Modern Geography*", Routledge and Kegan Paul Limited, London, pp 78-80, 116-118.
- Dickinson, R.E. 1964: "*City and Region, A Geographical Interpretation*", Routledge and Kegan Paul Ltd., London.
- Dickinson, R.E 1960: "*City Region and Regionalism, A Geographical Contribution to Human Ecology*", Routledge and Kegan Paul Ltd. London.
- Dikshit, K.R. and Sewant, S.B. 1968: "Hinterland as a Region, its type Hierarchy, Demarcation and Characteristics, The Characteristics of the Case of Poona", The National Geographical Review of India, Vol 14 PP 1-22.

- Deshpande, C.D. et. all. 1980: *"Impact of a Metropolitan City on the Surrounding Region-A Study of South Kalaba, Maharastra"* Concept Publishing Company, New Delhi.
- Das, M.M: "Pattern of Soil Distribution in Assam", The North Eastern Geographer Vol. XII (Guwahati, 1981), P.22 .
- Das, M.1999: "Patterns of Social Change among the major Tribal Groups in Guwahati City", An Unpublished M. Phil Dissertation, Gauhati University.
- Das, M.C: "Yuge Yuge Guwahatir Ruprekha", Paura Bichitra, GMC Journal, 1st Issue, 1978.
- Das, N.N: "A Preliminary Study of Pollution in Water of Bharalu River at Gauhati", Symposium, Assam Science Society, Gauhati, 1977.
- Das, P.C: "Water Pollution Status of Sewage Pollution in Gauhati", MSc. Dissertation, Gauhati University, 1977.
- Elson, M. 1979: "Urban Fringe Management Problem-The Planner", Vol. 65 No 2, pp. 521-554.
- Lampard, E.E: "Historical Aspects of Urbanisation" in P.M . Hauser and L. F. Schnore (Ed): *"The Study of Urbanisation"*, N.Y. (1965).
- Erickson, E.G: *"Urban Behaviour"*, New York 1964, P.265.
- Enruch, et. al 1977: *"Eco-science Population Resource Environments"*, Freeman and Company San Francisco P.556 .
- Forbes, R.J. 1965: "Irrigation and Power Studies in Ancient Technology", Vol. 2 Laiden.
- Greggory, M.D. and Arnold, C.E. 1993: "Rational Runoff Formulas", Trans Am . Soc. Civil Engineers Vol 96 pp. 1038-1099.
- Grossling, B. F. 1976: "An Estimate of the Amounts of Oil Entering the Oceans in Sources, Effects and Sinks of Hydrocarbons in the Aquatic Environments", Proc, Symp. Washington D.C., 9–11 August, p.p. 6–34. American Institute of Biological Sciences, Washington DC.
- Gedds, 1949: *"Cities in Abolition"*, William Norgate, London.
- Ghose, S.N. 1986: *"Flood Control and Drainage Engineering"*, Oxford and IBH Publishing CO Pvt, Ltd New Delhi.
- Gupta, M.P. and Sharma,S.1998: "Flood Situation in Raipur District", Madhya Pradesh, India, p.1.
- Goswami, A.C. 1972: "Regional Flood Frequency Analysis of Brahamaputra Basin in N.E. India", Jr. of Institute of Engineers, India, Vol. 77.
- Goswami, D.C. 1990: "Impact of the Pagladia River (Assam) on Human Occupance in its lower Basin", an unpublished M. Phil Dissertation, G.U.
- Govt. of Assam Gazetter at Sivsagar, (Shillong, 1976) .
- Herbert, D: *"Urban Geography – A Social Perspective"*, Douglas David and Charles Limited, Von. Couver, B.C. 1977 p.64 .
- Herbet, D.T. and Johnson, R.J.ed, 1979: "Geography and the Urban Environment Progress in Research and Application" Vol. II Jhon Willing and Sons, New York.

- Hodges, L. 1977: *"Environmental pollution"*, Rinchart and Winston, New York.
- Hanumappa, H.G. 1981: *"Urbanisation Trend in India-Case study of a Medium Town"*, New Delhi.
- Harris, C. and Ullman, E.L. 1945: "The nature of cities" The annals of the American academic of Political and Social Science.
- Harvey, D. 1976: "Social Justice and the City", Edward Arnold, London
- Harvey, R.O. and Clark, W.A.B. 1965: "The nature and Economics of Urban Spraw Land Economics" Vol. 41 .
- Hoyt, W.A and Longbein W.B. 1995: *"Floods"* Ronald Press, New York.
- Huson, J.C. 2001: "Chicago Pattern of the Metropolis" Journal of Geography p.110.
- Herald, M.M., 1954: *"Urban Geography"* (ed. Tresten), E. James Clarence, Jones F. American Geography, Inventory and Prospects Syracuse university,p. 144.
- IASH/UNESCO/WMO, 1969: "Floods and their Computation", 2 Vols. Pros. of Leningrad Symposium August 1967.
- Jervis, C.S. 1926: *"Flood Flow Characteristics"* Trans, Ams, Soc, Civ, Engrs 89 Pp 985-1032
- Janaki, V.A. and Sayed, Z.A. 1962: *"The Geography of PadraTown"*, Baroda University Press Baroda.
- Knox, P.1982: *"Urban Social Geo: An Introduction"*, Longman, London
- Kuichling,E.1889: "The Relation between the Rainfall and Discharge of Sewers in Populous Districts".
- Kar, N.R. 1963: "Economic Character of Metropolitan Sphere of Influence of Calcutta", Geographical Review of India, June pp.108-137 .
- Kar, M. 1995: "Flood Hazard in Nagaon and Marigaon Districts of Assam-A Geomorphology Perspective"-An unpublished PhD Thesis G.U.
- Kates, 1962: "Hazard and Choice Perception in Flood Plain Management", University Chicago Deptt. Geog, Res, Paper-78 .
- Kalita, S. and Sharma, S.K.1982: "Diurnal Variation of Monsoon rainfall of an Inland station in the Brahmaputra Valley", Current Science, Vol.No 51 .
- Krishnan, A. others: "Probable Maximum Twenty Four Hour Rainfall over India", Proceedings of Symposium on Meteorological and Hydrological Aspects of Floods and Droughts in India, 1959.
- Kakati, G. N: "Study of Surface Water Pollution in Greater Guwahati", PhD. Thesis, Guwahati University, 1991.
- Konwar,N.B: "Analysis and Synthesis of Flood Control Measures of Pagladia River in Brahmaputra River System", M.Eng.Thesis.Gauhati University,1980.
- Lampard, E.F.1965: "Historical Aspects of Urbanisation in Schnoru" (ed), *"The study of Urbanisation"*, New York.
- Leopold, L.B. and Maddock, T. 1954: "The Flood Control Controversy", Ronald, Press New York.
- Leopold, L.B. et al 1964: *"Fluvial Processes in Geomorphology"*, Eurasia Publishing House (pvt) ltd, New York.

- Lambart, W.G. and Milland, A.R. 1969: *"Atrahasis the Babylonian Story of the flood"*, Oxford University press, London.
- Mayer, H.M. and Kolin, C.F. 1969: *"Readings in Geography"*, University of Chicago.
- Murphy, P.O. 1958: "Regulating Flood plan Development", university of Chicago Deptt. Of Geography, Res. Paper no 56.
- Mishra, T.K. 1982: "Studies on Some Water Pollutants", Unpublished PhD. Thesis, Visva Bharati, Santi Niketan .
- Munsi, S.K.1998: "Problems of Flood Management in India", Policies and Programmes, Geographical Review of India, P.239 .
- Mohan, M. 1998: "Quarrying Activities on the Northern Flank of the Arawallis", The Indian Geographical Journal pp.130-136.
- Mohan, T.M. 1998: "Air and Water pollution Mysore city", National Geography P.45.
- Mulky, G.R. 1958: "Indian J. Met Geophy" Vol.9 p. 403.
- Micharl, J.F: *"The North East Frontiers of India"*, First ed Delhi, P 21.
- Marcus, M.G. and Detwyler, T. R: "Urbanisation and Environment in perspective, Urbanisation and environment", *"The Physical Geography of the City"*, p.7.
- Mutreja, K.N. 1988: *"Applied Hydrology"*, Tata Mc.Grow-Hill Publishing Company Ltd. New Delhi.
- Merril, R.L and Erickson, R. 1969: "Problems of modeling interaction in K. Cox and R. Gollege" (eds), *"Behavioural Problems in Geography"*, North Western University Press Eranston.
- Merril, R.L. and Kelly, M.B. 1973: "The simulation of Hospital use and the Estimation of Location Efficiency", Geog. Anal. Vol. 2 pp.283-300 .
- Merril, B. 1938: "Modified Rational Method of Estimating flood flows". Appendix A. in low Dams, National Resource Committee, Washington.
- Millar, D.H. 1966, "Cultural Hydrology", A Review Economic Geog- 4 pp.82-89.
- Monkhouse, F.J, and Wilkinson, H.R, 1967 *"Maps and Diagrams"*, Methuen and Co Ltd, London.
- Mishra, D. R 1983: "Growth Poles and Growth Centres in the Context of India's Urban and Regional Development Problem in Contribution to Indian Geography", Vol. I, Concept and Approaches (Ed. Heritage Publishers, New Delhi) .
- Northam, R, M. 1979: "Urban Geography" Oregon State University, New York.
- Nangia, S. 1976*: "Delhi Metropolitan Region"*, K.B. Publication, New Delhi.
- Perroux, F. 1955: *"Note Sur La Notion de Pale de Crissance"*, Economic Applique, 7.
- Pennig, R.F.C. and Underwood, L. 1972: "Flood Hazard and Flood Plain Management survey of Existing studies", Middlesen, Polytechnic Flood Hazard Res. Project Progress report 2.
- Prasad, B. 1970: Indian J. Met, Geophys vol. 21, p.443 .

- Phookan, J. 1977: "*Fauna and Flora of Kaziranga*" Ghy p.7 .
- Puri, B.N 1968: "*Studies in Early History and Administration in Assam*", Ghy, p 5.
- Report on Master Plan for Water Supply, Sewerage and Drainage for Guwahati Metropolitan District, 1987-2001, Kolkatta Metropolitan Planning Organisation, 1972.
- Rondinelli, D. A. 1983: "Town and Small Cities in Developing Countries", The Geographical review Vol.73.
- Robson, B.T. 1969: "*Urban Analysis A Study of City Structure with Special - reference to Sunderland*", Cambridge University Press London pp.3-35.
- Raghunath, H.M. 1992, "Groundwater" Wiley Eastern Limited, New Delhi.
- Ravenstein, E.G. 1885-1889: "The Laws of Migration", Journal of Royal Statistical Society, vol.48, pp.167-235 and vol. 52 pp 493-496 .
- Richardson, H. W 1978: *"Regional and Urban Economics"*, London and New York, Penguin.
- Ramswamy, R., 2001: "Water Charting - A Curse For The Future" Economic and Political Weekly.
- Ramakrishnan, K. K. 2000: "State of the Environment in Kerala", Economic and Political weekly, p.1801.
- Rao, V.V, 1978: "Early History of the Guwahati Municipal Board", Poura Bichitra, (G.M.C Journal),First Issue .
- Ravenstein, E.G. 1885-1889: "The Laws of Migration Journal of Royal Statistical Society", Vol 48 pp.167-235 and vol. 52 pp 493-496 .
- Simons, D.B. 1969: "Perspective on processes", Assoc. Amer. Geographical Resource paper.
- Schuman, S.A. and Litchi, R.W. 1963: "Channel Widening and Floodplain Construction Along Cimmeron River in Knasas", U.S. Geol, Sur, Prof. paper 352-353 pp.71-88 .
- Stewart, J.G. 1942: "*A Measure of the influence of population of Distance Sociometry*" vol.5 pp.63-71.
- Sharma, H.N. 1975: "Elements of Urban Impact on Rural Society in India - A Spatial Analysis and Social Characteristics".
- Sharma, H.N. 1978: "Elements of Urban impact on rural society in India - A Spatial Analysis on Scarce Natural Resources".
- Sharma, B: " Guwahati Master Plan", The Assam Tribune, 12th August, 2007.
- Sharma, S. 1986: "Cartographic Representation of Water Logging Areas in the Guwahati City and its Development Planning", Proc symp. Landuse mapping NATMO p.32.
- Singh, R.L. (ed) India, "*A Regional Geography*" (First ed) Varanashi, 1971, p.306 .
- Sarma, J.N. and Basumallik S ,1984: "Bankline Migration of the Burhi Dihing River, Assam", Inc. Junior, Earth Science vol. nos 3 and 4 pp. 199-206 .
- Smallest, A.E. 1948: "Urban Fields and their Delimitation", Geography. Vol 34 .

- Sundaron, K.V. 1977: *"Urban and Regional Planning in India"*, Vikas publication House Pvt .ltd. New Delhi.
- Swell, W.R.D. 1969: "Human Response to Flood" in chorly R.J. (ed) *"Introduction to Geographical Hydrology"*. Methuen and Co ltd. , London .
- Strahler, A.N. 1971: *"Physical Geography"* Wiley, Eastern Pvt. New Delhi, pp.415-500.
- Smith, K. 1972: "*Water in Britain*", McMillan London.
- Stewart, J.G. 1942: "A Measure of the Influence of Population at Distance Sociometry Vol. 5. pp.63 -71.
- Singh, R.C. and Srivastava, A 1995: "Landuse Management and Urban Planning, Bhillai -An Industrial Complex", Geographical Review of India pp.195-201.
- Singh, R and Sangwan, 1999: "Flood Hazard in Rahtak City",Transactions Institute of Indian Geographers p. 65 .
- Singh S.B and others, 1998: "Urban Environment Problems and Planning , National Geography p. 28 .
- Supplementary Papers on "World's Environmental Day",The Assam Tribune,Guwahati, 5th June,1982.
- Sarma,S.K.and Kalita,S. 1982: Diurnal Variation of Monsoon Rainfallat an Inland Station in the Brahmaputra Valley", Current Science, September,20,Vol 5.
- Sarma,S.1982: "Drainage Problem of Gauhati and It's Environs", Seminar Paper,8th Annual Conferenc ,North East India Geographical Society,20th December.
- Sarma,S,1983: "Drainage Problem of Gauhati and it's Environs-A geographical Study", Dissertation submitted as a Partial Fulfillment of Master of Philosophy of Gauhati University.
- Thakur, P. 1988: "Profile of Development Strategy for India's North Eastern Region", Span Publications.
- Tibbetts, J. 2000: "Water World, 2000", Environmental Health Journal of the National Institute of Environment p.69 .
- Truman, A. H. and Alexander, J. W 1988: *"Economic Geography"*, Prentice Hall of India Private Ltd. New Delhi p. 278.
- Tripathi, R.M. 1999: "Spatial Characteristic of Drainage pattern in Allahabad City" National Geographer .
- Taher, M. 1988: "The Population in Assam", North Eastern Geographer, G.U. Vol. 19. Nos. 1 and 2 pp 1-16 .
- Taher, M.1969: "Physiography of Assam" ,Extension Lecturer Series 1 NE I.G.S. Ghy.
- "Urbanisation and Settlement System", International Perspective, Oxford University Press, 1984.
- Vink, P. A, 1975: "Landuse in Advancing Agricultures", Spinger Veriag, Berlin etc.
- Versety, R.S. and Lahr, M.1974: "*Engineering Hydrology*", New Chand and Brothers Roorke, U.P. India .

- White, G.F. 1945: "Human Adjustment on Flood Problems", University of Chicago, Deptt. Of Geography,Res. Paper 30 .
- Webber, 1899: "*The Growth of Cities in Nineteenthe Century, A Study of Statistics*", New York.
- Ward, R.C. 1978: "Flood - A Geographical Perspective", McMillan London, Institute of Civil Engineers, 1996, "*River Flood Hydrology*", ICE. London .
- Willey, G.R. 1953: "*Classification and Use of Irrigation Waters*", U.S. Deptt. of Agriculture, Circular no 969 .
- Walman, M.G. and Leopold, L.B. 1957: "River and Floodplain-Some Observations of their Formations", U.S. Geol Surv. Prof. Paper 282-c .
- Whipple, W. and Hunter, J.V. 1974: "*Unrecorded Pollution from Urban Run off*", J. Water Pollution Control Fed, 46 (5) 873-85 .
- Whipple, W. 1975: "Water Quality Planning for the Delaware Estnary, an Example", Water Resource Bull II (2) 300-305.
- Wentworth, C.K: "A Simplified Method of Determining the Average . Slope of Land Surfaces", Americal Journal of Science, Vol. 220, 1930.
- Yarnell, D.L 1936: "*Rainfall Intensity – Frequency Data*", US Department, Agr. Misc. publications .
- Yeats, M. 1974: "*An Introduction to Quantitative Analysis in Human Geography*", Mc Grow Hill Book Company New York, p.131.
- Yadav, C.S. 1987: "*Morphology of Towns*", Concept Publishing Company, New Delhi .
- Zen, S.W. and Mcpherson, "*Quantitative Determination of Urban Stormwater Runoff*" (eds) .
- Zipf, G.K. 1949: "*Human Behaviour and Principle of Least Efforts*", Addison Wesley Cambridge.

APPENDIX – A

Household Schedule, 2004

1. a) Name of wards..... ..... b) Religion .....

   c) Caste/Tribe..... d) Education Qualification.....

2. a) Name of the Head of the family.....

   b) No. of family members (M/F) .....

   c) Types of the family (Joint/Single) .....

   d) Profession (with income) .....

   e) Type of dwelling houses (floor, roof, wall) .....

   f) No. of rooms including kitchen .....

3. Food Habits

a) What are the main food intakes commonly? (Rice/ Bread)

.....

b) What is the calorie amount present in diet (Approx)?
(high-fats & oil / low- nuts & green vegetables)

.....

c) Total average cost of the diet per head in family members?

.....

d) Category of diet in respect of time?

[fast food (less time to cook) / raw food (moderate time to cook) /cooked food (high time to food)]

.....

e) Category of diet in respect of cost? (economic / costly / moderate)

.....

f) Hygienic condition of the food to be intake?

(certified by local vendors trademark / govt. labs / open food market – not germ free)

.....

4. Demographic and Social Structure

Sl. No.	Year	Relationship with head of the family	Educational Qualification	Occupation (Full time/Part time)	Place of work	Distance from the house	Mode of Transport
1	2	3	4	5	6	7	8

5) Family Workforce

Types of works	Number of workers	Number of working days/week	Additional Skill	Wage
1	2	3	4	5
Service				
Business				
Cultivators				
Petty Trade				
Others				

5. a) Do you own a house (Yes/No) .....

If Yes, then

Rooms Detail	RCC	Assam Type
1	2	3
No. of Rooms		
Electrified		
Size of Bed Room		
Size of the Kitchen		

b) The important usage of house is put under

Use	Amount
1	2
Residence	
Residence and Renting	
Residence and Shop	
Rent and Shop	
Residence, Rent and Shop	
Shop	
Rent	
Others	

c) If rented house, what number of accommodation house do you rent?

d) Your expenditure on house rent

Amount on Rent and Maintenance	Cost of Electricity	Cost on Drinking water	Cost on Garbage disposal system	Cost on waste water disposal system
1	2	3	4	5

6. Drinking Water

Source (urban/deep tubewell/municipality)	Required water per day	Expenditure per month	Available/Scarce	If non available the reson for the crisis
1	2	3	4	5

7. Drainage System

a) Are you having good drainage system in your area?

b) If yes, under whose maintenance? (Municipality / T&CP/ END Dept. /PWD)

c) If no, have you tken any steps towards the improvement of the drainage system? And what are the ways, mentioned?

8. Drainage System (House Hold).

Is there any outlet system for throughing out waste water? (Yes/No)

a) If yes, then

<table>
<tr><td colspan="3">Types of drains</td><td>Nearest river/streams if any</td><td colspan="2">Connection of the outlets</td><td colspan="2">Depth of the drain</td></tr>
<tr><td colspan="3">1.</td><td>2.</td><td colspan="2">3.</td><td colspan="2">4.</td></tr>
<tr><td colspan="2">Pucca</td><td>Kacha</td><td rowspan="3"></td><td>Streams</td><td>Open space</td><td>2ft></td><td>>2ft</td></tr>
<tr><td>Covered</td><td>Un covered.</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td></td><td></td></tr>
</table>

<table>
<tr><td>Expenditure</td><td colspan="2">Cleaning System</td></tr>
<tr><td>5.</td><td colspan="2">6.</td></tr>
<tr><td rowspan="2"></td><td>One time in a month</td><td>More than one time in a months</td></tr>
<tr><td></td><td></td></tr>
</table>

9. Types of Garbage.

a)

Category	Quantity (Kg per day)
1	2
Organic Waste	
Paper	
Glass	
Plastic	
Kitchen Waste	

b) Means of throwing garbage

Open Air	On river/Streams	Road side	Collected by Municipality	Expenditure	Remarks
1	2	3	4	5	6

10. Flood situation

a) Whether the area is affected by flood ? (Yes/No)

b) If yes, the reason of the flood. (Natural/Artificial)

c. Water Logged Situation

Name of the Location	**Directions**	**Major/ Minor**	**Stream/River nearest to those locations**	**Duration of water logging (in hours)**				
				April	**May**	**June**	**July**	**August**
1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**

Basic Problem that you face at that time.	Loss if any	Comments.
10.	11.	12.

d. Have you received any assistance from the local administration? Yes/No

If Yes, then

i. Name of the year.

ii. Name of the Local Administration.

iii. Nature of assistance. (Cash/Implement)

iv. Performance.....

11. Pesence of rain water harvesting system (With capacity).

Presence of rainwater harvesting system (with capacity), Yes/No.	Distance from the source	Method of water conservation
1	2	3

12. Types of illness.....

13.Social Status(Responsibility)

a) Religion.....

b)Politics.....

c) Voluntary association or organization.....

APPENDIX : B

Hourly Average Rainfall , 2001, 2002 and 2003, May to September.

Rainfall in millimeter

Hour	1	2	3	4	5	6	7	8	9	10	11	12
MAY, 2001	5.38	2.73	1.92	5.7	2.03	1.21	3.81	0.4	3.8	.4	2.9	.4
2002	4.95	1.77	.97	3.46	3.45	2.17	1.21	.45	.5	.5	0	.2
2003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AVERAGE	5.16	2.25	1.44	4.58	2.74	1.69	2.51	.42	2.15	.45	1.45	.3
JUNE, 2001	8.1	5.38	1.3	3.25	1.05	.45	.2	0	3.83	3.93	2.45	8.63
2002	0	0	1.03	1.8	1.7	.54	.2	.1	0	.46	.86	5.46
2003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AVERAGE	4.5	2.69	1.16	2.52	1.37	1.49	.2	.05	1.91	2.19	3.15	7.04
JULY, 2001	1.1	3.75	1.74	1.01	1.6	2.26	1.93	3.81	5.0	6.62	4.42	0
2002	6.73	7.33	2.4	.77	1.01	.67	1.28	.75	.2	.36	.46	.38
2003	2.0	3.13	.73	1.36	.86	2.08	3.92	.7	8.5	3.23	2.1	1.75
AVERAGE	3.27	4.73	1.62	1.04	1.15	1.67	2.37	1.75	4.56	3.40	2.32	.71
AUGUST, 2001	4.8	2.35	.72	.12	1.84	4.34	4.47	5.64	4.27	.5	.72	1.26
2002	2.03	.23	2.9	.7	4.27	10.32	3.27	1.38	8.4	7.36	1.76	0.36
2003	6.75	2/43	4.75	3.25	1.08	3/08	3.65	2.00	1.95	2.50	2.12	2.83
AVERAGE	4.52	1.67	2.79	1.35	2.39	5.91	3.79	3.00	4.87	3.45	1.53	1.48
SEPT, 2001	0	.2	1.95	1.4	.55	.2	.1	.6	0	.3	.8	1.4.
2002	5.4	1.02	22.9	2.0	1.8	1.46	.25	.66	0	.1	.2	6/2
2003	1.8	1.1	5.15	7/9	2.1	1.07	1.27	2.8	2.72	2.92	5.75	3.38
AVEGRAGE	2.4	.77	9.33	3.76	1.48	0.57	.54	1.35	.90	1.10	2.25	3.38
SEASONAL AVERAGE	3.97	2.41	3.6	2.65	1.82	2.06	1.88	1.31	2.87	2.11	2.14	2.58

Contd..

Hour	13	14	15	16	17	18	19	20	21	22	23	24
MAY, 2001	2.05	2.3	5.03	.8	1.43	1.63	4.1	,55	2.05	1.38	6.87	6.36
2002	.1	3.88	.61	1.08	1.65	.2	2.7	6.0	.2	0	23.6	10.0
2003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AVERAGE	1.75	1.45	4.45	.94	1.54	.91	3.4	3.27	1.12	.69	15.2	6.63
JUNE, 2001	9.07	13.07	0.78	1.02	2.9	0.85	2.1	5.8	3.7	11.5	1.2	2.8
2002	.53	1.68	.5	.35	2.87	.5	.15	.23	1.6	2.86	.2	.21
2003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AVERAGE	4.8	7.37	.64	.68	2.88	.67	1.12	3.10	2.65	7.18	.7	1.50
JULY, 2001	0	1.95	2.75	0	21.0	0	2.3	.57	1.56	2.07	2.8	5.65
2002	.11	.84	2.13	2.52	1.58	.74	.15	.77	1.22	2.08	7.85	3.55
2003	1.38	.24	.23	.1	.75	.1	4.4	3.5	24.85	.9	.7	.8
AVERAGE	.49	1.06	1.69	.87	7.77	.28	2.28	1.61	9.21	1.68	3.78	3.33
AUGUST, 2001	.57	.13	.35	.39	.52	2.48	3.55	6.85	4.93	7.4	1.17	4.9
2002	1.73	3.8	3.16	1.28	1.22	.6	.06	.35	2.6	1.83	5.66	1.93
2003	5.25	3.25	3.04	1.58	1.12	2.25	.75	1.13	14.25	.83	4.41	4.61
AVERAGE	2.51	1.25	2.18	1.08	.95	1.99	1.78	2.77	7.26	4.02	2.74	3.81
SEPT, 2001	0	.3	1.85	1.36	4.3	.3	5.3	4.6	3.0	3.15	3.85	1.4
2002	1.25	.53	2.9	3.68	.45	3.6	2.3	1.3	.7	2.25	5.5	2.56
2003	2.35	.8	.65	.5	.6	1.4	.1	0	0	1.5	.7	0
AVEGRAGE	1.2	.54	1.8	1.84	1.78	1.76	2.56	1.96	1.23	2.3	3.35	1.32
SEASONAL AVERAGE	2.15	2.33	2.15	1.08	2.98	1.07	2.90	2.57	4.29	3.17	5.15	3.31