HYDROLOGICAL STUDY FOR MINOR IRRIGATION SCHEME

A thesis submitted towards the partial fulfilment of the requirements for the degree of Master of Engineering in Water Resources and Hydraulic Engineering

Submitted by

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I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of my Master of Engineering in Water Resources & Hydraulic Engineering in the Faculty Council of Inter disciplinary Studies, Law & Management, and Jadavpur University during academic session 2023-24.

All information in this document have been obtained and presented in accordance with academic rules and ethical conduct.

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This foregoing thesis is hereby approved as a credible study of an engineering subject carried out and presented in a manner satisfactorily to warranty its acceptance as a prerequisite to the degree for which it has been submitted. It is understood that by this approval the undersigned do not endorse or approve any statement made or opinion expressed, or conclusion drawn therein but approve the thesis only for purpose for which it has been submitted.

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Abstract

Tripura faces significant surface water deficiency for irrigation, impacting agricultural productivity and sustainability. The state's predominantly hilly terrain and erratic rainfall patterns contribute to challenges in capturing and utilizing surface water effectively. This deficiency hampers crop growth, especially during critical non-monsoon periods, and limits the agricultural potential of the region. Addressing this issue requires innovative solutions such as constructing rainwater storage reservoirs, enhancing water management practices and optimizing the use of available water resources.Constructing rainwater storage reservoirs for minor irrigation schemes in ManikunjCherra, Tripura, addressing both water management and agricultural challenges.The flow in these river varies with season with maximum flow during monsoon.By capturing monsoon rainwater, the reservoirs reduce farmers dependence on erratic monsoon rains,reduce periods of low rainfall or drought thus stabilizing agricultural production and enabling the cultivation of diverse and high-value crops. In the present study we have analyze historical flow data, identify seasonal variations data available from discharge data station to calculate the return period of a hydrological event using Gumbel's method. To determine the capacity of a storage reservoir based on its contour area and contour interval data by GIS by using two types of methods.The runoff coefficient represents the fraction of rainfall that becomes surface runoff to find out design discharge from rainfall data station.Proper selection of design flood value is of great importance also to estimate how much sediment settles and deposits in the reservoir.Estimating evapotranspiration of reservoir by using Penman’s equation to determine how much quantity of water decrease from reservoir throughout the year. A making of rainwater storage reservoir provides a reliable supply of irrigation water throughout the cropping seasons, especially during non-monsoon periods, to ensure consistent crop growth and productivity.

Key words: Irrigation, Agricultural, Monsoon, Productivity, Discharge, Rainfall

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Chapter 1

1.1 Introduction

Water is a precious natural resource. Development of surface as well as ground water for increasing the agricultural production to meet the growing requirement of the country is very important. Despite large scale industrialisation during the plan periods more and more emphasis has been given on increasing agricultural production. It is essential to mobilise all efforts to maximise the productivity of agricultural land. One of the major impediments of full exploitation of the possibility of intensive agriculture is the lack of assured and dependable irrigation water supply throughout the year. The rainfall in large parts of the cropped area is low and uncertain in its distribution. Therefore, there is a strong need for irrigation. The average yield, which is dependent on effective irrigation, is usually low with high fluctuations from year to year. The area under irrigation has increased substantially during the post independence period and construction of a large number of major, medium and minor irrigation projects have contributed to this to a large extent. The minor irrigation schemes provide the farmers with controlled and timely irrigation which the new high yielding varieties of seeds demand. These schemes are labour intensive, less implementation period and involve reasonable investments for their commissioning. As part of various development programmes, innumerable new schemes are being taken up in the states. As the surface water projects alone are not able to meet the full demand of water, farmers install wells and tube-wells in their command area to provide supplementary irrigation. All ground water schemes and surface water schemes (both flow and lift) having culturable command area up to 2000 ha. Individually are classified as minor irrigation schemes. Ground water schemes comprise of dug wells, dug-cum-bore wells, borings, private shallow tubewells, filter points and deep tubewells. It delineates minor irrigation schemes, which encompass both ground and surface water projects, aiming to serve smaller cultivable areas. Groundwater schemes include various types of wells and bore wells, with the state governments providing assistance in their installation, primarily through technical guidance and credit facilities. Surface water schemes encompass structures like tanks and check dams, serving as water conservation and recharge mechanisms, particularly prevalent in hilly regions.The text underscores the grassroots nature of these schemes, with farmers taking on the responsibility of construction, operation, and maintenance, albeit with state support and subsidies, especially for

marginalized farming communities.In essence, the text highlights the vital role of minor irrigation schemes in enhancing agricultural productivity, particularly in areas where rainfall is unreliable, and larger irrigation projects may not be feasible or sufficient. It emphasizes a decentralized approach, empowering local communities to manage and benefit from these schemes.

1.2 Present status of MI scheme scarcity

The status of minor irrigation in India was critically examined by National Commission on Agriculture which found that many State governments publish some information on the number of principal irrigation sources viz. wells,tube wells, tanks, etc. in their agricultural statistics reports but detailed information on irrigation potential created or utilized was not available at all India level. As such a sub-committee on irrigation statistics set up by the Planning Commission in 1970 following the report of the National Commission on Agriculture recommended for conducting detailed census of minor irrigation schemes. The National Commission on Agriculture had recommended that a census of sources of minor irrigation may be undertaken along with the Agricultural Census once in five years. The Technical Committee on Agricultural Census 1980-81 discussed the list of items in respect of data relating to minor irrigation proposed to be collected along with the agricultural census in 1980-81. It was considered that the agricultural census data are being compiled from the existing land records in various States and the information as required for minor irrigation structures do not figure in the land records, and it would not be possible to collect this information through the main agricultural census. While discussing various issues and problems in the irrigation sector in the Planning Commission in 1986, it was stressed that census of minor irrigation schemes be conducted quinquennially, i.e. once every five years to take care of growth in minor irrigation sector and changes in types,capacity, sources of energy, finance etc. Minor irrigation programs in the States are dealt by different departments under different sectors. The progress reports relating to minor irrigation programs received from different departments at the Centre are used for compilation of minor irrigation data for the States concerned.There has not been a single nodal department in the State to compile the minor irrigation statistics for the entire State. The structures installed by the farmers from their own efforts are generally not recorded. The irrigation potential of groundwater schemes is usually reported on the basis of certain assumed yardsticks. Usually no efforts have been made at the State level to provide a scientific basis for such yardsticks.In case of State

irrigation works the irrigation potential and utilisation are usually estimated on the basis of such assumed duties/water allowances.The reported figures of irrigation potential created by certain schemes during a particular period might have been reduced over a period of time but no depreciation etc. has been taken into account in reporting the figures of cumulative irrigation potential created. Alternative Sources of Data are given below:

Land Use Statistics (LUS) of Ministry of Agriculture, which provide information on Gross and Net Area irrigated by season and crops. The information on area irrigated is an ancillary product from the Land Use Statistics as part of Agricultural Statistics ever year. The net area irrigated by the government canals, private canals, tanks,tube wells, other wells and other sources are compiled for village/tehsil/district and the State level. Similarly, area irrigated more than once under different crops are also compiled. The Directorate of Economics and Statistics, Ministry of Agriculture, Government of India publishes regularly the national level information with time lag of about 3 to 4 years

(ii) Periodical Progress Reports from State Government Departments provide financial provision for construction of MI Schemes in the public sector and actual construction of MI Schemes by Government or local bodies.

Annual Administrative Reports compiled by the State Government Departments presented along with budget give details of budget provisions. In certain States there are no field agencies in the minor irrigation department to collect data relating to minor irrigation programs for their annual administrative reports.

Ad-hoc reports prepared by various agencies from time to time on the basis of sample surveys to access the performance of minor irrigation works. Thead-hoc surveys are sometimes intended to throw light upon the socio-economic impact in certain areas for improving agricultural activities etc. The data collected on irrigation works under such surveys have a definite purpose and accordingly the priorities and weightage given to irrigation data for such minor irrigation statistics suffer from several deficiencies between the sets of progressive figures compiled on the basis of these statistics.

Agriculture Census provides information on the basis of records maintained as part of Agricultural Statistics about the number of irrigation sources by type, e.g. Tanks, Wells, Tube Wells in use and out of use by types of social classes and size class of farmers owning these

assets. Agricultural Census also provides data on area irrigated by the different sources of irrigation by social classes as well as by size class of holding of farmers once in five years.

Input survey as part of Agricultural Census is also done on sample basis, under which information on number of MI schemes is also obtained as per use for irrigationalong with cost of irrigation.

Cost of Cultivation Studies(CCS) conducted to estimate the average cost of cultivation of different crops across states by the Agricultural Universities also provide some information on use of minor irrigation schemes and cost of irrigation by different sources by state and by crops. However these data are not available for analysis and further use by the various stake holders for policy purposes.

1.3 Development of Minor Irrigation

Minor Irrigation works are of different sizes and for varying uses and as such are controlled and monitored by different departments and organizations in the state governments. The availability of ground water, its level and terrain varies from region to region and from state to state in this sub-continent. In the plain areas with mainly alluvial soil created over the years by flow of many rivers in the north-central, eastern and north-western part of India generally has plenty of ground water at reasonable depth. These areas are also historically very well developed with a number of major and medium irrigation projects.Due to very high growth of population and very good climate besides plenty of fertile land for growing different crops in all the seasons provided great opportunity for agricultural production and its diversity.In spite of water availability from major and medium irrigation projects ground water based minor irrigation schemes have been taken up in large numbers in this area. In the Southern tropical region with older but not so high mountains and plateau region with coastal areas on the two sides of the peninsula south of Vindhyachal ranges, the availability of ground water is limited. There are significant forest areas in central India and in the Eastern and Western Ghats with uneven terrain and very few perennial rivers. As such in Southern and Central states, mainly pond/reservoir based surface water schemes have been constructed/used by farmers. There has been some development in major and medium irrigation projects also in this part, still with better technologies available to extract water from deep aquifers and availability of irrigation through pipes.

Chapter 2

Literature review

There are various studies have been made to minor irrigation scheme of the water distribution system to irrigate command area. Literature review helps to understand the summary of related subject. Some case studies are described given below to review an idea about minor irrigation scheme, efficiency, cost effictiveness and economical design structures for irrigation to provide best result for farmers.

Joseph*et al*. (2023) discussed about Surface water minor irrigation schemes are critical for sustaining agricultural activities in regions like Kerala, India, where water availability significantly impacts crop production. This literature review evaluates the effectiveness of such irrigation schemes through the lens of performance indicators. By synthesizing existing research, the study aims to provide insights into the efficiency, sustainability, and overall performance of these systems. Through an analysis of performance indicators, including but not limited to water use efficiency, crop productivity, and environmental impact, the review identifies key areas of success and areas requiring improvement in the management and implementation of surface water minor irrigation schemes. The findings of this review contribute to a better understanding of how these schemes impact agricultural practices and water resource management in the context of Kerala, India.

W. Ray Norman (1998) examines the transformation in land tenure and utilization over three decades of small irrigation system operation in the Sahel region. Focusing on a case study, the review explores the evolution of land ownership patterns, cropping practices, and socio-economic dynamics influenced by the implementation and operation of small-scale irrigation systems. Through a comprehensive analysis of existing literature, the study elucidates the impact of irrigation on land tenure systems, agricultural productivity, and livelihoods in the Sahelian context. By identifying shifts in land use and tenure arrangements, the review provides valuable insights into the long-term implications of small irrigation systems on rural communities and sustainable agricultural development in the Sahel.

D. Madan Mohan (2018) investigates the effects of minor irrigation schemes in the state of Telangana. With a focus on empirical studies and data analysis, the review aims to analyze the impact of minor irrigation schemes on agricultural productivity, water resource management, and rural livelihoods in Telangana. Through a comprehensive examination of existing research, the study explores the strengths, weaknesses, opportunities, and threats associated with the implementation and operation of minor irrigation schemes in the region. By synthesizing findings from various sources, the review provides insights into the socio-economic, environmental, and institutional aspects of minor irrigation development in Telangana. The outcomes of this study contribute to a better understanding of the effectiveness and challenges of minor irrigation interventions, informing policy and decision-making processes for sustainable water resource management and agricultural development in the state.

Radha Rani Kothakalla (2013) explores the development and policy framework surrounding minor irrigation systems utilizing modern technologies and various water sources in Andhra Pradesh. Focusing on empirical studies, policy documents, and government reports, the review aims to analyze the trajectory of minor irrigation development, including canal-based, tank-based, and groundwater-based systems. By examining the evolution of policies and interventions, the study seeks to assess their effectiveness in promoting sustainable water use, agricultural productivity, and rural livelihoods in Andhra Pradesh. Through a comprehensive synthesis of existing literature, the review identifies key challenges and opportunities in minor irrigation development and recommends strategies for enhancing the efficiency and equity of irrigation systems in the state. The findings of this review contribute to the understanding of minor irrigation policies and practices, facilitating evidence-based decision-making for agricultural development and water resource management in Andhra Pradesh.

Mishra*et. al*. (2009) conducts an impact assessment of the rehabilitation and irrigation management transfer (IMT) initiatives implemented in the minor irrigation systems of Orissa, India. Utilizing empirical data, policy analysis, and stakeholder interviews, the assessment aims to evaluate the effectiveness and outcomes of these interventions on the performance, sustainability, and equity of minor irrigation systems in the region. The study

examines the socio-economic, institutional, and environmental impacts of rehabilitation and IMT, considering factors such as water availability, agricultural productivity, livelihoods, and governance structures. Through a comprehensive analysis, the assessment identifies strengths, weaknesses, opportunities, and challenges associated with the implementation of rehabilitation and IMT measures in Orissa. The findings of this study provide insights into the factors influencing the success or failure of such interventions, informing policy decisions and management strategies for sustainable water resource management and agricultural development in the state.

A.K.Koshta & M.R.Chandrakar (2005) said that assess the economic returns from investment in minor irrigation projects in the rainfed farming areas of Raipur District, Chhattisgarh State. Utilizing empirical data, economic analysis, and stakeholder consultations, the study evaluates the financial viability and socio-economic impacts of investing in minor irrigation infrastructure in rainfed agricultural regions. By considering factors such as crop yields, water availability, input costs, and market prices, the analysis estimates the return on investment and evaluates its implications for farm income, livelihoods, and rural development. The findings of this study contribute to understanding the potential benefits and challenges of investing in minor irrigation projects in rainfed areas, informing policymakers, practitioners, and farmers about the economic feasibility and potential outcomes of such interventions in Chhattisgarh State.

Md. Mosarof Hossain (2014) conducts a comprehensive performance evaluation of various modes of minor irrigation in the Lower Meghna River floodplain. Utilizing empirical data, field observations, and stakeholder consultations, the evaluation aims to assess the effectiveness, efficiency, and sustainability of different irrigation methods employed in the region. By comparing traditional methods with modern technologies, such as drip irrigation, sprinkler irrigation, and canal-based systems, the study analyzes factors such as water use efficiency, crop productivity, economic viability, and environmental impact. Through a thorough examination of irrigation practices and their outcomes, the evaluation provides insights into the strengths, weaknesses, opportunities, and challenges associated with different modes of minor irrigation in the Lower Meghna River floodplain.

The findings of this study contribute to enhancing the understanding of irrigation management practices and informing policy decisions for sustainable water resource management and agricultural development in the region.

Oh Ho-Sung (1976) investigates the customary rules of water management governing small irrigation reservoirs in Koria. Through ethnographic research, interviews with local communities, and analysis of historical documents, the study aims to elucidate the traditional practices and indigenous knowledge systems that regulate water use, allocation, and distribution in small reservoirs for agricultural purposes. By documenting the customary rules and norms established by local communities over generations, the study explores the socio-cultural, economic, and ecological dimensions of water management in Koria. Furthermore, it examines the resilience and adaptability of these customary rules in the face of environmental changes and modernization pressures. The findings of this research contribute to understanding the role of customary institutions in sustainable water resource management and provide insights for policymakers and practitioners seeking to integrate traditional knowledge into contemporary water governance frameworks.

Tripathi*et. al*.(2018) presents a performance evaluation of a minor irrigation project utilizing canal performance indicators. By employing empirical data, field assessments, and stakeholder consultations, the evaluation aims to gauge the effectiveness, efficiency, and sustainability of the irrigation project. Through the application of canal performance indicators such as water delivery ratio, water distribution uniformity, and conveyance efficiency, the study assesses the project's ability to meet irrigation demands, optimize water use, and minimize losses. Furthermore, the evaluation considers socio-economic factors, environmental impacts, and institutional arrangements to provide a comprehensive analysis of the project's performance. The findings of this study contribute to enhancing our understanding of minor irrigation project management and provide insights for improving irrigation system design, operation, and maintenance.

P.B. Dharmasena (1996) explores planning strategies for crop diversification within minor irrigation schemes. By synthesizing existing literature, empirical data, and stakeholder consultations, the study aims to identify effective strategies for promoting crop

diversification in areas served by minor irrigation systems. The research assesses various factors influencing crop choice, including soil type, water availability, market demand, and agro-climatic conditions. Additionally, the study examines policy frameworks, institutional mechanisms, and farmer preferences to develop comprehensive planning strategies. By integrating agronomic, economic, and socio-cultural considerations, the study provides insights into optimizing crop diversification efforts within minor irrigation schemes. The findings contribute to enhancing agricultural productivity, resilience, and sustainability in regions dependent on minor irrigation for crop production.

Dr. Santosh S. Pharande (2022) examines the role of minor irrigation projects in driving agricultural development within Satara District. Utilizing empirical data, stakeholder interviews, and policy analysis, the research aims to assess the impact of minor irrigation interventions on agricultural productivity, water resource management, and rural livelihoods. By evaluating the implementation, performance, and outcomes of these projects, the study seeks to elucidate their contributions to enhancing crop yields, diversification, and income generation opportunities for farmers in Satara District. Additionally, the research explores the socio-economic, environmental, and institutional factors influencing the effectiveness of minor irrigation initiatives. The findings of this study provide insights into the significance of minor irrigation projects in fostering sustainable agricultural development and inform future policy decisions and resource allocation strategies in Satara District.

Mishra*et. al*.(2008) investigates the optimal size of auxiliary storage reservoirs for rainwater harvesting and enhanced crop planning within a minor irrigation project. By employing hydrological modeling, economic analysis, and crop yield simulation, the research aims to identify the most suitable reservoir capacity to maximize water availability during dry periods and optimize agricultural production throughout the cropping season. Through the integration of rainfall data, soil moisture dynamics, and crop water requirements, the study evaluates the potential benefits of different reservoir sizes in improving irrigation efficiency, mitigating water scarcity, and enhancing crop yields. Additionally, the research considers socio-economic factors, such as farm size, cropping patterns, and resource constraints, to develop practical guidelines for reservoir sizing and

crop planning strategies within the context of minor irrigation projects. The findings of this study contribute to enhancing water resource management and agricultural sustainability in regions reliant on rainfed agriculture and minor irrigation systems.

Abdul Haque Ahmed, **Bipul Kumar Rabha (2014)** investigates the irrigation potential and agricultural transformation facilitated by the Deosila Minor Irrigation Project in Goalpara District, Assam. Through empirical data collection, field surveys, and stakeholder interviews, the study aims to assess the impact of the irrigation project on agricultural productivity, cropping patterns, and rural livelihoods in the region. By analyzing factors such as water availability, land use changes, crop diversification, and socio-economic indicators, the research elucidates the role of the irrigation project in transforming traditional rainfed agriculture into a more resilient and productive farming system. Additionally, the study examines the institutional arrangements, policy frameworks, and community participation mechanisms that have contributed to the success of the project. The findings of this case study provide valuable insights into the potential of minor irrigation projects to enhance agricultural development and livelihood security in Assam and similar regions.

K. Madhava Chandran, G. K. Ambili (2016) conducts an evaluation of minor irrigation schemes in South India utilizing performance indicators. Through case studies and empirical data analysis, the research aims to assess the effectiveness, efficiency, and sustainability of various minor irrigation projects in the region. By employing performance indicators such as water use efficiency, crop productivity, infrastructure maintenance, and socioeconomic impacts, the study provides insights into the performance of these schemes. The research examines the strengths, weaknesses, opportunities, and challenges associated with the implementation and management of minor irrigation projects in South India. By synthesizing case studies, the study offers valuable lessons and recommendations for improving the design, operation, and outcomes of minor irrigation schemes to enhance agricultural productivity and rural livelihoods in the region.

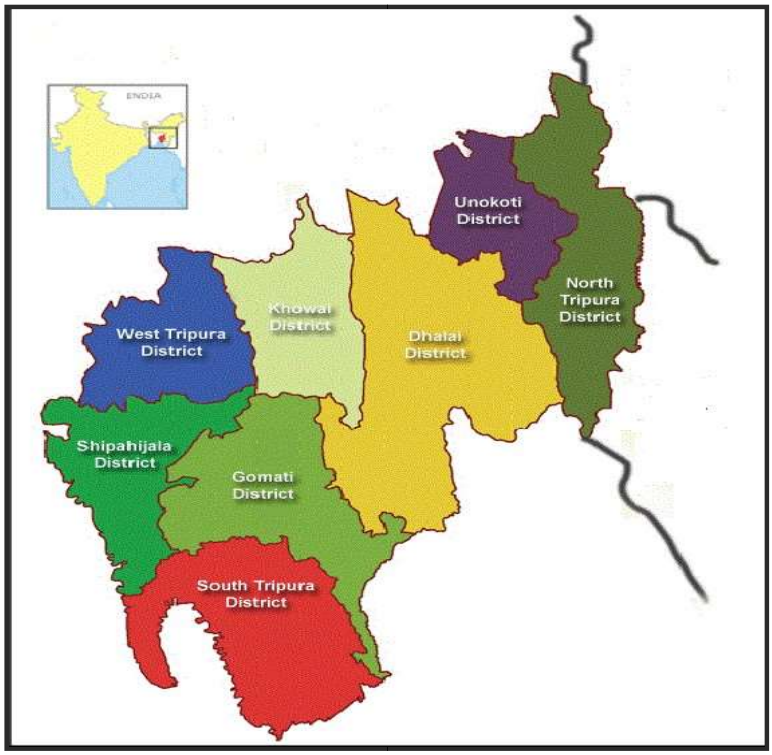
Mishra*et al*.(2013) presents a performance evaluation of a rehabilitated minor irrigation project and the augmentation of its water resource through a secondary storage reservoir. Through empirical data analysis, field assessments, and stakeholder consultations, the study aims to assess the effectiveness, efficiency, and sustainability of the rehabilitated irrigation project. Additionally, it evaluates the impact of augmenting water resources through the construction of a secondary storage reservoir on irrigation outcomes. By comparing pre-rehabilitation and post-augmentation data, the study provides insights into the project's ability to meet irrigation demands, optimize water use, and enhance agricultural productivity. Furthermore, socio-economic factors, environmental considerations, and institutional arrangements are analyzed to provide a comprehensive assessment of the project's performance. The findings of this study contribute to understanding the effectiveness of rehabilitation and augmentation strategies in improving irrigation infrastructure and water resource management in minor irrigation projects.

Chapter 3

3.1 Objective of the study

- Analyze historical flow data, identify seasonal variations, and determine maximum flow during the monsoon season.
- Develop design plans for rainwater storage reservoirs tailored for minor irrigation purposes.
- Calculate the required storage capacity of reservoirs based on rainfall patterns and water demand for irrigation.
- Consider the size of the agricultural area served when determining capacity needs.
- Implement strategies to prevent siltation and sedimentation in reservoirs.

3.2 Study area



Tripura lies in the north-eastern part of India between 22^0 56' N and 24^0 32' N latitude and 90^0 09' E and 92^0 20' E longitude. The geographical area of the state is about 10,491.69 sq. km. The state consists of eight districts viz. West Tripura, North Tripura, South Tripura, Dhalai, Unakoti, Gomati, Khowai and Sipahijala. The state has parallel hills running from north west to south eastand intermittent narrow to moderate flat valleys.The state has a sub-tropical climate and receives seasonal heavy rains from the south west monsoon. All the rivers in the state originates from the hills. Some of the major rivers in the state are the

Gumti, the Dhalai, the Haora, the Manu, the Khowai, the Muhari etc. The flow in these rivers varies with the season with maximum flow during monsoon.About half of Tripura's land area is under forest cover. The major crop is rice, which is grown throughout the state.

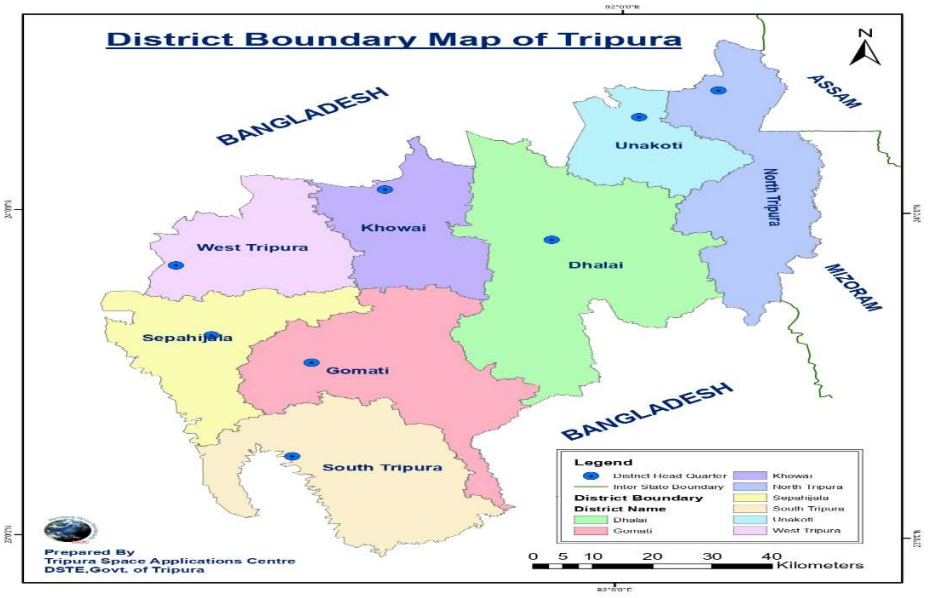


Figure 1 : Map of Tripura State

The Manikunj MI Scheme is proposed to be located in the Dinakobra ADC village, Mandai block of West Tripura district. The scheme is situated on the Manikunj Chhera which is one of the tributaries of the Haora River. There are no existing stream gauge stations on the river.



Figure 2 :Manikunj Cherra River

Chapter 4

4.1 Methodology of the study

To achieve the constructing rainwater storage reservoirs for minor irrigation schemes in Manikunj Cherra, Tripura state, the following steps can be taken:

Site Selection and Survey: Identify suitable locations along the Manikunj Cherra river for constructing rainwater storage reservoirs. Consider factors such as topography, soil type, availability of land, and proximity to agricultural areas.

Hydrological Analysis: Conduct a thorough hydrological analysis of the Manikunj Cherra river to understand its flow patterns throughout the year. This analysis should include studying historical flow data, seasonal variations, and maximum flow during the monsoon season.

Design of Capacity Reservoirs: Develop design plans for the rainwater storage reservoirs based on the hydrological analysis and the intended purpose of minor irrigation. The design should account for capturing and storing maximum rainwater during the monsoon season while ensuring efficient utilization during non-monsoon periods.

Capacity Planning: Determine the storage capacity required for the reservoirs based on the anticipated rainfall patterns, water demand for irrigation during non-monsoon seasons, and the size of the agricultural area to be served.

Water Management Infrastructure: Install necessary infrastructure such as inlet structures, outlet structures, and distribution channels to manage water inflow, outflow, and distribution to the irrigation schemes.

Siltation Management: Implement measures to prevent siltation and sedimentation within the reservoirs, which can reduce storage capacity over time. This may include periodic dredging and sediment removal.

By following these steps, the constructing rainwater storage reservoirs for minor irrigation schemes in Manikunj Cherra can be achieved, allowing for the efficient utilization of rainwater during the monsoon season to support agricultural activities during non-monsoon periods.

Chapter 5

5.1 Data Collection& Review

Storage reservoirs are planned to provide a consistent supply of irrigation water to the farms over the cropping seasons in general and during non-monsoon period in particular. In order to design reservoir capacity and to meet up successful irrigation demand it is very essential to know the crop water requirement of the project area. The water demand of any crop depends upon a number of factors such as climate, type of soil, cropping pattern, intensity of irrigation etc.

5.2 Command Area

The command area of the scheme lies in the foothill area. Due to undulated terrain, it is proposed to convey water to Outlet level through canal irrigation network. Distribution of water to the chaks may be done through Field Channels. The assessment of the CCA has been done on the basis of the following parameters:

- Assessment of available command area through Google Earth imagery and DEM.
- Assessment of annual water availability.
- Iterative water balance studies.
- Feasible layout of Canal network and number of cross-drainage structures.
- The available project GCA for this scheme is 350 ha as per Google Earth imagery and DEM and projected CCA 320 ha.

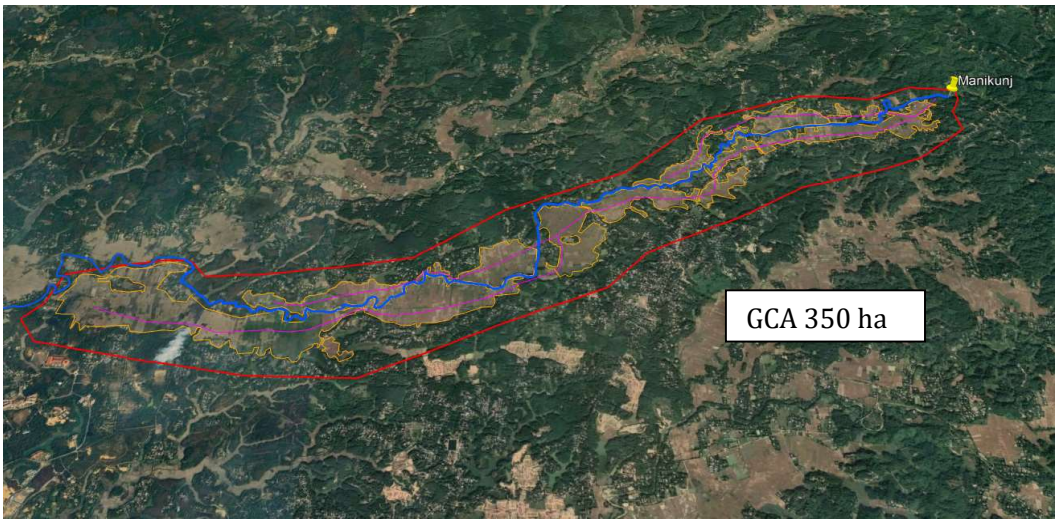


Fig 3: Gross Command Area

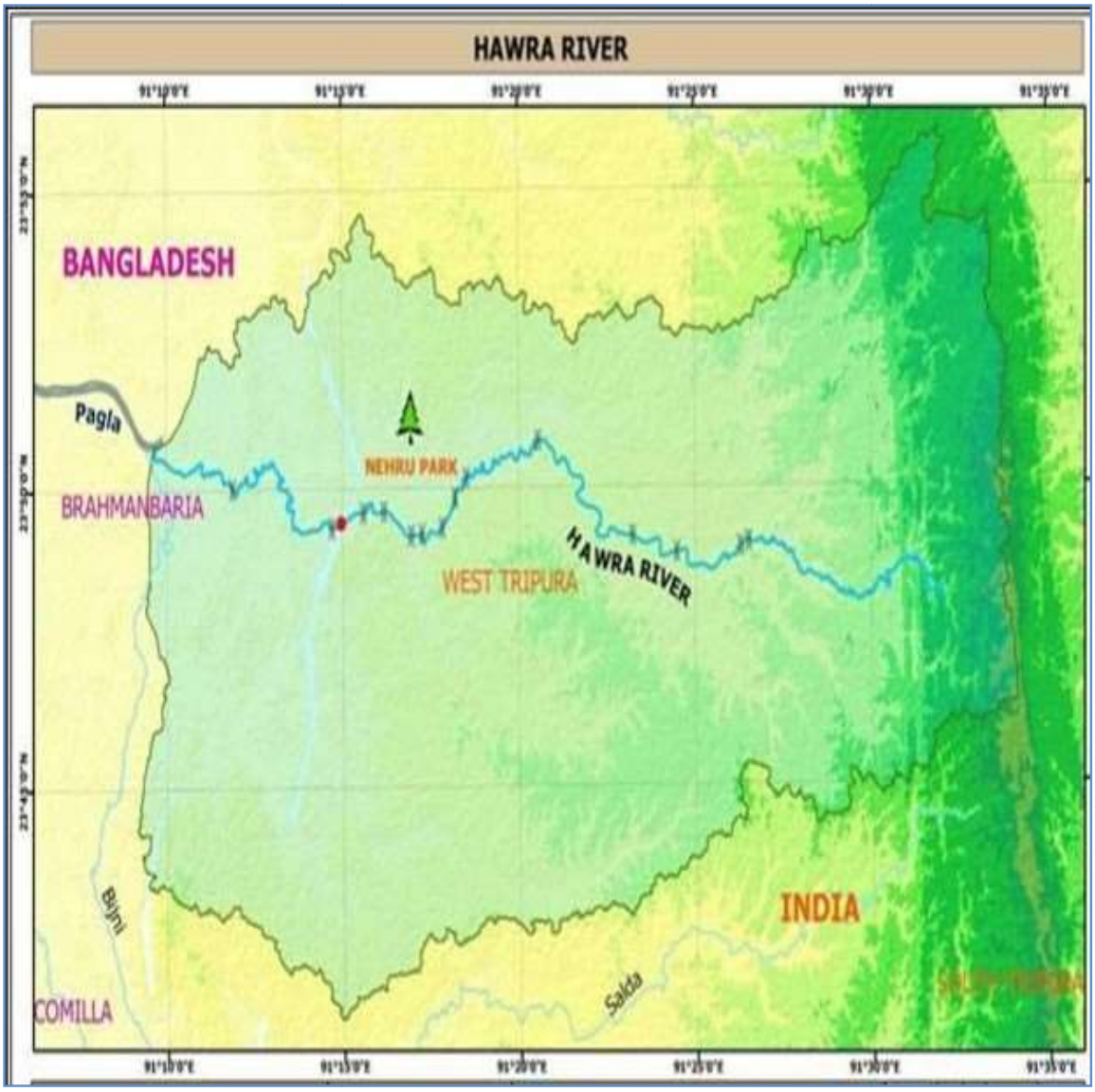


Fig 4: Picture of Hawra River

5.3 Rainfall

Analyzing rainfall patterns in Tripura district is indeed crucial for effective crop planning, especially in rainfed agricultural systems where crop yields heavily depend on precipitation. Here's a structured approach to integrating rainfall analysis into crop planning: rainfall data for Tripura district spanning several years. This data will provide insights into the typical rainfall pattern, including average monthly rainfall, seasonal variations, and any trends or anomalies.Monthly Rainfall Data for Seven Districts of Tripura. Data available for West Tripura district in particular is tabulated below

No.	Raingauge Stations	Frequency of Data	Length of data available year		Remarks
			From	To	
1.	Sadar	Monthly	1990	2021	collected from IMD, Pune and Agricultural Deptt. GoT.
2.	Jirania	Monthly	2003	2021	

Table 1: Data Available for West Tripura District

Rainfall data of Sadar Station:

Month / Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total annual rainfall in mm
1990	0	42.9	344.8	310.2	345.7	234.9	282.1	215.1	179.2	222.4	43.1	18.4	2238.8
1991	30.2	25.1	106.5	236.4	564.8	420.5	263.4	270.6	392.7	480.1	25.4	68	2883.7
1992	0	119	0	81	237.9	275.8	321.2	137.3	179	166	2	0	1519.2
1993	0	209.1	56.5	142.5	548.1	466	532	154.6	302.8	102	14	0	2527.6
1994	11.8	41.8	112.7	160.9	162.3	219.6	134.4	184.9	68.4	100.4	8	0	1205.2
1995	5.9	35.2	18.4	95.2	296.8	428.1	297.7	390.6	182.3	135	127.4	0	2012.6
1996	0	15.4	143.6	125	331.8	426.5	343.4	171.7	204	258.3	0	0	2019.7
1997	3.6	59.86	109	103.5	171.9	431	596	215	293.2	81	55	27	2146.06
1998	32.8	50.2	261.2	242.6	331.2	97.8	776.5	151.1	124.9	81.2	93.6	0	2243.1
1999	0	0	39.8	2.2	267	230.1	457.4	231.6	89.5	192.1	4.6	0	1514.3
2000	29.8	21.1	134.2	187.6	286.2	224.7	139.8	261.6	137	72.9	0	0	1494.9
2001	0	26	11	58.5	357.6	529.4	91.6	197.6	357.7	174	74.1	0	1877.5
2002	9	0	83	101.9	272	526	696.9	293.9	227.4	84	144.1	0	2438.2

2003	0	15.8	48.7	233.4	458.6	779.8	278.9	98.4	293	187.3	0	65.8	2459.7
2004	1.8	14.2	4.6	386.8	199.6	672.9	559.7	215.3	496	224.6	0	0	2775.5
2005	0	0	92	144.7	335.8	182.6	337.1	390.4	350.7	244.2	0	0	2077.5
2006	0	0	0	146.2	550.2	313.6	156.8	333.2	213.2	120.8	1.8	0	1835.8
2007	0	42	9.8	279.3	258	713	715.8	230.5	217.6	245.8	108	0	2819.8
2008	43	37	75	30.5	254.8	212.3	406.4	228	157.9	203.4	0	0	1648.3
2009	0	9.5	15.3	38.7	239.7	217.4	485.8	363.1	219	132.6	0	0	1721.1
2010	0	0	147.2	181.6	525.8	401.6	128.2	214	190.3	303	1.1	46	2138.8
2011	0	0	34	73.1	229.2	300.1	240.5	351.7	152.4	0	0	0	1381
2012	1.3	1.8	5	198	145.9	363.7	295.6	454.6	137.4	103.4	0	0	1706.7
2013	0	9.1	4	91.1	728.6	190.8	187.8	194.7	294.9	165	0	0	1866
2014	0	9.6	15	80.1	249.9	448.3	161.5	391.5	251.4	89.9	0	0	1697.2
2015	0	7	7.7	301.1	298.9	300.1	623	272.2	179	209.1	1.2	3.6	2202.9
2016	0	8	110.6	145.7	401.4	143.9	372.6	158.9	139.2	98	206.7	0	1785
2017	0	13	169.7	283.5	178.7	539.1	368.6	571.8	549.2	298.3	1.6	101.8	3075.3
2018	0	9.1	28.4	172	558	444.9	215	160.7	83.2	46.9	21	23.5	1762.7
2019	0	79.8	31	192.9	234.5	297.8	617.7	164	140.5	158.6	38.9	4.1	1959.8
2020	16.6	0	2.3	117.2	278.2	513.5	387.7	241.4	394	195.1	29	0	2175
2021	2.3	0	26.6	4.8	221.8	261.9	423.9	255	208.3	159.9	11.4	140.3	1716.2

Table 2: Rainfall data of Sadar Station

Rainfall data of Jirania Station:

Month/ Year	January	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec	Total rainfall mm
2003	0	0	16	160.4	419	651.6	292.8	121.2	215.6	199.4	0	84.6	2160.6
2004	0	0	0	403	219.6	685.7	481.6	188.2	572.8	116.6	0	0	2667.5
2005	0	13.2	167.4	191	617.7	106.6	401.4	388.8	271.2	219.6	0	0	2376.9
2006	0	0	0	238.6	461.6	506.3	152.3	241.1	293.8	93.6	0	0	1987.3
2007	6.62	10.46	32.12	142.82	319.62	365.92	649.2	283.4	298.1	70.4	96.6	0	2275.26
2008	56	15	16.2	8.5	107.4	250.2	276	235.4	87	153	0	0	1204.7
2009	0	5.2	4	23.4	248.4	257.8	494.2	463.8	242.4	168.4	0	0	1907.6
2010	0	38	51.4	167.8	525.8	424	171.5	209.3	199.8	229.8	0	0	2017.4
2011	0	0	21.6	28.2	285.5	344.5	163.5	406.8	93.1	0	0	0	1343.2
2012	48	4	0	217.5	199.4	385.1	212.9	251.9	63.2	62	35.2	0	1479.2
2013	0	10	0	0	107	256.8	138.1	127.2	186.7	87	0	0	912.8
2014	0	7.2	14.2	93.3	334.7	338.2	125.9	282.7	276.8	94.1	0	0	1567.1
2015	0	5.2	9.6	280.8	290.2	269.1	538.5	293.1	280.6	104.2	0	5	2076.3
2016	0	13	89.6	122.3	361.4	182.6	244.3	136.5	206.4	87.2	57.4	0	1500.7
2017	0	13	108	236	153.6	504.1	331.4	398.7	455.5	243.2	0	64	2507.5
2018	0	8.2	28.2	149.2	661.6	521.5	202	228.7	108.5	53.7	19	25	2005.6
2019	0	56.3	31	129	242	256	451.5	214.7	221.5	93.4	39.5	9.1	1744
2020	15.1	0	0	101.7	293.3	346.9	383.4	153.8	372.2	199	18.3	0	1883.7
2021	0	0	21	20	225	299.5	316.7	184.2	209	148	8.5	131.3	1563.2

Table 3: Rainfall data of Jirania Station

5.4 Contour

The purpose of contour data was to calculate the storage of reservoir for predicting more accurate in more difficult conditions and peak time intervals.Having accurate contour data for the reservoir can indeed be crucial for predicting storage capacity, especially during peak demand periods or under challenging conditions.Conduct a survey of the reservoir area to gather contour data directly. This may involve using surveying equipment such as total stations or GPS devices to measure elevations at various points around the reservoir.Utilize satellite imagery and digital elevation models (DEMs) to estimate contour data. Services like Google Earth or specialized GIS software can provide elevation

information that use to approximate contour lines. Access existing topographic maps of the area. These maps often include contour lines indicating changes in elevation, which can be useful for estimating reservoir storage capacity

Sl No.	Contour	Contour Area (sq m)
1	59	209.72
2	59.5	793.92
3	60	1846.75
4	60.5	2032.86
5	61	2057.72
6	61.5	4841.35
7	62	4542.61
8	62.5	4570.01
9	63	6761.49
10	63.5	6350.04
11	64	7926.94
12	64.5	11626.02
13	65	15358.68
14	65.5	17469.55
15	66	18130.84
16	66.5	23490.33
17	67	25408.55
18	67.5	21689.27
19	68	23223.06
20	68.5	32047.26
21	69	26061.65
22	69.5	26245
23	70	27677.15
24	70.5	33012.4
25	71	28157.79
26	71.5	27530.58
27	72	34944.29
28	72.5	29130.66
29	73	31831.68
30	73.5	29213.76
31	74	29339.54
32	74.5	28991.22
33	75	29008.35
34	75.5	29950.52
35	76	32502.2

Table 4: Contour Data for Storage Reservoir

5.5 Regional Geomorphology and Geology

Tripura is characterized by a series of ridges and valleys.These landforms primarily trend in a north-south (NS) to north-northwest to south-southeast (NNW-SSE) direction.The formation of these ridges and valleys is influenced by both geological structures and lithology.The geological formations in Tripura consist mainly of younger sedimentary rocks. These sedimentary rocks belong to the Miocene to Pliocene age.The prominent geological groups include the Surma Group, Tipam Group, and Dupitala Group.In addition to the sedimentary rocks, Tripura also has Quaternary deposits.These deposits include alluvium, colluvium, slopewash material (scree/talus), and laterite/latosol (lateritic soil).Quaternary deposits typically form the surficial cover of the region.The rocks of the above Groups are mainly sandstone and shale. The rocks have undergone folding tectonism along N-S axis. As a result, repetitive sequence of sandstone and shale occur along north-south trending ridges and valleys.

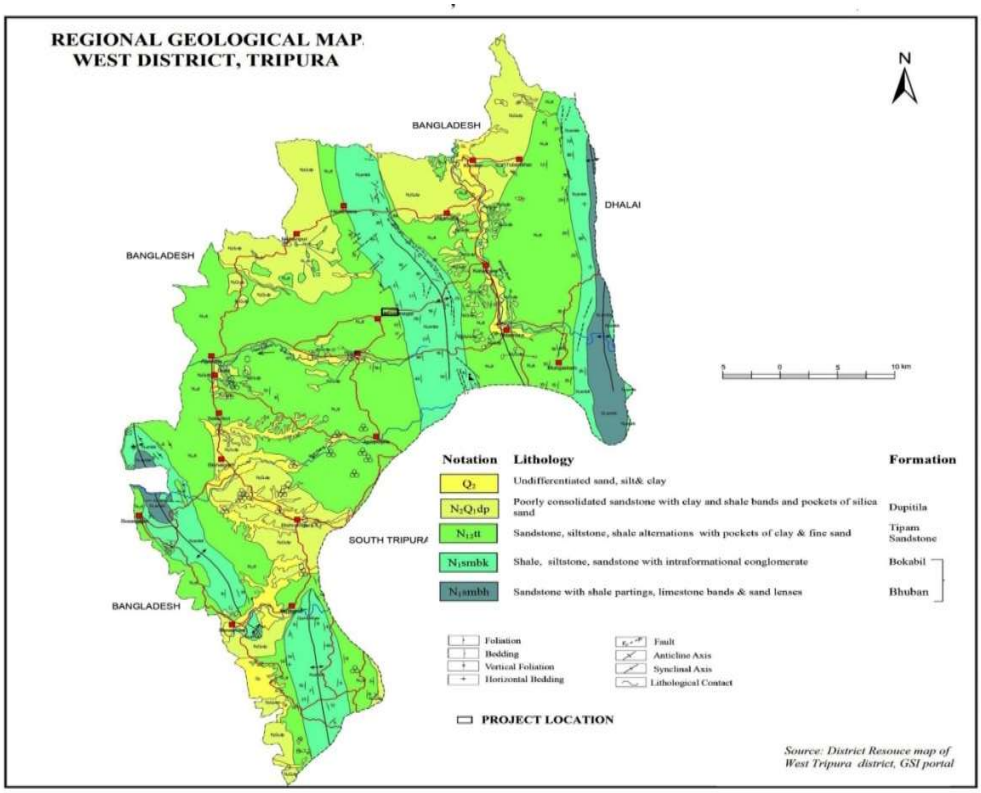


Fig 5: Regional Geological map of Tripura

5.6 Relative Humidity

The relative humidity of Tripura, like any region, can vary throughout the year and even within a single day due to factors such as temperature, proximity to water bodies, and prevailing weather patterns. Generally, Tripura, being in the northeastern part of India, experiences a humid subtropical climate with high humidity levels, especially during the monsoon season. During the summer months, relative humidity can be relatively high, often exceeding 70-80% or even higher, especially in the mornings and evenings when temperatures are lower. In the monsoon season, which typically lasts from June to September, humidity levels are particularly high due to frequent rainfall and moisture-laden air masses. In the winter months, relative humidity may decrease slightly, but it still tends to remain relatively high compared to many other parts of India due to the region's proximity to the Bay of Bengal and its lush vegetation.

RELATIVE HUMIDITY	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	2011	70.44	56.62	54.56	59.69	80.94	88.5	88.06	91.12	89.94	85.62	71.69	64.62
	2012	58.06	41.06	45.5	73.06	78.88	88.69	88.69	90.75	92.69	89.94	80.88	68.25
	2013	506	45.38	48.75	58.56	87.31	90	88.94	90.69	91.75	90.19	84.69	73.56
	2014	65.56	54.06	47.31	52.06	74.56	88.81	88.81	90.19	89.88	86.19	80.88	70.94
	2015	63.06	53	47.31	79.88	86.62	89.56	91.94	90.94	90.19	87.5	81.88	71.62
	2016	61.06	61.5	57.88	79.19	84.5	89.25	90.5	90.06	92.12	89.19	86.5	83.62
	2017	68.5	58.81	71.19	86	87.88	92.12	91.5	91.19	92.06	89.06	85.69	84.62
	2018	79.44	76	64.12	76.12	88.44	91.5	89.75	89.88	89.81	85.44	78.5	68.44
	2019	58.06	56.94	59.56	70.94	81	89.62	90.94	89.88	90.94	89.81	86.12	84.06
	2020	80.19	64.81	55.38	68.75	84.19	91.19	90.88	90.69	91.38	90.56	85.94	83.38
Monthly Average Value		66.04	56.82	55.16	70.43	83.43	89.92	90	90.54	91.08	88.35	82.28	75.31
Maximum Value		80.19	76	71.19	86	88.44	92.12	91.94	91.19	92.69	90.56	86.5	84.62

Table 5:Relative Humidity (%) Data for West Tripura District

5.7 Wind Speed

The wind speed in Tripura, like relative humidity, can vary based on factors such as location, time of year, and prevailing weather systems. Tripura, being in the northeastern part of India, generally experiences a variety of wind patterns influenced by regional climate dynamics.During the monsoon season (June to September), wind speeds can be relatively lower, especially during periods of heavy rainfall and calm weather associated with the monsoon. However, gusty winds and occasional storms can also occur during this time, particularly if cyclonic systems affect the region.In the post-monsoon and winter months (October to February), wind speeds may vary depending on local weather conditions. Calm winds can prevail during clear, dry days, while stronger winds may occur during frontal passages or other weather disturbances.In the spring months (March to May), as temperatures rise in the buildup to the monsoon, local wind patterns may become more variable. Some days may experience moderate to strong winds, while others may be relatively calm.

WINDSPEED	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	2011	0.3	0.27	0.14	0.09	0.04	0.05	0.04	0.05	0.05	0.2	0.27	0.22
	2012	0.2	0.29	0.11	0.05	0.06	0.03	0.03	0.03	0.05	0.09	0.25	0.29
	2013	0.26	0.17	0.1	0.04	0.03	0.03	0.03	0.03	0.07	0.12	0.31	0.35
	2014	0.3	0.23	0.2	0.09	0.04	0.03	0.05	0.04	0.05	0.2	0.35	0.34
	2015	0.3	0.28	0.22	0.08	0.05	0.03	0.03	0.04	0.07	0.17	0.33	0.34
	2016	0.38	0.23	0.14	0.03	0.05	0.02	0.03	0.04	0.06	0.16	0.28	0.38
	2017	0.39	0.31	0.18	0.07	0.06	0.03	0.03	0.03	0.06	0.15	0.27	0.34
	2018	0.38	0.3	0.22	0.1	0.05	0.04	0.03	0.05	0.09	0.18	0.32	0.37
	2019	0.38	0.28	0.2	0.13	0.04	0.04	0.03	0.05	0.07	0.15	0.31	0.35
	2020	0.33	0.3	0.21	0.09	0.08	0.03	0.03	0.04	0.06	0.12	0.28	0.4
Monthly Average		0.32	0.27	0.17	0.08	0.05	0.03	0.03	0.04	0.06	0.15	0.3	0.34

Table 6: Wind Speed (m/s) Data for West Tripura District

5.8 Temperature

The temperature in Tripura, like in many regions, varies throughout the year due to seasonal changes and other factors. Tripura, located in northeastern India, generally experiences a humid subtropical climate with relatively high temperatures and humidity levels.In Summer (March to June)months, temperatures in Tripura can be quite warm to hot.Daytime temperatures often range from 30°C to 35°C (86°F to 95°F) or higher, especially in April and May, which are typically the hottest months.Nighttime temperatures may cool down but can still remain relatively warm, usually ranging from 20°C to 25°C (68°F to 77°F).The onset of the monsoon season (June to September) brings relief from the heat but also increases humidity levels.Daytime temperatures may moderate slightly, ranging from 28°C to 32°C (82°F to 90°F) on average.Heavy rainfall during this period can help keep temperatures lower, but humidity levels tend to be high.Post-Monsoon (October to November) season, temperatures gradually start to decrease.Daytime temperatures typically range from 25°C to 30°C (77°F to 86°F), with cooler nights ranging from 18°C to 22°C (64°F to 72°F).Winter (December to February) in Tripura is generally mild, but temperatures can still drop, especially during the night.Daytime temperatures usually range from 20°C to 25°C (68°F to 77°F).Nighttime temperatures can drop to around 10°C to 15°C (50°F to 59°F) or lower in some areas.These temperature ranges are approximate and can vary from year to year based on local weather conditions, elevation, and other factors.

	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Temperature at 2m Max. (°C)	2011	27.22	31.85	35.34	37.55	35.57	33.33	33.53	34.09	33.08	32.17	30.84	30.19
	2012	28.9	34.14	38.01	38.14	35.87	33.94	33.6	32.83	31.52	30.5	29.29	27.09
	2013	28.97	34.61	36.56	39.33	36.69	34.3	33.73	32.86	32.02	31.26	28.55	28
	2014	29.82	31.66	38.89	40.44	38.64	34.39	33.33	32.97	32.25	31.51	29.2	28.01
	2015	29.17	32.51	36.54	33.91	33.9	33.12	32.52	32.22	32.35	30.78	28.25	27.49
	2016	27.39	33.24	36.69	35.66	35.05	34.24	33.36	32.79	31.56	31.49	29.83	26.2
	2017	28.36	31.11	32.38	32.19	33.17	32.95	32.45	32.66	31.81	31.8	28.76	26.32
	2018	24.28	30.17	34.61	35.42	33.25	32.64	34.67	33.5	32.62	31.01	28.8	28.04
	2019	30.29	31.58	35.01	37.75	36.33	34.56	34.06	33.66	32.45	30.41	28.61	26.28

	2020	25.4	30.37	36.61	37.88	33.95	33.66	33.58	33.65	33.65	32.04	29.24	26.25
Average Monthly Max.		27.98	32.12	36.06	36.83	35.24	33.71	33.48	33.12	32.33	31.3	29.14	27.39
	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Temperature at 2m Min. (°C)	2011	7.61	11.31	13.39	18.71	22.67	23.29	23.65	23.05	22.67	17.71	15.5	9.15
	2012	8.87	9.83	16.09	19.26	21.64	24.05	23.97	23.08	23.95	17.5	11.59	8.06
	2013	6.04	11.76	14.95	20.95	22.78	24.18	24.16	23.06	23.51	18.08	15.61	9.38
	2014	11.03	10.38	16.14	21.15	23.39	24.55	23.75	23.64	21.8	17.08	13.46	10.8
	2015	10.65	11.45	15.29	20.81	22.42	23.46	23.15	23.1	23.15	18.8	14.33	10.27
	2016	9.15	12.81	17.35	19.19	22.15	23.44	23.56	22.85	23.49	20.51	15.07	13.18
	2017	9.27	11.83	13.79	19.51	22.01	23.15	23.47	24.06	23.68	17.08	14.01	12.78
	2018	7.12	10.36	15.37	18.41	22.15	23.35	24.23	23.84	23.19	18.16	14.12	9.3
	2019	9.19	10.36	10.43	19.68	22.76	22.94	24.08	23.74	22.4	19.45	14.19	9.45
	2020	9.35	10.2	14.47	19.63	21.79	22.87	24.4	23.87	23.91	22.2	12.94	9.93
Average Monthly Min.		8.83	11.03	14.73	19.73	22.38	23.53	23.84	23.43	23.18	18.66	14.08	10.23
Monthly Average		18.4	21.58	25.4	28.28	28.81	28.62	28.66	28.28	27.75	24.98	21.61	18.81

Table 7: Temperature (°C) Data for West Tripura District

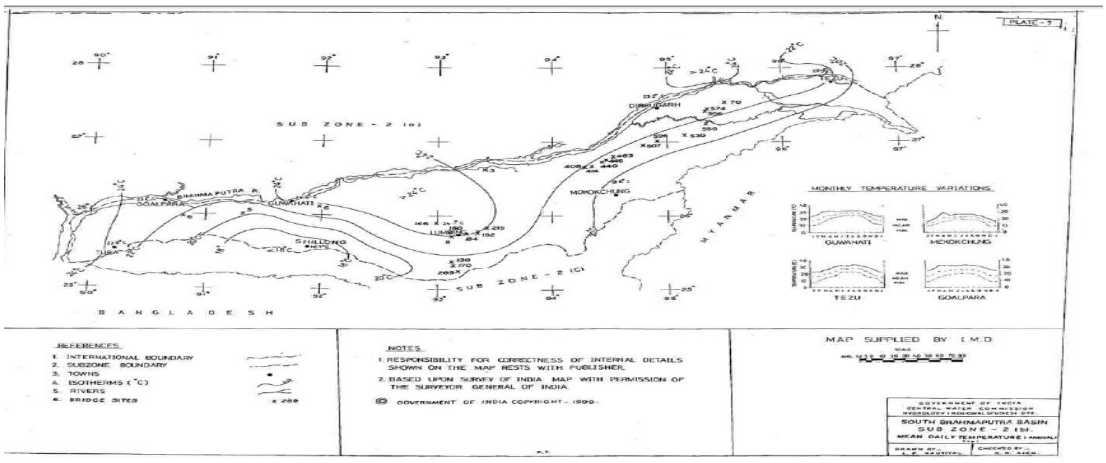


Fig 6: Temperature (°C) Data for South Brahmaputra Sub zone

5.9 Sunshine

Tripura, being in northeastern India, generally experiences a range of sunshine hours throughout the year, influenced by seasonal variations and weather patterns.During the summer (March to June) months, Tripura typically receives a relatively high number of sunshine hours.Clear skies and longer daylight hours contribute to ample sunshine, although this period may also see occasional cloud cover and thunderstorms.The monsoon (June to September) season brings increased cloud cover and rainfall to Tripura.Sunshine hours during this period can vary widely depending on the intensity and frequency of rainfall and cloud cover. Generally, there are fewer sunshine hours compared to the summer months.Post-Monsoon (October to November) sunshine hours may start to increase again.Clearer skies and fewer rain events contribute to more sunshine during this transitional period.Winter (December to February) in Tripura typically sees moderate sunshine hours.While days may be sunny and clear at times, there can also be periods of fog or haze, particularly during the early mornings.Tripura tends to have a relatively sunny climate, especially during the summer months, but sunshine hours can vary seasonally and are also influenced by local weather conditions.

Sunshine Hours (2011-2020)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
11.58	11.68	11.52	10.27	8.87	5.67	5.16	7.16	7.2	7.61	11.73	12

Table 8: Sunshine Hours Data for West Tripura District

5.10 Sedimentation

Sedimentation in rivers is a natural process influenced by various factors such as geology, climate, land use, and human activities. While I don't have specific data on sedimentation rates in Tripura's rivers.The geological composition of the region, including the types of rocks and soils, can influence the sediment load carried by rivers. For example, areas with soft, erodible sedimentary rocks may contribute more sediment to rivers compared to regions with harder, more resistant rocks. The steepness of the terrain and the presence of slopes can affect erosion rates and the transport of sediment into rivers. Steeper slopes may lead to faster erosion and increased sediment delivery to rivers, especially during heavy

rainfall events.Human activities such as deforestation, agriculture, mining, and urbanization can accelerate erosion and sedimentation in rivers. Deforestation, in particular, can lead to increased soil erosion, while agricultural practices such as improper land management and excessive tilling can contribute sediment to rivers.Rainfall patterns, particularly the intensity and frequency of rainfall events, can influence erosion rates and sediment transport. Heavy rainfall can lead to erosion of soil and sediment mobilization, increasing sediment loads in rivers. The shape and characteristics of river channels, including their width, depth, and sinuosity, can affect sediment transport and deposition. Changes in river morphology due to natural processes or human alterations can influence sedimentation rates.Human interventions such as dam construction, river channelization, and sand mining can alter natural sediment transport processes and lead to changes in sedimentation patterns in rivers.The rate of sedimentation has been adopted as 0.022 ham/year/sqkm as per the Master Plan of Manu sub-basin prepared by Brahmaputra Board.

5.11 Seismicity

Tripura lies in close proximity to the eastern Himalayan region, which is a seismically active zone due to the collision of the Indian and Eurasian tectonic plates. The region is characterized by complex geological structures and active fault systems. The Indian Meteorological Department (IMD) operates a network of seismic monitoring stations across the country, including in northeastern states like Tripura. These stations monitor seismic activity and provide real-time data on earthquakes and seismic events. Tripura falls under Seismic Zone V, the highest seismic zone as per Seismic Zonation Map of India.

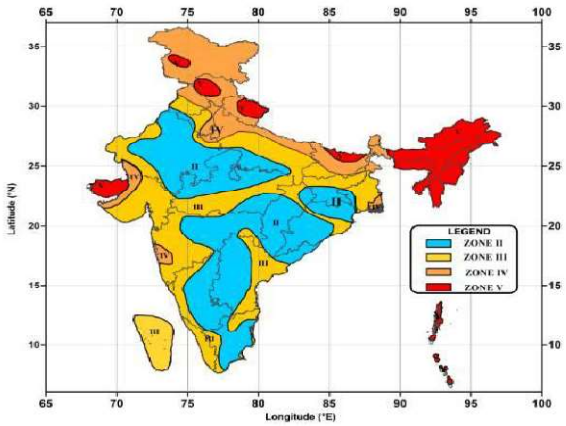


Fig 7: Seismic Zone map of India

5.12 Evapotranspiration

Estimating evapotranspiration in Tripura, like in any region, involves considering various factors such as climate, vegetation cover, land use, and soil characteristics. Evapotranspiration refers to the combined processes of evaporation from the soil surface and transpiration from plants.Given Tripura's location in northeastern India, which generally experiences a humid subtropical climate, evapotranspiration rates can be relatively high, especially during the warmer and wetter months. The topography of Tripura, including elevation and slope, can impact local climate conditions and evapotranspiration rates. Higher elevations may experience lower temperatures and evapotranspiration rates compared to low-lying areas. The availability of water sources, such as rivers, lakes, and groundwater, can influence evapotranspiration rates. Areas with ample water supply may exhibit higher evapotranspiration rates compared to water-stressed regions. Soil properties, such as texture, moisture content, and permeability, affect the rate of evaporation from the soil surface. Sandy soils, for instance, tend to have higher evaporation rates compared to clayey soils. Land use practices, such as irrigation, deforestation, and urbanization, can influence evapotranspiration rates. For example, irrigated agricultural land may have higher evapotranspiration rates compared to natural vegetation cover.

Month	Latitude (^{O}N)	Mean Temperature (^{O}C)	Mean Relative Humidity RH (%)	Maximum Relative Humidity RH (%)	Wind Speed at 2.0 m Height U_2 (Km/hr)	Actual Sunshine n (Hrs)	Evapo-Transpiration ET (mm/day)
January	23.52	18.4	66.04	80.19	1.16	11.58	3.08
February	23.52	21.57	56.82	76	0.96	11.68	4.17
March	23.52	25.39	55.16	71.19	0.62	11.52	5.42
April	23.52	28.27	70.43	86	0.28	10.27	5.9
May	23.52	28.8	83.43	88.44	0.18	8.87	5.69
June	23.52	28.62	89.92	92.12	0.12	5.67	4.57
July	23.52	28.66	90	91.94	0.12	5.16	4.4
August	23.52	28.27	90.54	91.19	0.14	7.16	4.85
September	23.52	27.75	91.08	92.69	0.23	7.2	4.51
October	23.52	24.97	88.35	90.56	0.55	7.61	3.77
November	23.52	21.61	82.28	86.5	1.07	11.73	3.48
December	23.52	18.81	75.31	84.62	1.22	12	2.82

Table 9: Evapo-transpiration Data for Reservoir Area

Chapter 6

DATA ANALYSIS & RESULT

6.1 RUN-OFF CALCULATION

Utilize regionalization techniques to develop a rainfall-runoff model based on data from nearby or similar catchments where data is available. These techniques involve transferring knowledge and parameters from one catchment to another based on similarities in physiographic, climatic, and hydrological characteristics. However runoff at Haora GD site is available. A rainfall-runoff correlation is developed based on the average rainfall data of Sadar and Jirania station and runoff data at Haora GD site for Haora river (CA 414 sq km) which is the major river of the district. As Manikunj Cherra is one of the tributary of Haora river, the rainfall runoff equation developed for Haora river is used to calculate the inflow discharge of the scheme. The linear equation developed is as given below:

R=Runoff, P=Rainfall

N = 15

R = aP + b

$$a = \frac{N(\Sigma PR) - (\Sigma P)(\Sigma R)}{N(\Sigma P^2) - (\Sigma P)^2}$$

a = 0.7229

$$b = \frac{(\Sigma R) - a(\Sigma P)}{N}$$

b = -528.38

$$r = \frac{N(\sum PR) - (\sum P)(\Sigma R)}{\sqrt{[N(\sum P^2) - (\sum P)^2][N(\sum R^2) - (\sum R)^2]}}$$

r =0.9 (0.6<r<1)(Good correlation)

r^2 = 0.81,

R>=0 R>=0 (Coefficient of determination)

∴ The linear equation is : R = 0.723P -528.38

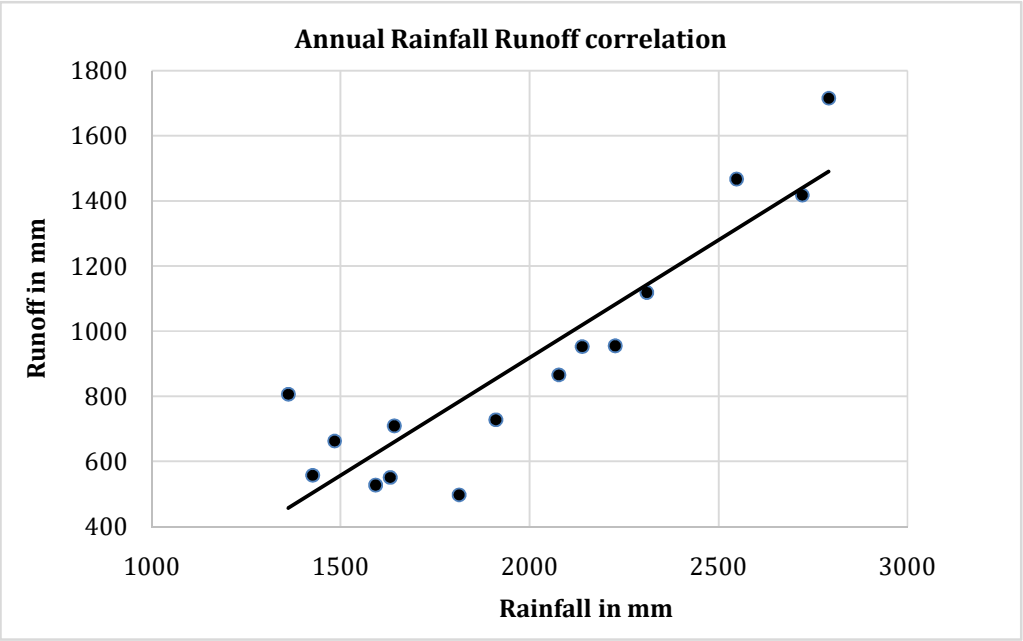


Fig 8: Graph of rainfall runoff correlation

Month/ Year	Annual Rainfall at Sadar Station	Annual Rainfall at Jirania Station	Avg. Annual Rainfall(P)	Annual Runoff (R)	P X R	P^2	R^2
2003	2459.7	2160.6	2310.15	1118.07	2582909.4	5336793	1250080.5
2004	2775.5	2667.5	2721.5	1417.98	3859032.6	7406562.3	2010667.3
2005	2077.5	2376.9	2227.2	954.48	2125817.9	4960419.8	911032.07
2006	1835.8	1987.3	1911.55	728.26	1392105.4	3654023.4	530362.63
2007	2819.8	2275.26	2547.53	1466.32	3735494.2	6489909.1	2150094.3
2008	1648.3	1204.7	1426.5	557.83	795744.5	2034902.3	311174.31
2009	1721.1	1907.6	1814.35	497.71	903020.14	3291865.9	247715.24
2010	2138.8	2017.4	2078.1	866.15	1799946.3	4318499.6	750215.82
2011	1381	1343.2	1362.1	806.69	1098792.4	1855316.4	650748.76
2012	1706.7	1479.2	1592.95	527.01	839500.58	2537489.7	277739.54
2013	1866	1101.87	1483.935	663.2	984145.69	2202063.1	439834.24
2014	1697.2	1567.1	1632.15	551.21	899657.4	2663913.6	303832.46
2015	2202.9	2076.3	2139.6	952.95	2038931.8	4577888.2	908113.7
2016	1785	1500.7	1642.85	708.33	1163679.9	2698956.1	501731.39
2017	3075.3	2507.5	2791.4	1715.63	4789009.6	7791914	2943386.3

Table 10: Data of rainfall runoff correlation

Using this equation findout runoff of two station.

Sadar station annual runoff

Month/ Year	Total annual rainfall in mm	Annual Runoff mm by equation R(mm)=0.723P-528.38
1990	2238.8	1090
1991	2883.7	1557
1992	1519.2	570
1993	2527.6	1299
1994	1205.2	343
1995	2012.6	927
1996	2019.7	932
1997	2146.06	1023
1998	2243.1	1093
1999	1514.3	566
2000	1494.9	552
2001	1877.5	829
2002	2438.2	1234
2003	2459.7	1250
2004	2775.5	1478
2005	2077.5	974
2006	1835.8	799
2007	2819.8	1510
2008	1648.3	663
2009	1721.1	716
2010	2138.8	1018
2011	1381	470
2012	1706.7	706
2013	1866	821
2014	1697.2	699
2015	2202.9	1064
2016	1785	762
2017	3075.3	1695
2018	1762.7	746
2019	1959.8	889
2020	2175	1044
2021	1716.2	712

Table 11:Data of Sadar station annual runoff

Jirana station annual runoff

Year	total rainfall mm	Annual Runoff mm by using equation R (mm)=0.723P-528.38
2003	2160.6	1034
2004	2667.5	1400
2005	2376.9	1190
2006	1987.3	908
2007	2275.26	1117
2008	1204.7	343
2009	1907.6	851
2010	2017.4	930
2011	1343.2	443
2012	1479.2	541
2013	912.8	132
2014	1567.1	605
2015	2076.3	973
2016	1500.7	557
2017	2507.5	1285
2018	2005.6	922
2019	1744	733
2020	1883.7	834
2021	1563.2	602

Table 12: Data of Jirana station annual runoff

6.2 CAPACITY OF STORAGE RESERVOIR

To calculate the capacity of a storage reservoir based on its contour area and contour interval.Contour area refers to the total area enclosed by the contour lines on a topographic map. It represents the surface area of the reservoir.Contour interval is the vertical distance between contour lines on a topographic map. It represents the change in elevation between each contour line.The average depth of the reservoir can be estimated by dividing the total volume by the surface area. This provides a rough estimate assuming uniform depth distribution.

Total Volume = Contour Area × Contour Interval

This calculation assumes that each contour line represents a consistent change in elevation throughout the reservoir.The Prismoidal Method and the Average Method are two

common techniques used to calculate the volume of a reservoir or any irregularly shaped object.

Volume Calculation Using the Prismoidal Method							
Sl No.	Contour	Contour Area (sq m)	Previous area B	Area=(A + √(AxB) + B) / 3	Contour interval	Volume between Contours(Cubic Meters)	Cumulative Volume between Contours(Cubic Meters)
1	59	209.72	0	69.90666667	0	0	0
2	59.5	793.92	209.72	470.5617403	0.5	235.2808702	235.2808702
3	60	1846.75	793.92	1283.841932	0.5	641.9209661	877.2018363
4	60.5	2032.86	1846.75	1939.060576	0.5	969.5302882	1846.732124
5	61	2057.72	2032.86	2045.27741	0.5	1022.638705	2869.370829
6	61.5	4841.35	2057.72	3351.785408	0.5	1675.892704	4545.263533
7	62	4542.61	4841.35	4691.187262	0.5	2345.593631	6890.857164
8	62.5	4570.01	4542.61	4556.303134	0.5	2278.151567	9169.008731
9	63	6761.49	4570.01	5630.094587	0.5	2815.047294	11984.05603
10	63.5	6350.04	6761.49	6554.688767	0.5	3277.344383	15261.40041
11	64	7926.94	6350.04	7123.931342	0.5	3561.965671	18823.36608
12	64.5	11626.02	7926.94	9717.631857	0.5	4858.815929	23682.18201
13	65	15358.68	11626	13449.11549	0.5	6724.557746	30406.73975
14	65.5	17469.55	15358.7	16402.79246	0.5	8201.39623	38608.13598
15	66	18130.84	17469.6	17799.17127	0.5	8899.585635	47507.72162
16	66.5	23490.33	18130.8	20752.83354	0.5	10376.41677	57884.13839
17	67	25408.55	23490.3	24443.16688	0.5	12221.58344	70105.72183
18	67.5	21689.27	25408.6	23524.39599	0.5	11762.19799	81867.91982
19	68	23223.06	21689.3	22451.79872	0.5	11225.89936	93093.81918
20	68.5	32047.26	23223.1	27516.99964	0.5	13758.49982	106852.319

21	69	26061.65	32047.3	29002.93813	0.5	14501.46906	121353.7881
22	69.5	26245	26061.7	26153.27144	0.5	13076.63572	134430.4238
23	70	27677.15	26245	26957.90466	0.5	13478.95233	147909.3761
24	70.5	33012.4	27677.2	30305.61381	0.5	15152.8069	163062.183
25	71	28157.79	33012.4	30552.93818	0.5	15276.46909	178338.6521
26	71.5	27530.58	28157.8	27843.5963	0.5	13921.79815	192260.4503
27	72	34944.29	27530.6	31163.86146	0.5	15581.93073	207842.381
28	72.5	29130.66	34944.3	31993.42744	0.5	15996.71372	223839.0947
29	73	31831.68	29130.7	30471.1924	0.5	15235.5962	239074.6909
30	73.5	29213.76	31831.7	30513.35995	0.5	15256.67998	254331.3709
31	74	29339.54	29213.8	29276.62748	0.5	14638.31374	268969.6846
32	74.5	28991.22	29339.54	29165.20667	0.5	14582.60333	283552.288
33	75	29008.35	28991.22	28999.78458	0.5	14499.89229	298052.1803
34	75.5	29950.52	29008.35	29478.18025	0.5	14739.09013	312791.2704
35	76	32502.2	29950.52	31217.66837	0.5	15608.83419	328400.1046

Table 13: Volume Calculation Using the Prismoidal Method

The Manikunj Reservoir capacity(using the prismoidal method) =32.84 ha-m

Volume Calculation Using Average Method							
Sl No.	Contour	Contour Area (sq m)	Previous area B	Area=(A + B)/ 2	Contour interval	Volume between Contours(Cubic Meters)	Cumulative Volume between Contours(Cubic Meters)
1	59	209.72	0	104.86	0	0	0
2	59.5	793.92	209.72	501.82	0.5	250.91	250.91
3	60	1846.75	793.92	1320.335	0.5	660.1675	911.0775
4	60.5	2032.86	1846.75	1939.805	0.5	969.9025	1880.98

5	61	2057.72	2032.86	2045.29	0.5	1022.645	2903.625
6	61.5	4841.35	2057.72	3449.535	0.5	1724.7675	4628.3925
7	62	4542.61	4841.35	4691.98	0.5	2345.99	6974.3825
8	62.5	4570.01	4542.61	4556.31	0.5	2278.155	9252.5375
9	63	6761.49	4570.01	5665.75	0.5	2832.875	12085.4125
10	63.5	6350.04	6761.49	6555.765	0.5	3277.8825	15363.295
11	64	7926.94	6350.04	7138.49	0.5	3569.245	18932.54
12	64.5	11626.02	7926.94	9776.48	0.5	4888.24	23820.78
13	65	15358.68	11626	13492.35	0.5	6746.175	30566.955
14	65.5	17469.55	15358.7	16414.115	0.5	8207.0575	38774.0125
15	66	18130.84	17469.6	17800.195	0.5	8900.0975	47674.11
16	66.5	23490.33	18130.8	20810.585	0.5	10405.2925	58079.4025
17	67	25408.55	23490.3	24449.44	0.5	12224.72	70304.1225
18	67.5	21689.27	25408.6	23548.91	0.5	11774.455	82078.5775
19	68	23223.06	21689.3	22456.165	0.5	11228.0825	93306.66
20	68.5	32047.26	23223.1	27635.16	0.5	13817.58	107124.24
21	69	26061.65	32047.3	29054.455	0.5	14527.2275	121651.4675
22	69.5	26245	26061.7	26153.325	0.5	13076.6625	134728.13
23	70	27677.15	26245	26961.075	0.5	13480.5375	148208.6675
24	70.5	33012.4	27677.2	30344.775	0.5	15172.3875	163381.055
25	71	28157.79	33012.4	30585.095	0.5	15292.5475	178673.6025
26	71.5	27530.58	28157.8	27844.185	0.5	13922.0925	192595.695
27	72	34944.29	27530.6	31237.435	0.5	15618.7175	208214.4125
28	72.5	29130.66	34944.3	32037.475	0.5	16018.7375	224233.15
29	73	31831.68	29130.7	30481.17	0.5	15240.585	239473.735
30	73.5	29213.76	31831.7	30522.72	0.5	15261.36	254735.095
31	74	29339.54	29213.8	29276.65	0.5	14638.325	269373.42
32	74.5	28991.22	29339.54	29165.38	0.5	14582.69	283956.11
33	75	29008.35	28991.22	28999.785	0.5	14499.8925	298456.0025
34	75.5	29950.52	29008.35	29479.435	0.5	14739.7175	313195.72
35	76	32502.2	29950.52	31226.36	0.5	15613.18	328808.9

Table 14: Volume Calculation Using the Average Method

The Manikunj Reservoir capacity(using the average method) =32.88 ha-m

6.3 RUNOFF COEFFICIENT

The runoff coefficient, often denoted as "C" in hydrological studies, represents the fraction of rainfall that becomes surface runoff. It varies based on factors such as land use, soil type, vegetation cover, and slope of the terrain. To determine the specific runoff coefficient for Tripura, a northeastern state in India, you would typically need detailed hydrological and land use data for the region.

Month/ Year	Annual Rainfall at Sadar Station	Annual Rainfall at Jirania Station	Avg.Annual Rainfall(P)	Annual Runoff (R)	Coefficient of runoff =runoff/rainfall
2003	2459.7	2160.6	2310.15	1118.07	0.48
2004	2775.5	2667.5	2721.5	1417.98	0.52
2005	2077.5	2376.9	2227.2	954.48	0.43
2006	1835.8	1987.3	1911.55	728.26	0.38
2007	2819.8	2275.26	2547.53	1466.32	0.58
2008	1648.3	1204.7	1426.5	557.83	0.39
2009	1721.1	1907.6	1814.35	497.71	0.27
2010	2138.8	2017.4	2078.1	866.15	0.42
2011	1381	1343.2	1362.1	806.69	0.59
2012	1706.7	1479.2	1592.95	527.01	0.33
2013	1866	1101.87	1483.935	663.2	0.45
2014	1697.2	1567.1	1632.15	551.21	0.34
2015	2202.9	2076.3	2139.6	952.95	0.45
2016	1785	1500.7	1642.85	708.33	0.43
2017	3075.3	2507.5	2791.4	1715.63	0.61

Table 15: Runoff Coefficient

So average coefficient of runoff is 0.44

6.4 DESIGN FLOOD CALCULATION

Estimation of design flood for the design of different types of structures is very significant component of hydrological studies. Proper selection of design flood value is of great importance. While a higher value results in increase in the cost of hydraulic structure, an under estimated value is likely to place the structure and downstream population at risk.

For carrying out design flood studies, following information / data are generally required.

- Historical flood series in case the basin is gauged
- For ungauged basins, design flood is generally calculated with the help of widely accepted Rainfall-Runoff Formula for small basins less than 25 SqKm or Synthetic Unit Hydrograph Method (for catchments between 25 SqKm and 5000 SqKm) as recommended by Flood Estimation Reports of CWC.
- Catchment area plans showing the river network, location of rain gauge stations and gauge and discharge sites if any, storages, habilitations, forests, agricultural and irrigated areas, soils, topography and relief etc.;
- Longitudinal section of the river upstream and downstream of the proposed project.
- Details of upstream projects, utilizations etc.

The Manikunj Catchment is ungauged and the catchment area estimated from GIS Analysis is about 16.36sq km. The design flood is therefore calculated on the basis of Rational Formula as per IRC:SP:13-2004.

a) Fixation of Return Period

To determine the return period of a hydrological event using Gumbel's method, also known as the Gumbel distribution or Extreme Value Type I distribution, follow these steps:

Data Collection: Gather annual maximum values of the hydrological event (e.g., annual peak river discharge, annual maximum rainfall) over a period of years.

Arrange Data: Arrange the collected data in ascending order.

Compute the Mean and Standard Deviation: Calculate the mean ($\overline{X}$) and standard

deviation (σ) of the collected data.

Gumbel Reduced Variate Calculation: The Gumbel reduced variate, Y_T for a given return period T is calculated using:

$Y_T = -\ln(\ln((T-1)/T))$

Calculate the Event Magnitude: The magnitude of the event, X_T, corresponding to the return period T is given by:

$X_T = \overline{X} + K_T \cdot \sigma$

where K_T is the frequency factor, defined as:

$K_T = (Y_T - Y) / \overline{S_Y}$

Y is the mean of the reduced variate and S_Y is its standard deviation, which are Constant

Return Period Calculation: Rearrange the formulas to solve for the return period Twhen given a specific event magnitude X_T.

Discharge data in m^3/sec for Haora river at Haora GD Station given below:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual discharge data
1990	93.37	113.59	343.95	351.46	525.54	776.6	667.6	603.55	507.72	610.35	264.36	162.96	5021.05
1991	245.9	130.81	82.25	191.73	1758.1	1162.03	612.95	632.31	722.8	989.85	538.36	323.36	7390.45
1992	199.24	219.71	101.63	85.89	201.39	214.8	368.67	279.33	183.56	328.78	93.63	81.71	2358.34
1993	200.14	373.7	73.86	123.17	1051.66	974.42	1344.17	634.68	635.34	456.48	241.74	151.92	6261.28
1994	120.66	158.49	314.61	286.03	228.98	151	202.9	209.62	218.55	127.43	66.25	56.34	2140.86
1995	61.06	43.75	38.01	79.74	217.1	505.99	389.58	1032.34	411.65	416.62	249.48	117.3	3562.62
1996	86.2	62.13	127.9	103.48	559.37	829.5	734.34	383.77	492.41	528.26	173.29	109.68	4190.33
1997	78.91	60.06	82.64	88.01	191.24	990.43	1329.23	663.31	635.94	313.73	159.92	137.04	4730.46
1998	121.38	99.08	408.62	436.56	771.5	353.36	1291.33	594.82	353.91	213.8	225.88	113.43	4983.67
1999	88.49	55.8	64.82	35.19	156.22	231.37	1123.62	589.48	557.64	563.59	160.77	113.67	3740.66
2000	98.59	72.47	164.39	259.36	873.34	766.46	778.94	1309.62	516.84	485.76	228.37	136.8	5690.94
2001	105.86	86.36	88.89	70.9	631.3	999.67	324.8	486.36	856.7	591.47	280.71	147.63	4670.65
2002	112.53	92.7	138.08	159	643.88	814.15	1692.56	921.68	436.51	396.22	295.67	157.67	5860.65
2003	121.55	114.38	112.73	252.02	826.37	1443.5	778.83	354.28	517.88	478.82	171.42	185.66	5357.44

2004	106.6	65.9	47.47	510.68	240.98	1571.43	1631.04	504.63	1229.99	498.33	219.85	167.58	6794.48
2005	153.95	125.34	278.43	241.13	523.09	218.91	500.56	595.36	625.46	984.69	191.74	134.9	4573.56
2006	97.59	71.8	61.65	125.61	597.08	684.53	302.89	601.94	375.28	295.47	146	129.72	3489.56
2007	128.65	142.94	107.94	521.6	323.98	1309.55	1273.27	774.53	818.84	915.39	486.6	222.81	7026.1
2008	214.08	171.41	146.67	141.21	172.36	159.23	347.12	403.98	273.16	330.24	183.32	130.16	2672.94
2009	103.83	74.12	48.68	34.39	68.84	223.45	462.03	500.11	313.76	285.9	153.31	116.42	2384.84
2010	111.6	106.05	143.96	148.86	462.06	859.6	381.79	441.7	427.06	539.19	268.46	259.97	4150.3
2011	263.6	196.4	177.6	148.16	457.99	674.06	423.23	578	315.23	276.27	193.95	160.91	3865.4
2012	177.75	149.15	131.69	169.38	264.28	375.56	320.53	343.14	173.52	148.46	134.39	137.39	2525.24
2013	127.76	118.78	130.24	312.83	488.87	455.48	300.38	326.03	470.3	176.12	140.11	130.93	3177.83
2014	131.51	123.1	129.08	212.21	170.39	488.61	121.81	444.12	473.26	139.64	103.51	103.96	2641.2
2015	105.56	98.17	193.74	221.56	287.94	497.27	1113.72	745.15	669.59	189.69	228.31	215.51	4566.21
2016	170.25	158.98	142.04	87.93	263.23	260.16	480.6	377.92	375.24	657.83	249.23	170.67	3394.08
2017	180.97	174.79	192.43	392.56	480.55	1089.65	641.6	2015.5	1042.72	1003.7	468.31	537.93	8220.71
2018	416.7	419.87	378.4	640.29	1315.76	1302.83	691.1	628.09	587.69	497.08	248.35	314.82	7440.98

Table 16: Discharge data in m^3/sec for Haora river at Haora GD Station

Applying Gumbel's method

N= 29 years

Year	Discharge (m^3/sec)	Order (m)	Discharge x (m^3/sec)	Tp(years) Tp=(N+1)/m	$\overline{x}$	x- $\overline{x}$	$(X-\overline{X})^2$	$\Sigma(X-\overline{X})^2$	$\partial_{n-1}=\sqrt{(\Sigma(X-\overline{X})^2)/(N-1)}$
1990	5021	1	8221	30.00	4582.137931	3638.86	13241317	81386523.45	1705
1991	7390	2	7441	15.00		2858.86	8173092		
1992	2358	3	7390	10.00		2807.86	7884089		
1993	6261	4	7026	7.50		2443.86	5972462		
1994	2141	5	6794	6.00		2211.86	4892334		
1995	3563	6	6261	5.00		1678.86	2818578		
1996	4190	7	5861	4.29		1278.86	1635488		
1997	4730	8	5691	3.75		1108.86	1229575		
1998	4984	9	5357	3.33		774.86	600411.2		
1999	3741	10	5021	3.00		438.86	192599.9		
2000	5691	11	4984	2.73		401.86	161493.1		
2001	4671	12	4730	2.50		147.86	21863.19		
2002	5861	13	4671	2.31		88.86	7896.467		

2003	5357	14	4574	2.14		-8.14	66.22592		
2004	6794	15	4566	2.00		-16.14	260.4328		
2005	4574	16	4190	1.88		-392.14	153772.2		
2006	3490	17	4150	1.76		-432.14	186743.2		
2007	7026	18	3865	1.67		-717.14	514286.8		
2008	2673	19	3741	1.58		-841.14	707513		
2009	2385	20	3563	1.50		-1019.14	1038642		
2010	4150	21	3490	1.43		-1092.14	1192765		
2011	3865	22	3394	1.36		-1188.14	1411672		
2012	2525	23	3178	1.30		-1404.14	1971603		
2013	3178	24	2673	1.25		-1909.14	3644808		
2014	2641	25	2641	1.20		-1941.14	3768016		
2015	4566	26	2525	1.15		-2057.14	4231816		
2016	3394	27	2385	1.11		-2197.14	4827415		
2017	8221	28	2358	1.07		-2224.14	4946790		
2018	7441	29	2141	1.03		-2441.14	5959154		

Table 17: Gumble's method

Let,

T=10 Years

Y_t= -ln x ln(T / T-1)

y_t = 2.25

K= (y_t-y_n) / S_n

From table (Reduced mean and reduced standard deviation in gumbel's value distribution)

y_n = 0.5353

S_n = 1.1086

K = 1.55

$X_T = \overline{X} + K.\partial n\text{-}1$

= 7,219 cumec

Again,

Let T=25 years,

Y_t= 3.2

$K=(y_t-y_n)/S_n$

= 2.40

$X_T = \overline{X} + K.\partial n\text{-}1$

= 8,680 cumec

b) Design Flood Calculation

Computation of 100 yrs Discharge using Rational method:

Catchment Area=1670 ha= 16.70 sq km

Length of longest stream L = 7.60 km =7600 m

Difference in elevation b/w the

most remote point on the catchment and outlet, H =73 m

Now, Determine Time of Concentration (tc in minute)

Time of Concentration by Kirpich equation

$tc = 0.01947 \times L^{0.77} \times S^{-0.385}$ where, S= H/L=(73/7600)=0.0096

$= 0.01947 \times (7600)^{0.77} \times (0.0096)\text{-}0.385$

= 113.35 minute

= 1.89 hr

100 years Return period rainfall for 24 hours

(isopluvial maps rainfall intensity of South Brahmapura Board) =320 mm

Conversion ratio for tc hours as per CWC,South Brahmaputra Subzone (Table 4.1)

= 0.5423

t_c hr rainfall =320 x 0.5423 = 173.54 mm

Intensity of rainfall = 173.54 /1.89

= 91.82 mm/hr

Peak Discharge using Rational method:

Q_P = (C x i x A)/3.6

= (0.44 x 91.82 x16.70)/3.6

= 187.41 m^3/sec

Compare with two others formula

i) Dickens formula (1865)

$Q_p = C_D \times A^{3/4}$

$= 13 \times (16.70)^{3/4}$ (C_D = Dickens coefficient)

= 107.39 m^3/sec

ii) Ryve's formula (1884)

$Q_p = C_R \times A^{2/3}$

$= 10.2x (16.70)^{2/3}$ (C_R = Ryve's coefficient)

= 66.64 m^3/sec

The Inflow Flood Peak thus obtained is distributed through an approximated Triangular Hydrograph with :

Length of rising Limb = Tc = 2 Hrs

Length of Falling Limb = 2*Tc = 4 Hrs

Total Length of Base of Triangular Inflow Hydrograph = 3*Tc = 3 *2 = 6 Hrs

Peak of Triangular Inflow Hydrograph = 188Cumec

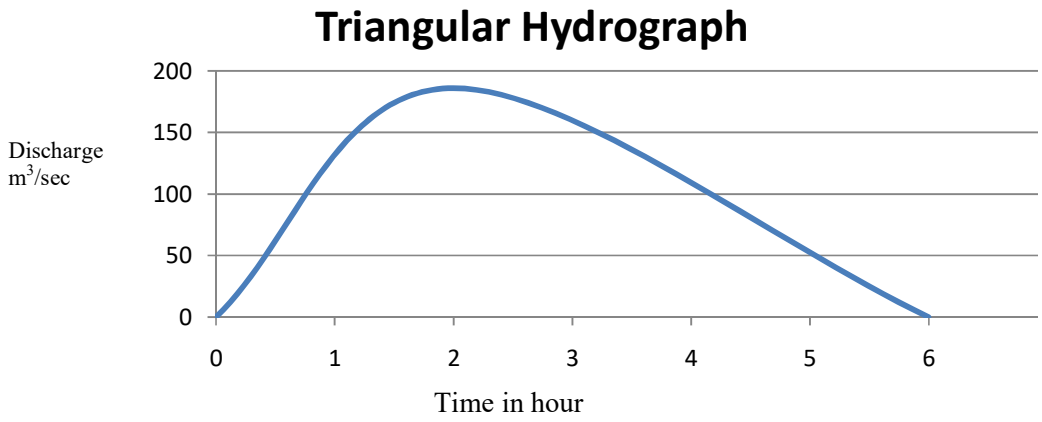


Fig 9: Graph of Triangular Hydrograph

So, the design flood for Manikunj Minor Irrigation Scheme is 188 Cumec.

Table 4.1
(Conversion Ratios)

Rainfall Duration (t) In Hours	Conversion Ratio 10-Year t-Hour Rainfall/10 year-24-Hour Rainfall
1	0.48
3	0.62
6	0.74
9	0.81
12	0.87
15	0.91
18	0.95
24	1.00

Any 25, 50 or 100 - year 24 - hour point rainfall in the sub zone, as read from isopluvial maps in Plates 8, 9 and 10, can be converted into corresponding 25, 50 or 100 - year t - hour rainfall by multiplying with t - hour ratio as read from the curve in fig.10.

Table 18: Flood estimation conversion ratio of South Brahmaputra subzone 2(b)

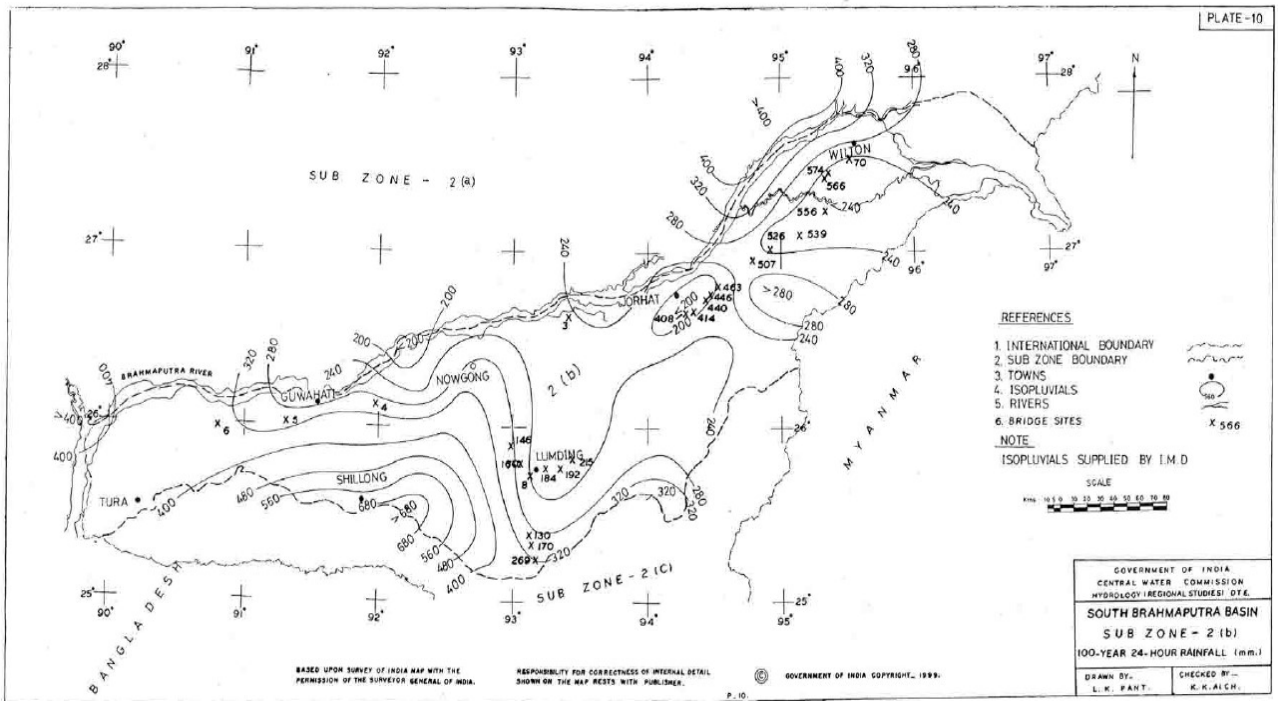


Fig 10: Isopluvial map of rainfall intensity of South Brahmaputra Sub zone

6.5 SEDIMENT CALCULATION

Calculating sedimentation in a reservoir involves estimating the rate at which sediment accumulates over time.Estimate how much sediment settles and deposits in the reservoir. This depends on factors like the reservoir's size, shape, depth, and sediment transport dynamics.Determine the amount of sediment entering the reservoir from its tributaries, erosion of its watershed, and other sources. This can be done using various methods such as sediment sampling, erosion modeling, or historical data analysis.Providing the value of sediment transport rate is 0.022 ham/year/sqkm as per the Master Plan of Manu sub-basin prepared by Brahmaputra Board.

So,Total sediment per year = rate of sediment x reservoir area

= 0.022 x 0.6576

= 0.014 ham/ year

= 140 sqm/year (accumulated sediment in reservoir)

6.6 EVAPOTRANSPRATION CALCULATION

EVAPOTRANSPRATION CALCULATION BY PENMAN'S EQUATION

$PET = (A.Hn + Ea .\gamma)/(A+ \gamma)$

Where,

PET=Daily potential evapotraspiration in mm per day

A= Slope of the saturation vapour pressure vs temperature curve at the mean air temparature ,in mm of mercury per °C

Hn= net radiation in mm of evaporable water per day

$Hn= Ha(1-r)(a+bn/N)-\sigma\ T4a(0.56-0.092\sqrt{}\ ea)(0.10+0.90n/N)$

Where

Ha = incident solar radiation outside the atmosphere on a horizontal surface, expressed in mm of evaporable water per day (it is a function of the latitude and period of the year.

a = a constant depending upon the latitude Φ and is given by $a = 0.29 \cos\Phi$

b = a constant with an average value of 0.52

n = actual duration of bright sunshine in hours

N = maximum possible hours of bright sunshine (it is a function of latitude as indicated in Table 3.5)

r = reflection coefficient (albedo)=water surface=0.05

σ=Stefan-Boltzman constant = 2.01 x10–9 mm/day

Ta = mean air temperature in degrees Kelvin = 273 + °C

e_a = actual mean vapour pressure in the air in mm of mercury

E_a=parameter including wind velocity and saturation deficit

$E_a = 0.35 (1+u_2/ 160)(e_w-e_a)$

u_2 = mean wind speed at 2 m above ground in km/day

ew = saturation vapour pressure at mean air temperature in mm of mercury

e_a = actual vapour pressure, defined earlier

γ=psychometric constant =0.49 mm of mercury/°C

January Month

Latitude= Φ 23°52' N

Elevation= 59 m

Mean monthly temperature= 18.4 °C

Mean relative humidity = 66.04 %

Mean observed sunshine hours = 11.58 h

Wind velocity at 2 m height = 27.65 km/day

Nature of surface = reservoir

$$PET = \frac{AH_n + E_a\gamma}{A + \gamma}$$

PET = daily potential evapotranspiration in mm per day

PET = 3.08 mm /day

Other month's evapotranspiration calculated value by using this equation and given in table no. 9

6.7 DISCUSSION

Based on hydrological studies and information received from site reconnaissance and data analysis following observation done

- The Manikunj cherra has a catchment area of 16.70 sq km.
- The weir is designed for a hydraulic head of 4 m (FRL) from the deepest point in the reservoir.
- As per study, 320 ha CCA can be irrigated with the available water from the catchment area.
- The Manikunj Cherra scheme reservoir capacity 33 ha-m.
- Design discharge 188 cumec.
- Accumulated sediment in reservoir is 140 sqm/year.

Begin by summarizing the key findings study, the main insights regarding the resilience and sustainability of minor irrigation systems in Tripura that emerged from research.Compare your findings with existing literature on minor irrigation systems, both globally and within similar geographical contexts. Discuss how your results align with or diverge from previous research and theories.Analyze the technical aspects of the minor irrigation systems studied. Evaluate their efficiency in terms of water delivery, storage, and

distribution, and discuss any challenges or limitations identified during your investigation.Discuss the environmental implications of the minor irrigation systems in Tripura. Reflect on any observed changes in soil quality, water availability, or biodiversity, and consider the long-term sustainability of these systems from an ecological perspective.Explore the socioeconomic impact of minor irrigation schemes on local communities in Tripura. Discuss how these systems have influenced factors such as crop yields, income generation, employment opportunities, and social equity in irrigation access.Reflect on the role of community engagement and participation in the development and management of minor irrigation projects. Assess the effectiveness of participatory approaches in enhancing system resilience and sustainability, and discuss any challenges encountered in engaging local stakeholders.Consider the policy implications of your findings. Discuss the adequacy of existing policies and governance structures governing minor irrigation in Tripura, and propose recommendations for policy improvements or institutional reforms to promote resilience and sustainability.Evaluate the resilience of minor irrigation systems in Tripura to climate variability and change. Discuss adaptation strategies implemented or recommended to enhance system resilience in the face of climate-related challenges.

Limitations and Future Research Directions: Acknowledge any limitations of study and suggest avenues for future research. Consider areas where further investigation is needed to deepen understanding of the resilience and sustainability of minor irrigation systems in Tripura.

Chapter 7

7.1 CONCLUSION

Constructing rainwater storage reservoirs for minor irrigation schemes in Manikunj Cherra, Tripura state will increase the availability of water for irrigation purposes, especially during periods of low rainfall or drought. This will help farmers maintain crop yields and ensure food security in the region.By capturing and storing rainwater during the monsoon season, farmers can reduce their reliance on erratic monsoon rains for irrigation. This resilience to climatic variability can stabilize agricultural production with reliable access to water throughout the year, farmers can diversify their crop choices and introduce high-value crops that require irrigation. This can lead to increased agricultural productivity and income generation for local communities.Rainwater harvesting and storage promote sustainable water management practices by harnessing natural resources efficiently. It reduces reliance on groundwater extraction, which can help mitigate the risk of groundwater depletion and associated environmental impacts.Constructing reservoirs can help mitigate the risk of flooding during the monsoon season by capturing excess rainwater. Additionally, the controlled release of stored water for irrigation can reduce soil erosion and sedimentation in the river basin. Access to reliable water for irrigation can enhance livelihoods and contribute to rural development in the Manikunj Cherra area. Increased agricultural productivity can stimulate economic growth, create employment opportunities, and improve living standards for local communities.Rainwater harvesting and storage contribute to environmental conservation by conserving water resources and preserving ecosystems. It promotes biodiversity by maintaining water flow in rivers and supporting aquatic habitats.Building rainwater storage reservoirs enhances the resilience of agricultural systems to climate change by providing a buffer against extreme weather events and prolonged droughts. It helps communities adapt to changing climatic conditions and reduce vulnerability to water scarcity.

Overall, constructing rainwater storage reservoirs for minor irrigation schemes in Manikunj Cherra can have far-reaching positive impacts on water security, agricultural productivity, livelihoods, and environmental sustainability in the region.

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