Hiralal Bhakat College
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Affiliated to the University of Burdwan and Re-accredited by NAAC
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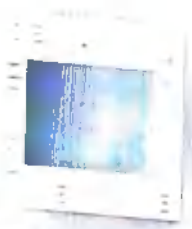
Re. No. ..... Date: 11.08.2024

Timeless Tales from Bengal

An Anthology of Bangla Children's and Young Adults' Stories

Edited by
Dipankar Roy
Saurav Dasthakur

THORNBIRD
NIYOGI BOOKS



Published by
NIYOGI BOOKS
Block D, Building No. 77,
Okhla Industrial Area, Phase-I,
New Delhi-110 020, INDIA
Tel: 91-11-26816301, 26818960
Email: niyogibooks@gmail.com
Website: www.niyogibooksindia.com

Original Text © Individual authors/ legal heirs
Translation © Individual translators
Introduction text © Dipankar Roy and Saurav Dasthakur

Editor: Sucharita Ghosh
Design: Nabanita Das
Cover Illustration: Manjari Chakravarti

ISBN: 978-93-86906-23-6
Publication: 2018

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Printed at: Niyogi Offset Pvt. Ltd., New Delhi, India

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The Notebook

Rabindranath Thakur

Uma has been a nuisance ever since she learned to write. Every wall of the house is smeared with scribbling in charcoal—rain splutters, leaf sways.[6]

She discovered *Haridaser Guptakatha*,[7] lying beneath her sister-in-law's pillow, and scrawled with pencil across the pages—black water, red flower.

The stars and planets in the almanac seem to be eclipsed by large alphabets.

In the middle of her father's daily account of credit and debit, she has written—one who studies, rides carriages.[8]

Her literary efforts were so forth unhindered; finally something terrible happened.

Uma's elder brother Gobindalal looks extremely timid, but he regularly contributes to the newspapers. From his conversations his relations and neighbours have never suspected him to be a contemplative person. Actually, he could not be accused of thinking but he writes; and the majority of the reading public of Bengal agrees with his views.

Gobindalal had composed an interesting article repudiating the fallacies of the European scientists regarding physiology; he had taken recourse to bombastic language rather than logically establishing his point.

He came and sat on the bed. Then he ordered in a voice like thunder, 'Give me the notebook.' Finding that his order had not yet been carried out, he ordered a bit softly, 'Give it to me.'

Holding the notebook tight the girl stared, with a look of earnest supplication, at the face of her husband. But when she saw Pyarimohan proceeding to snatch the notebook, she dropped it and lay down on the ground covering her face with both her hands.

Pyarimohan lifted the notebook and started to read the words aloud. At this Uma embraced the earth with all her strength and the listeners, the three little girls, burst out in laughter.

Since then Uma did not get her notebook back. Pyarimohan also had a notebook full of his varied essays, infested with the thorns of his subtle theories. But there was no such philanthropist of calibre there, who would snatch it away and destroy it.

Translated from the Bangla original 'Khata'
by Amlan Das Gupta, Bipasha Raha,
Shuddhasattwa Banerjee and Anindita Chongdar

The Prince of Peshawar

Narayan Gangopadhyay

Seated on the ledge in front of the Chatujje house, I was trying to bring to size a ripe mango. But the effort did not last long. A couple of bites later I had to throw it away—it was terribly sour. My teeth began to clatter—I was now in a foul mood. I had seen there was mutton at home for dinner tonight—who knows whether I would be able to do justice to it and chew the bones!

At that moment, Tenida, who stayed at Pataldanga, appeared out of nowhere. He boomed, 'Pyala! You threw away the mango?'

'It's horribly sour. Can one eat it?'

'Sour?' Tenida squatted down beside me and said, 'Just because it was sour it wasn't worth anything? If there was nothing sour in the world, where would you have got pickles? If there was nothing sour, how would curd thicken? If there was nothing sour, how would we distinguish between ash gourds and star fruits? If there was nothing sour, then how would ants taste sour? If there was nothing sour—'

If there was nothing sour in the world, many other disasters would have occurred—but I was not in the mood to hear a long list of such happenings. I stopped him saying, 'Does that mean a civilised person can eat such a sour mango?'

The smell of the mango attracted a large bluebottle from somewhere, which tried to sit on Tenida's big hooked nose. My

The entire household started wailing. You can well imagine what was going on in my mind! But the next day, there was a miracle! Early in the morning the sahib's second orderly brought a letter for Gablumama.

'Gablumama got the job. A situation worth two hundred and fifty rupees.

'How did the wonder work? It is so simple. The sahib fell down from the fan and realised something phenomenal had taken place. A bite of the Prince of Peshawar had eured his ten-year-old rheumatism—he could not move his hands and feet earlier, but the day before he had played football all afternoon, in sheer delight made faces at everybody, back home he even had a tussle with his enormous memsahib.

'And Gablumama's fever? Instant remission! He bathed in ten buckets of water, had his meal, put on coat-pants and hurried to greet the sahib.

'So Pyala—as I was saying—a sour mango should not be scorned! If you slip it to someone at the right moment, it can change your fortunes!'

Tenida paused, finishing the packet of dalmut.

'Such a remedy for rheumatism!' I wondered, 'The mango tree—'

Tenida heaved a sigh, 'That was a divine gift—could it last long in this world? The very next day, the tree was uprooted in a norwester.'

Translated from the Bangla original
'Peshwar ki Aamir' by Amlan Das Gupta, Bipasha Raha,
Shuddhasattwa Banerjee and Anindita Chongdar

JOURNEYS INTO THE PAST

HISTORICAL AND HERITAGE TOURISM IN BENGAL

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NEW ACADEMIC PUBLISHERS
NEW DELHI-110002

New Academic Publishers
4760-61/23, Ansari Road
Daryaganj
New Delhi - 110002

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First Edition: **2018**

ISBN : **978-81-86772-98-0**

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Published by Ashish Puri for New Academic Publishers
New Delhi -110002.

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LANGUAGE & REALITY

Edited by
Dr. Sujit Kumar Moudai

SCHOLAR PUBLICATIONS
KARIMGANJ, ASSAM, INDIA

Language & Reality

ISBN: 978-81-935793-5-0
First Publication: JULY 2018
Cover Page design by: Kishore Biswas

Language & Reality Edited by **Dr. Sujit Kumar Mondal**
Published by **Biplab Bhattacharjee**, Scholar Publications, Karimganj, Assam, India.

Printed at:
Scholar Publications, Karimganj, Assam, India
Website: http://www.scholarpublications.in
Email: pub@scholarpublications.in

© Dr. Sujit Kumar Mondal

₹ 250
Tbis Book is available in tbese online stores
amazon.in • Scholarpublications

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International seminar on
Eternal India: Harmony and Peace

Organized by

IQAC and Department of Philosophy
Bijoy Krishna Girls' College
Howrah-711101





First Edition : 5 September, 2018

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ISBN 978-93-80736-96-9

Published by : Arati Mitra for Avenel Press, Memari, Burdwan and Printed at Sha
Packers. Kolkata.

Email: avenel.india@gmail.com; info@avenelpress.com
visit www.avenelpress.com

Composed by : ADSONATA, 9433452778, 9874522778

Cover Design : Babul Dey

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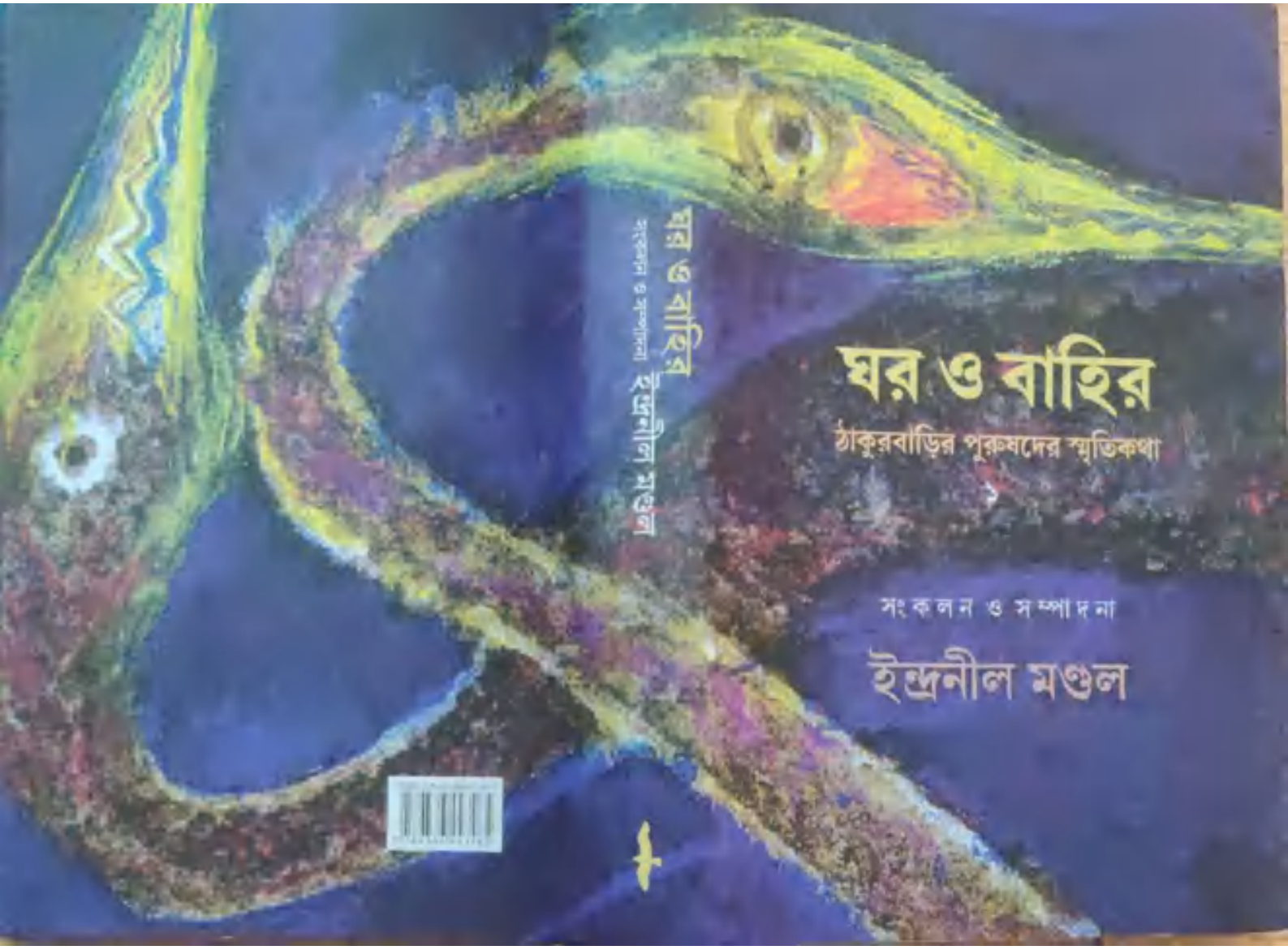
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Compiled and Edited by Indranil Mondal

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প্রকাশক
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কলকাতা ৭০০ ০০৭ ফোন ৯৪৩২৯ ৯১৫৩০; ৯৪৩২৪ ০৭৬৬৫
০৩৩ ২২৪১ ০৪০৪ (দুপুর ১২ থেকে ৭টা)

মুদ্রক
এস পি কমিউনিকেশনস ৩১বি রাজা দীনেন্দ্র স্ট্রিট, কলকাতা ৭০০ ০০৯

প্রচ্ছদ পরিকল্পনা ও রূপায়ণ
বিপুল গুহ

ISBN 978-93-86443-46-5

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INDIAN VILLAGE THROUGH THE AGES

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First Published
2019

BOOK SYNDICATE (P) LTD.
www.booksyndicate.in

Published by :
Biplab Bhowal
for **Book Syndicate (P) Ltd.**
35 College Street, Kolkata 700 073
☎ 2257 0754/55
booksyndicate.35@gmail.com

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First Published : **February, 2019**

Priee : Rupees two hundred fifty only
₹ 250

ISBN 978-93-87706-24-8

Printed by :
Kalyan Bhaumik
for **Mudran Bharati**
26 M. B. Road
Kolkata 700 049

PREFACE

The present volume contains some of the papers presented in the 16th. Annual Conference of Bharata Vidya Charcha Kendra held on 16th. February, 2018 in coliaboration with Syamsundar College, Syamsundar, Purba Bardhaman. The theme of the conference was Indian Village through the Ages. Bharat Vidya Charcha Kendra (BVCK) is an inter-discipiinary research organisation of Burdwan.

This book contains a set of the seleeted articles. Nine of them are in English while three are in Bengali. BVCK bas decided to publish this volume as a part of its academic activities and to circulate the selccted papers presented in the conference among the academic fraternities at large. We hope that this edited volume will help the students, teachers and researchers of the relevaat area. The major contribution of these articles is available in a summarized form from the Introduction which follcws.

We are thankful to the autborities of Syamsnndar College where the 16th. Annual Conference of BVCK was held. We are also thankful to thc contrihutors without whose cooperation this volume could not he published. Last but not the least we thank Sri Biplab Bhowal of Book Syndicate (P) Ltd for his cooperation and help to publish this volume within a short period of time. We heg to be excused for any deficiency that remains preseut in the book.

Jaydeb Sarkhel
Rupendra Kumar Chattopadhyay
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10. **ইন্দ্রানী হাজরা** : সহকারি অধ্যাপক, কবি জগদ্রাম রায় গভঃ জেনারেল ডিগ্রি কলেজ, মেজিয়া, বাঁকুড়া।
11. **মমতা খাঁ** : সহকারি অধ্যাপিকা, বাংলা বিভাগ, শ্রীগোপাল ব্যানার্জী কলেজ, বাগাটি, মগরা, হুগলী।
12. **আকরোজ নাসরিন** : গবেষক, সমাজতত্ত্ব বিভাগ, বর্ধমান বিশ্ববিদ্যালয়।
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Introduction

Villages occupy an important place in the economy, society and culture of India. Mahatma Gandhi is often quoted as having said, "Real India lives in its villages". In the early decades of the 20th century about 90% of the popuiation ilved in the villages. The development of village, for Gandhiji, was the development of India. Illiteracy, ignorance and poverty characterized the vast population of rural India. Gandhiji organized mass movement to draw attention to the problems of the rural people and also to involve the peasants in the freedom movement.

Indian villages have a prolonged history of their own. They existed in all the major stages of our socio-political history. As an important unit of the Indian social polity the village has played a prominent role.

The *Rig Veda* denotes "grama" as an aggregate of several families sharing the same habitation. During the period of Rig Veda, village was a unit of social and political organization of India. Each village or grama was haaded by a "gramani".

The Ramayana makes a mention of villages. According to the Ramayana, gramani or the head of the village was appointed by the king. He was assigned the duty of looking after the village defence. It was also his duty to collect state dues and to maintain records reiating to such collection. He was also vested with some judicial functions.

The Mahabharata mentions several types of hahitations and settlements. It refors to the village as the most fundamental unit of administration baving "gramani" as its leader and chief spohesman.

During the *Buddhist period* we have cnongh literature to speak of the position of the villages, towns and forts. Each grama was organised as a socio-polltical nnit under the authority of the headman. The most sigeificant aspect of the viliage organisation during this period was thet the village affairs were completely managed hy the villagers themselves. It means in several respects each grama was independent and autenomous.

"Arthashastra" of Kautilya provides us specific details about the village and its administration during the *Mauryan period*. Each village hed a wonderful administrative system. Village administrative staff cnnsisted of the headman, accountant, officials, veterinary doctor and

Prajñājyotiḥ

प्रज्ञाज्योतिः

প্রজ্ঞাজ্যোতিঃ



Chief Editor

Lokesh Mondal

Prajñājyotiḥ

प्रज्ञाज्योतिः

প্রজ্ঞাজ্যোতিঃ

MULTILINGUAL MULTIDISCIPLINARY PEER-REVIEWED BOOK

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Khayrasole, Birbhum

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(স্থাপিত : ১৮৭৯ খ্রীঃ)

পুস্তক প্রকাশক ও বিক্রেতা

৫/১, শ্যামাচরণ দে স্ট্রীট, কলকাতা-৭০০০৭৩

ফোন : ৯৪৩৩৭৯৮৪২১

প্রকাশক ঃ
শ্রীবিকাশ দত্ত, এম. কম. এল-এল-বি
৫/১, শ্যামাচরণ দে স্ট্রীট,
কলকাতা-৭০০ ০৭৩
daccastudent2015@gmail.com

Second Edition : June, 2018
Third Edition : December, 2020

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ISBN : 978-93-84054-17-5
www.daccastudentlibrary.com

মূল্য ঃ পাঁচশত টাকা মাত্র

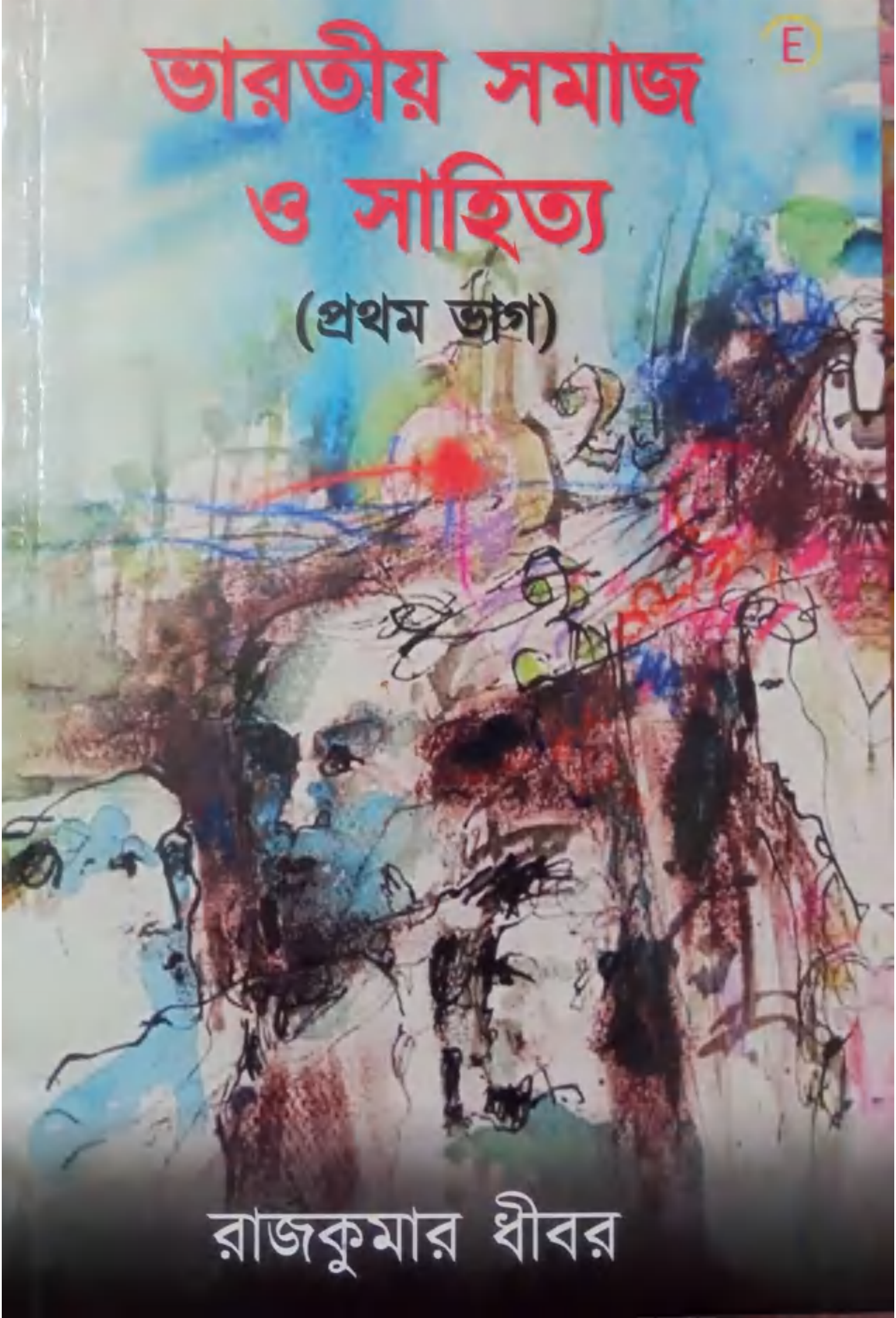
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(প্রথম ভাগ)



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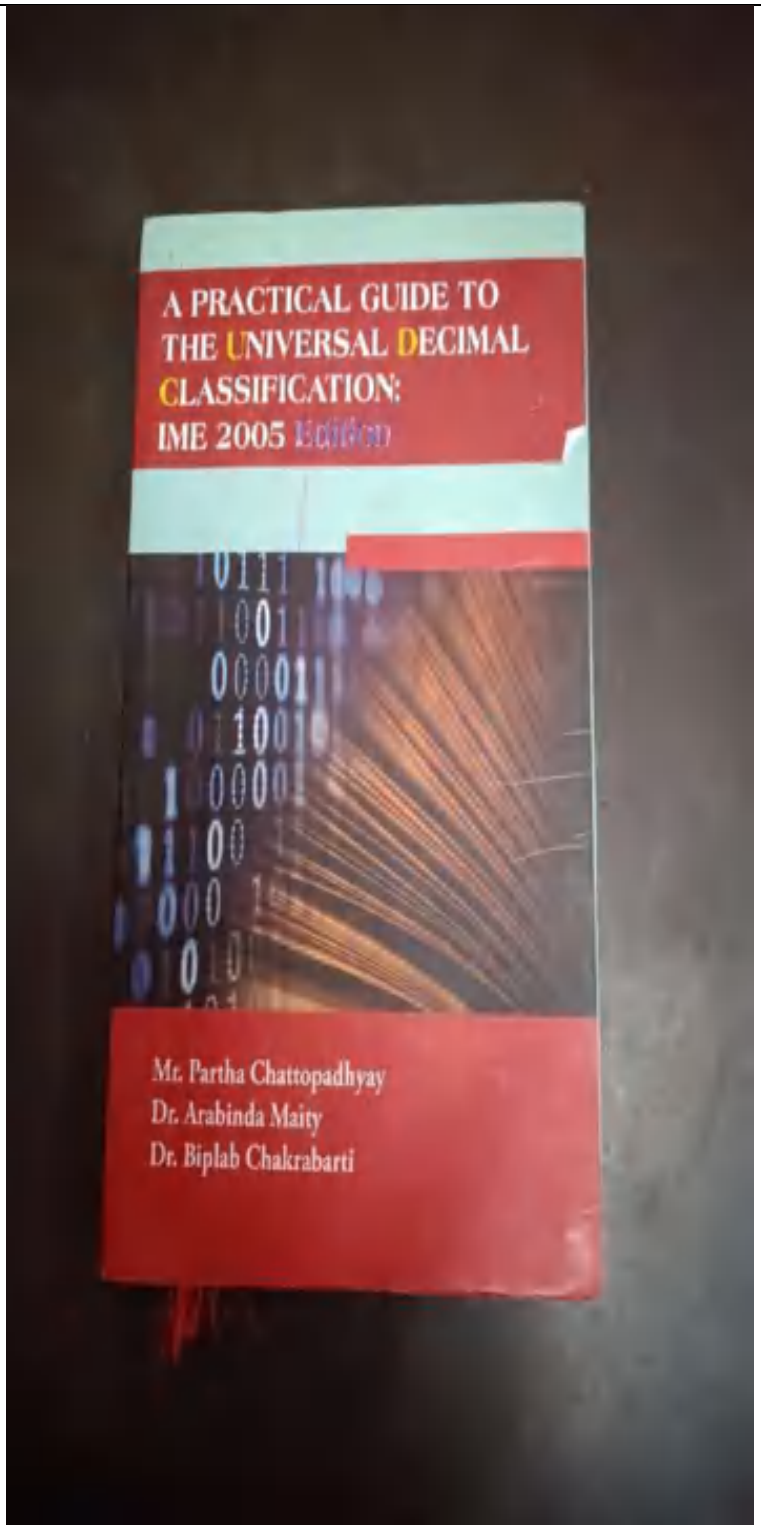
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Eviucepub Publishiug

Parijat Extension, Bilaspur, Chhattisgarh 495001
First Published by Evincepub Publishing 2021
Copyright © Rajkumar Dhibar 2021
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ISBN: 978-93-5446-361-7
Price: 550/-

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	A Practical Guide To The Uniersal Decimal Classification: IME 2005 Edition	Mr.Partha Chattopadhyay; Prof. Arabinda Maity & Prof. Biplab Chakrabarti Rohini Nandan; Kolkata	

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কৌটিল্য থেকে অমর্ত্য সেন

সম্পাদনা
অভিষেক মিত্র

BHARATIYA RASTRACHINTA

Kautilya Theke Amartya Sen

Edited by Abhishek Mitra

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প্রথম প্রকাশ : ১৫ আগস্ট, ২০২০

প্রচ্ছদ-শিল্পী : ঋতদীপ রায়

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দাম : ২৮০ টাকা
Rupees Two hundred eighty only

ISBN : 978-81-8064-337-8

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Principal
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Nalhati, Birbhum

দ্বাদশ অধ্যায় ঃ ভূপেন্দ্রনাথ দত্ত ঃ রাজনৈতিক ও সামাজিক ভাবনা ২২৩-২৪৪
অমিত কুমার বসু

ত্রয়োদশ অধ্যায় ঃ বিনায়ক দামোদর সাভারকর ঃ হিন্দুত্ববাদী সাংস্কৃতিক জাতীয়তাবাদ ২৪৫-২৫৩
অরুণাভ ব্যানার্জী

চতুর্দশ অধ্যায় ঃ ভারত রাষ্ট্রনির্মাণ ঃ মানবেন্দ্রনাথ রায়ের দর্শন ও চিন্তন ২৫৪-২৬৮
শিবাশিস ঘোষ

পঞ্চদশ অধ্যায় ঃ আচার্য নরেন্দ্রদেব ঃ ভারতীয় রাষ্ট্রভাবনায় সমাজতন্ত্রের পথিকৃৎ ২৬৯-২৯০
সত্রাজিৎ ব্যানার্জী

ষোড়শ অধ্যায় ঃ জওহরলাল নেহরু ঃ একটি পথ অনেক পাথেয় ২৯১-৩০৫
বিমান সাহা

সপ্তদশ অধ্যায় ঃ আম্বেদকর ঃ সমাজভাবনা ও রাষ্ট্রদর্শন ৩০৬-৩২২
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সৈয়দ এম. জামান

বিংশ অধ্যায় ঃ সমাজ ও রাষ্ট্রচিন্তায় রামমনোহর লোহিয়া ৩৬৫-৩৮০
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লেখক পরিচিতি ৩৯৫-৩৯৬

Attested
Principal
Hiralal Bhakat C
Bhati, Birb

Sesquicentennial Commemoration Volume of Jalpaiguri District (1869-2019)



Edited by :
Dr. Ananda Gopal Ghosh
Dr. Nilangshu Shekhar Das
Dr. Nirmal Chandra Roy
Dr. Kartik Chandra Sutradhar

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KUNAL BOOKS
New Delhi - 110002, (India)

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CHAPTER

9

A Snapshot on the History of Education in Jalpaiguri District (1869 – 2019)

Manojit Das & Ananda Gopal Ghosh

(I)

Educational landscape of Jalpaiguri district is vast, complex and diversified. The diversity lies in her language, ethnicity, religion and primordiality of life of a tiny section of people. History and Geography and also the British Colonialism and imperialism are responsible for such diversity. A district which has started from the foothills of the Himalaya and ended in a plain terrain. In addition to this Geo-Ethno-Historical diversity the district has been actually a settlers or immigrants habitation land particularly after the advent of the company-colonial-imperial of rule. It is to be noted that this is the only district of West Bengal where we find a Hindi Medium College as well as an English Medium College similarly, in the pre-primary, primary and post primary education sphere, we find on the one side a high-tech educational methodology and on the other side a primitive system of teaching. Further, if we cast our eyes over the medium of instructions in the primary stage, it will be visible a multilingual picture viz. Bengali, English, Nepali, Hindi, Rajbanshi / Kamtapuri (yet not introduce dricially), Urdu and Arabic (in Madrasa) Sanskrit (in Tol, Chatuspathi), Bhutia (in Bhutia School and Forest Village School). Truly speaking this is really a unique canvas of the elementary education of the district. It is in this linguistic canvas, we will present here a narrative on general, technical, engineering, Medical, law, Teachers Training and other wise abled (Blind School) etc. It is both literally and practically to bring all the aspects of education under one write-up. But for the sake of the general readers and concern persons, a comprehensive picture rather a total picture of education is urgently-needed we firmly believe that the readers of the different status will get their desire points from this discussion. It will meet the mental hunger of both the generalists and the specidists. Before entering

ISSN 2348-2036

উত্তর প্রসঙ্গ

একটি আর্থ-সামাজিক বিশ্লেষণধর্মী জার্নাল



গান্ধী ১৫০



RNI No. WBBEN/ 2007/ 21521
ISSN 2348 - 2036

Postal Registration No. COB.05/2020-2022

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প্রকাশিত মতামত লেখকের নিজস্ব, উত্তর উত্তর প্রসঙ্গের নয়।

সম্পাদকীয় দপ্তর

১৮, দিনহাটা রোড (নারায়ণ রোড), কোচবিহার -৭৩৬১০১, পঃ বঃ,ভারত
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দেশের ও বিদেশের 'গান্ধীদের' ইতিকথা

মনোজিৎ দাস

মহাত্মা গান্ধীর আদর্শে অনুপ্রাণিত হয়ে বিশ্বের বিভিন্ন দেশের ও দেশের অভ্যন্তরের সমাজমনস্ক ব্যক্তিরা গান্ধীর নামে আশ্রম বা মিশন, চরকাকাটা কেন্দ্র বা সেন্টার, সবরমতী বা সেবাগ্রাম আশ্রম ধাঁচের সংস্থা গড়ে তুলেছিলেন। গান্ধীর আদর্শ ও কর্মের প্রচার ও প্রসারে এরা আমৃত্যু কাজ করে গিয়েছেন। এমন অনেক দেশ আছে, যেখানে গান্ধী যাননি, কিন্তু তাঁর নামে নামাঙ্কিত সংস্থা স্থাপিত হয়েছে। দেশের অভ্যন্তরের ক্ষেত্রেও একই কথা প্রযোজ্য। তবে গান্ধীর সঙ্গে এদের কোথাও কোথাও সাক্ষাৎ হয়েছে এবং পত্রালাপও হয়েছে। গান্ধীর পক্ষে শারিরীকভাবে সর্বত্র উপস্থিত হওয়াও সম্ভব হয়নি। কিন্তু গান্ধীর কর্ম ও আদর্শে তাড়িত হয়েই তাঁরা এসব সংস্থা স্থাপন করেছেন। শুধু তাই নয় গান্ধীর সঙ্গে তাঁদের নাম জড়িয়ে বলেছেন নেপাল গান্ধী, শ্রীলঙ্কার গান্ধী ইত্যাকার বিশেষণ। এ প্রসঙ্গে একটা কথা বলার প্রলোভন সম্বরণ করতে পারছি না। সেটি হলো গান্ধীর পূর্বে আরও একজন ভারতীয় তথা বঙ্গজ সমাজসংস্কারক এরূপ সম্মান অর্জন করেছিলেন। তিনি হলেন ঈশ্বরচন্দ্র বিদ্যাসাগর। অবশ্য তাঁর নাম দেশের অভ্যন্তরেই সীমায়িত ছিল। কিন্তু তিনিই প্রথম আধুনিক সমাজ মনস্ক ব্যক্তি যার নামে ভারতের বিভিন্ন প্রান্তে সন্তানের নাম রাখার এবং বিদ্যাসাগর নামে ভূষিত করার প্রয়াস দেখেছি। যেমন অন্ধ্রের বিশিষ্ট সমাজসংস্কারক বীরেশলিঙ্গমকে 'দক্ষিণের বিদ্যাসাগর' বা 'Vidyasagar of the South' বলা হত। মহারাষ্ট্রের বিষ্ণু পরশুরাম শাস্ত্রীকে 'মহারাষ্ট্রের বিদ্যাসাগর' বলা হত। এরূপ উদাহরণের সংখ্যা বহু রয়েছে এবং তা ভারতের বিভিন্ন অংশেই রয়েছে। বলা যেতে পারে আসমুদ্রহিমাচলে। যাই হোক গান্ধিজীর কথায় ফিরে আসা যাক। প্রথমে বিদেশের কথাতে আসছি।

ভারতের নিকটতম প্রতিবেশী নেপালে গান্ধিজী কখনও যাননি। কিন্তু সেখানে গান্ধীর অনুরাগীর অভাব ছিল না। তুলসী মেহের শ্রেষ্ঠী নামে কাঠমাণ্ডুর একজন অধিবাসী গান্ধীর নামে একটি স্মারক নিধি সংস্থা খুলেছিলেন চরকাকাটা থেকে কুষ্ঠ রোগাক্রান্ত মানুষের পরিষেবা সবই তিনি করেছেন। নেপালের লোকেরা তাঁকে 'নেপাল গান্ধী' বলে সম্মান করতেন। নেপালে অবশ্য আরও একজনকে গান্ধী বলে আখ্যায়িত করা হয়েছিল। ইনি হলেন নেপালের এক সম্ভ্রান্ত পরিবারের সন্তান – কৃষ্ণপ্রসাদ কৈরালা। নেপালের রানাশাহী শাসনতন্ত্রের বিরুদ্ধে তিনি নিরন্তর সংগ্রাম চালিয়েছেন। শুধু তিনি একা নয়, তাঁর সুযোগ্য

দর্শনের আলোকে বাউল বৈষ্ণব রবীন্দ্রনাথ

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ড. সুজিত কুমার অগুচ

দর্শনের আলোকে বাউল বৈষ্ণব রবীন্দ্রনাথ

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স্কলার পাবলিকেশনস্
করিমগঞ্জ, আসাম, ৭৮৮৭১১

Darshoner Aloke Bawl-Boishnab-Rabindranath, Edited by Dr. Buddadeb Mondal & Dr. Sujit Kumar Mondal, Published by Biplab Bhattacharjee, Scholar Publications, Karimganj, Assam, 788711, January, 2021.

ISBN: 978-81-944113-1-4

প্রথম প্রকাশ
জানুয়ারি, ২০২১

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স্কলার পাবলিকেশনস্
করিমগঞ্জ, আসাম, ৭৮৮৭১১

মুদ্রক:
স্কলার পাবলিকেশনস্
করিমগঞ্জ, আসাম, ৭৮৮৭১১

প্রচ্ছদ: পঙ্কজ দত্ত

দাম: ৫০০ টাকা

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HISTORY, HERITAGE AND RELIGION : PROBLEMS AND PERSPECTIVES

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First Published
2020

BOOK SYNDICATE (P) LTD.
www.booksyndicate.in

Published by :
Biplab Bhowal
for **Book Syndicate (P) Ltd.**
35 College Street, Kolkata 700 073
☎ 2257 0754/55
booksyndicate.35@gmail.com

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First Published : **February, 2020**

Price : Rupees five hundred fifty only
₹ 550

ISBN 978-93-87706-43-9

Printed by :
Kalyan Bhaumik
for **Mudran Bharati**
26 M. B. Road
Kolkata 700 049

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مخلص الرحمن

صرير القلم

دراسات أدبية

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صرير القلم

يحتوي الكتاب على أربعة محاور وخمسة عشر عنوانا في مجال اللغة والأدب والثقافة والصحافة العربية؛ أولا يتحدث الكتاب عن نشأة اللغة العربية وتطورها في مجالات وعصور مختلفة كما يتحدث عن أثر القرآن في اللغة العربية وآدابها وتحديات العصر الحاضر التي تواجهها اللغة العربية في ظل العولمة، والمحور الثاني يحتوي على بحوث ودراسات تتركز على بعض الروايات أو السير الذاتية، والمحور الثالث يتمحور حول دراسات لغوية وثقافية فيلقي الضوء على التبادل اللغوي بين المنطقتين العربية والهندية ودور التعدد اللغوي في تعزيز قيم المواطنة العالمية وما إلى ذلك، أما المحور الرابع والأخير يسلط الضوء على شخصية أدبية هندية كرست حياتها في خدمة اللغة العربية درسا وتدريسا، تأليفا وكتابة.



أستاذ مساعد بقسم اللغة العربية في كلية إيتش. بي. التابعة لجامعة بردوان، الهند. نشر له كتابان بالعربية كما نشرت له عشرات من المقالات إضافة إلى مشاركته في المؤتمرات. ويدير التحرير لمجلة "هلال الهند"، كما يساعد التحرير لمجلة "قطوف الهند".

NOOR PUBLISHING

9 786204 721149

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Cover image: www.ingimage.com

Publisher:
Noor Publishing
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Dodo Books Indian Ocean Ltd., member of the OmniScriptum S.R.L Publishing group
str. A.Russo 15, of. 61, Chisinau-2068, Republic of Moldova Europe
Printed at: see last page
ISBN: 978-620-4-72114-9

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INTERFACE

A NATIONAL RESEARCH ANTNOLOOY ON INDIGENOUS LANOUAGE, LITERATURE & CULTURE



(Edited Volume)

INTERFACE

A NATIONAL RESEARCH ANTHOLOGY ON INDIGENOUS LANGUAGE, LITERATURE & CULTURE



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ISSN 2364-6454 ISSN 2364-6462 (electronic)
Springer Hydrogeology
ISBN 978-3-030-62396-8 ISBN 978-3-030-62397-5 (eBook)
https://doi.org/10.1007/978-3-030-62397-5

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This Springer imprint is published by the registered company Springer Nature Switzerland AG
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Identification of Groundwater Potential Zones Using Multi-influencing Factors (MIF) Technique: A Geospatial Study on Purba Bardhaman District of India



Niladri Das, Prolay Mondal, Subhasish Sutradhar, and Ranajit Ghosh

Abstract In the present era, the resource crisis and the deterioration of quality of resources is the primary concern of the geographical study. Groundwater resource is the primary depleted resource today due to massive population pressure and indiscriminate use in agriculture. Hence, proper planning and strategies are needed to facilitate groundwater recharge. Therefore, a study, like the delineation of potential groundwater zones, is one of the prime tasks of the geographer, the environmentalist, and the scientist also. Present research involves the assessment of potential groundwater recharge zone by using a popular statistical method, i.e., multi-influencing factors (MIF) along with the application of GIS. Based on the study, three major potential zones have been identified viz. high potential zone, which comprises 20.65% area, moderate potential zone with 45.61% area, and low potential zone covering 33.74% area out of the total geographical area of the Purba Bardhaman district of West Bengal, India. High potential zones are predominantly observed in the extreme west and east of the test area as well as along the river course. Moreover, low potential zones are found in the middle and the southern part of this concerned region. In the end, validation of these potential zones has been made by taking actual yield from the field observation and comparing it with the prepared potential model. Therefore, this kind of study for the delineation of potential groundwater zones is very much relevant for the improvement of groundwater status in the era of the water crisis. The validation of this model proves that this model is 73.17% accurate for the identification of the potential groundwater zones.

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P. P. Adhikary et al. (eds.), *Geostatistics and Geospatial Technologies for Groundwater Resources in India*, Springer Hydrogeology,
https://doi.org/10.1007/978-3-030-62397-5_10

Keywords Geographic information systems · Groundwater potential zones · Multi-influencing factors · Remote sensing · ROC curve

1 Introduction

With the march of time, various sectors like agriculture, industry, and urbanization have seen rapid development in developing countries like India, increasing the demand for water (Venkateswaran and Ayyandurai 2015). In the present world, groundwater is one of the precious resources, which pulling the chariot of human civilization (Magesh et al. 2012). It is also one of the largest sources of fresh water. To meet the daily need, like drinking and other domestic activities, nearly 90% rural population and 30% urban population of India depends on groundwater (Reddy et al. 1995; Bhunia et al. 2012)

The demand for groundwater is increasing day by day, leading to a groundwater crisis. In this crisis phase, we must delineate groundwater potential zones to use this precise resource sustainably. Now, with the advent of advance Remote Sensing and GIS techniques, it has become cost-effective and time-saving work (Das and Mukhopadhyay 2020; Thapa et al. 2017; Chaudhary and Kumar 2018; Adiat et al. 2012; Verma and Singh 2012). In the era of advanced science and technology, it has become very much easy to access spatial, spectral, and temporal data of the entire world within a few minutes (Sener et al. 2004; Gupta and Srivastava 2010; Panahi et al. 2017). GIS techniques are useful tools to capture, manipulate, store, analyze, manage, and represent various kind of spatial data (Chowdhury et al. 2008; Gupta and Srivastava 2010). Although it cannot directly be identified, but integrating multiple layers in a single frame such as geology, soil type, rainfall, lineament density, aquifer thickness, drainage density, Land use and Land cover, slope, NDVI, etc., groundwater potential zones can be demarcated (Dar et al. 2010; Agarwal et al. 2013; Thapa et al. 2017; Magesh et al. 2012; Das and Mukhopadhyay 2020; Bhunia et al. 2012; Panahi et al. 2017).

To detect groundwater potential zones, different quantitative techniques have been used by various researchers viz. Analytic hierarchy process (AHP) is one of the standard quantitative methods (Ajay Kumar et al. 2020; Arulbalaji et al. 2019; Mohammadi-Behzad et al. 2019; Murmu et al. 2019; Nithya et al. 2019; Siva et al. 2017; Phukon et al. 2004; Chowdhury et al. 2009; Murthy and Mamo 2009; Adiat et al. 2012; Panahi et al. 2017; Das and Mukhopadhyay 2020), frequency ratio model (Manap et al. 2014; Oh et al. 2011;Razandi et al. 2015) and multicriteria decision evaluation (Machiwal and Singh 2015; Murthy and Mamo 2009; Jothibasu and Anbazhagan 2016). After consideration of the previous studies, recognition of potential groundwater zones, Multi-influencing factors (MIF) method is rather simple and easy to apply (Magesh et al. 2012; Thapa et al. 2017; Das et al. 2017; Biswas et al. 2013).

Purba Bardhaman district is agriculturally endowed, and groundwater plays a significant role in maintaining its status in agriculture. But over-exploitation of

groundwater is bringing the region under threat. According to the report of The Telegraph, April 2016, a joint survey was done by the Central Ground Water Board and the State Water Investigation Directorate, which identified Katwa-I, Katwa-II Kalna-I, Kalna-II, and Manteswar community development blocks under threat. Before the survey, Purbasthali-I and II community development blocks were demarcated to be having toxic groundwater. Overexploitation of groundwater leads to a very slow recharge. Water resources development ministry of West Bengal has said that more than 1, 62,000 water bodies' viz. canals, Ponds, and lakes have already silted up. Although the region gets sufficient rainfall, the dead water bodies cannot store water, and these water bodies cannot act as recharge potential as these are silted up. Therefore, for optimum use of groundwater, it is essential to demarcate the potential groundwater zones, so that policymakers, planners and local government and local people can identify the suitable and unsuitable borehole locations (Thapa et al. 2017; Das et al. 2017).

2 Materials and Methods

2.1 Study Area

Purba Bardhaman district is a newly formed district of West Bengal, divided from the previous Bardhaman district. This district is extending from 22° 56′ 00″ N to 23° 51′ 00″ N latitude and 87° 26′ 00″ E to 88° 25′ 00″ E longitude, occupying 5416 km^2 area and contains 23 C.D. blocks (Fig. 1).

This district is bounded by Paschim Bardhaman district (newly created) in the west, Birbhum District in the north, separated by Ajoy river, Murshidabad in the north, and the Bhagirathi river forms eastern boundary separating Nadia District from Purba Bardhaman district. In the south-east direction, the Damodar River flows dividing the Bankura district from it, and in the south-west side of this district, Hugli district is located. Geographically Purba Bardhaman district is characterized by Ganga-Brahmaputra alluvial plain both in the northern part and in the eastern region.

2.2 Data Used

To prepare thematic layers, conventional data and satellite data have been utilized from different sources. The administrative map of India and West Bengal has been downloaded from the DIVA-GIS portal. The Community Development blocks of the Purba Bardhaman district have been digitized from the map derived from the official website of the Purba Bardhaman district (http://Purbabardhaman.gov.in/burdwan/for_citizen/maps.php). The geological variety of the Purba Bardhaman district

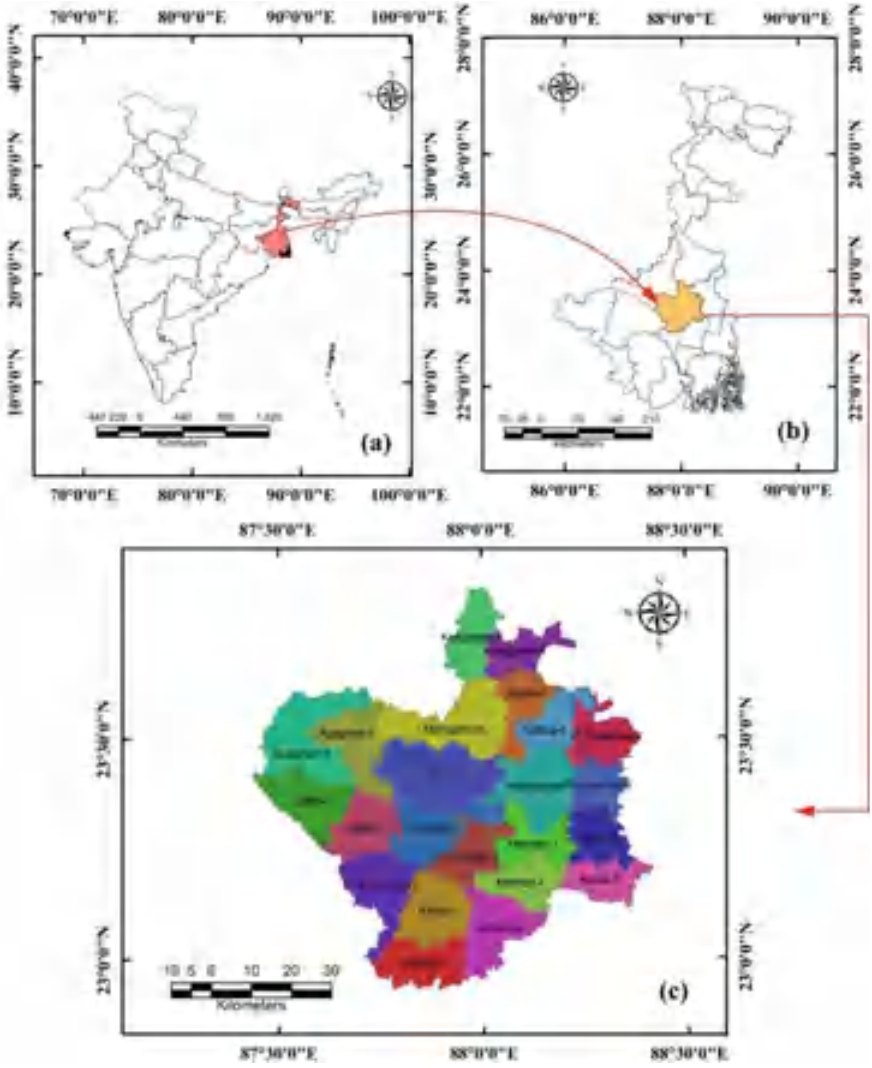


Fig. 1 **a** India. **b** West Bengal. **c** Purba Bardhaman

has been collected from the district resource map of Burdwan. Rainfall map and soil type map have been digitized from the district planning map of the NATMO. Aquifer thickness map has been digitized and prepared as a thematic layer in Arc GIS 10.5 from India-WRIS Web map services. The map of lineament density has been collected from BHUVAN Portal, and this map is made in ArcGIS 10.5 software using the line density tool. Land use/Land cover (LULC) map has been prepared from LANDSAT 8 OLI images (Table 1) of USGS EarthExplorer (https://earthexplorer.usgs.gov/) and supervised classification has been done in Arc GIS 10.5 using image analysis tool.

Table 1 LANDSAT 8 OLI images utilized in this study

Sl. no.	Image ID	Row/Path	Acquisition date	Spatial resolution (m)
1.	LC81380442018139LGN00	138/044	2018/05/19	30
2.	LC81390442018114LGN00	139/044	2018/04/24	30

Normalized difference vegetation index has been made using the above LANDSAT 8 OLI images of band 4 and band 5. To prepare slope and drainage map, SRTM DEM of 30 m resolution has been used and made in the Arc GIS 10.5 environment.

2.3 Multi-influencing Factors (MIF) for Weightage

To delineate potential groundwater zones, ranks were assigned to all the parameters statistically, using the MIF technique based on a literature review (Fig. 2). Factors which has dominant control on groundwater potentiality has been assigned as major effect and on the other hand, factors having less control assigned as a minor effect. A major factor has been assigned as weight 1, and minor factor has been assigned as weight 0.5, which is plotted in Table 2 based on Fig. 3 (Magesh et al. 2012; Thapa et al. 2017). Proposed Relative rates have been calculated by summing up the ranks of minor and major effect (Table 3). Then the proposed score of each factor has been calculated using this formula

$$PoposedScore = \left[\frac{(X_1 + X_2)}{\sum (X_1 + X_2)}\right] \times 100$$

where X_1 is Major effect and X_2 is minor effect.

With the help of the MIF, we can get weight for each parameter (Table 4). After reclassification with weightage, we made an overlay of all these selected layers with the help of Weighted overlay tool in spatial analyst in Arc GIS 10.5 software (evaluate copy) to delineate the potential zones.

3 Result and Discussion

To delineate the potential zones of Purba Bardhaman district, nine influencing factors of the groundwater recharge and storage have been considered viz. geology, lineament density, rainfall, soil type, slope, drainage density, aquifer thickness, land use/land cover and NDVI. All the factors have been studied individually concerning groundwater production and storage (Das et al. 2017).

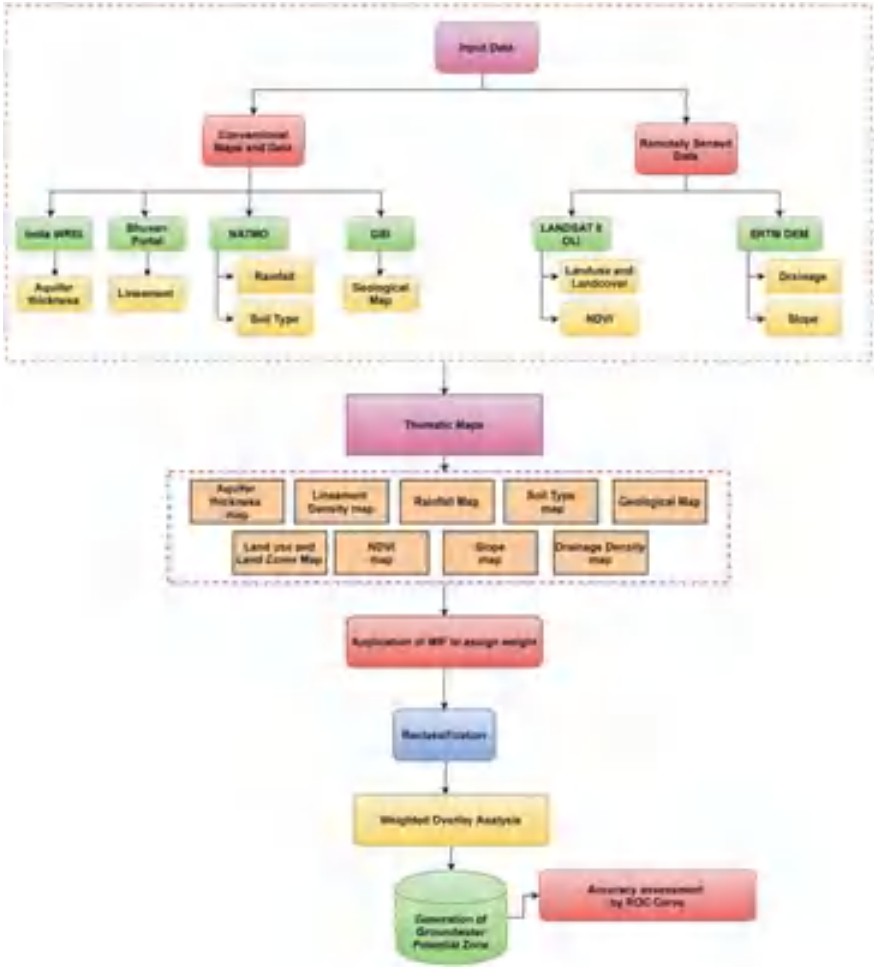


Fig. 2 Flowchart of the methodology of delineation of groundwater potential zones

3.1 Influencing Factors of Groundwater Potentiality

3.1.1 Slope

The slope is another significant physiographic factor and one of the best indicators for the identification of potential zones (Al Saud 2010; Ettazarini 2007). Slope controls the runoff process and infiltration rate of the groundwater (Gouri et al. 2019). Therefore, it strongly influences the groundwater recharge (Adiat et al. 2012; Bhunia et al. 2012; Kumar et al. 2014). Slope morphology explains that groundwater recharge is adversely related to it (Rahmati et al. 2016). Hence, the higher the degree of slope, the lower weightage has been assigned and vice versa. The slope map has been made

Table 2 Major effect and minor effect, proposed relative rates and scores for influencing factors (Magesh et al. 2012)

Factor	Major effect (X_1)	Minor effect (X_2)	Proposed relative rates ($X_1 + X_2$)	Proposed score of each influencing factor
Aquifer thickness	1	0.5	1.5	6
Geology	1 + 1 + 1 + 1	0.5	4.5	19
Lineament density	1	0.5	1.5	6
Rainfall	1 + 1	0.5 + 0.5	3	13
Drainage density	0	0.5	0.5	2
Soil type	1 + 1	0	2	9
Slope	1 + 1 + 1 + 1	0.5 + 0.5	5	21
LULC	1 + 1	0.5 + 0.5	3	13
NDVI	1 + 1	0.5	2.5	11
			∑23.5	∑100

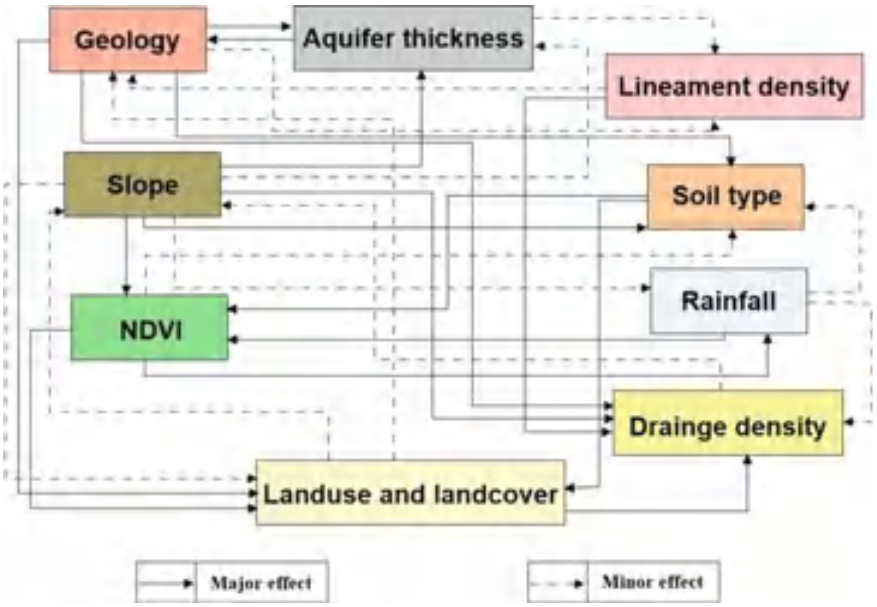


Fig. 3 Interrelationship and interdependence between influencing factors affecting the groundwater potential zone

Table 3 Factors assigning weightage concerning groundwater potential

Thematic map	Weightage	Groundwater potentiality
Geology	Clay alternating with silt & sand	Moderate
	Clay with caliche concretion	Very poor
	Laterite	High
	Sand, silt and clay	Poor
Rainfall	High (>1400 mm)	Good
	Moderate (1200–1400 mm)	Moderate
	Low (<1200 mm)	Poor
Soil	Alfisoils older alluvium	Poor
	Entisoils younger alluvium	Moderate
	Lateritic utisoils	Good
Slope	High	Poor
	Moderate	Moderate
	Low	High
Drainage density	High	Unsuitable for groundwater potential
	Moderate	Moderately suitable for groundwater potential
	Low	Suitable for groundwater potential
Lineament density	High	Suitable for groundwater potential
	Moderate	Moderately suitable for groundwater potential
	Low	Unsuitable for groundwater potential
Aquifer thickness	High	Good
	Moderate	Moderate
	Low	Poor
NDVI	High	Good
	Moderate	Moderate
	Low	Poor

from SRTM DEM of 30-m spatial resolution provided by USGS Earth Explorer, and it has been processed in Arc GIS 10.5 software (Fig. 4a). This region comprises with moderate category of the slope, which ranges between 1.27° and 2.97°.

3.1.2 Geology

Geology is the fundamental parameter that strongly influences groundwater recharge and helps to determine the potentiality of the groundwater. So, the groundwater storage initially depends upon the geological structure (Hachem et al. 2015). Geological formations ascertain the recharge and storage capacity of groundwater (Ayazi

Table 4 Thematic layers with its classes, ranks and weightage

Layers	Classes	Assigned ranking	Weightage
Geology	Clay alternating with silt & sand	14	19
	Clay with callche concretion	4	
	Laterite	19	
	Sand, silt and clay	9	
Rainfall	High (>1400 mm)	13	13
	Moderate (1200–1400 mm)	9	
	Low (<1200 mm)	5	
Soil Type	Alfisoils older alluvium	3	9
	Entisoils younger alluvium	6	
	Lateritic utisoils	9	
Slope	High	21	21
	Moderate	14	
	Low	7	
Drainage density	High	1	2
	Moderate	1	
	Low	2	
Lineament density	High	6	6
	Moderate	4	
	Low	2	
Aquifer thickness	High	6	6
	Moderate	5	
	Low	4	
	Very Low	3	
NDVI	High	11	11
	Moderate	7	
	Low	3	
LULC	Built up area	3	13
	Sandy area	9	
	Current fallow	5	
	Vegetation	11	
	Cultivated land	7	
	Water bodies	13	

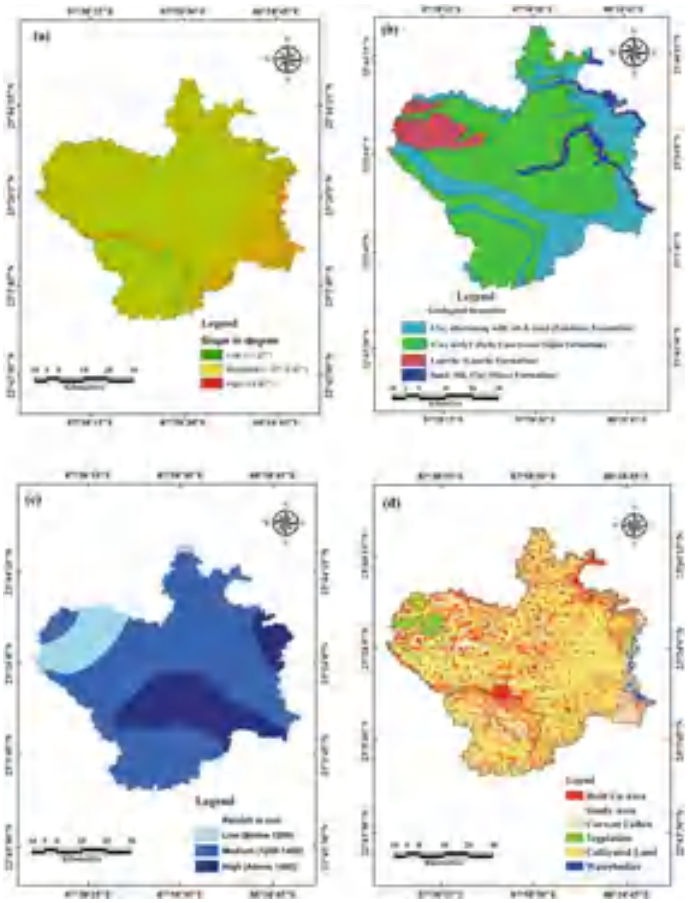


Fig. 4 Thematic maps: **a** Slope. **b** Geology. **c** Rainfall. **d** Land use and land cover. **e** NDVI. **f** Soil type. **g** Aquifer thickness. **h** Lineament density. **i** Drainage density

et al. 2010; Chowdhury et al. 2009; Jhariya et al. 2016). This region is characterized by four significant geological formations viz. sand, silt and clay formation, clay with caliche concretion formation, clay alternation with silt and sand formation, and laterite formation (Fig. 4b).

The concretion is a kind of hard and compact mass of materials formed by the precipitation of minerals and cemented pore spaces of the soil. Therefore it discourages the recharge of groundwater, and hence this formation leads to very low potentiality to groundwater availability. Laterite supplies productive groundwater storage because of good permeability (Das and Mukhopadhyay 2020). Thus it creates an excellent potential zone of groundwater storage. Therefore, laterite is given more weightage than other geological formation. Clay alternation with silt and sand also moderately influences groundwater potentiality.

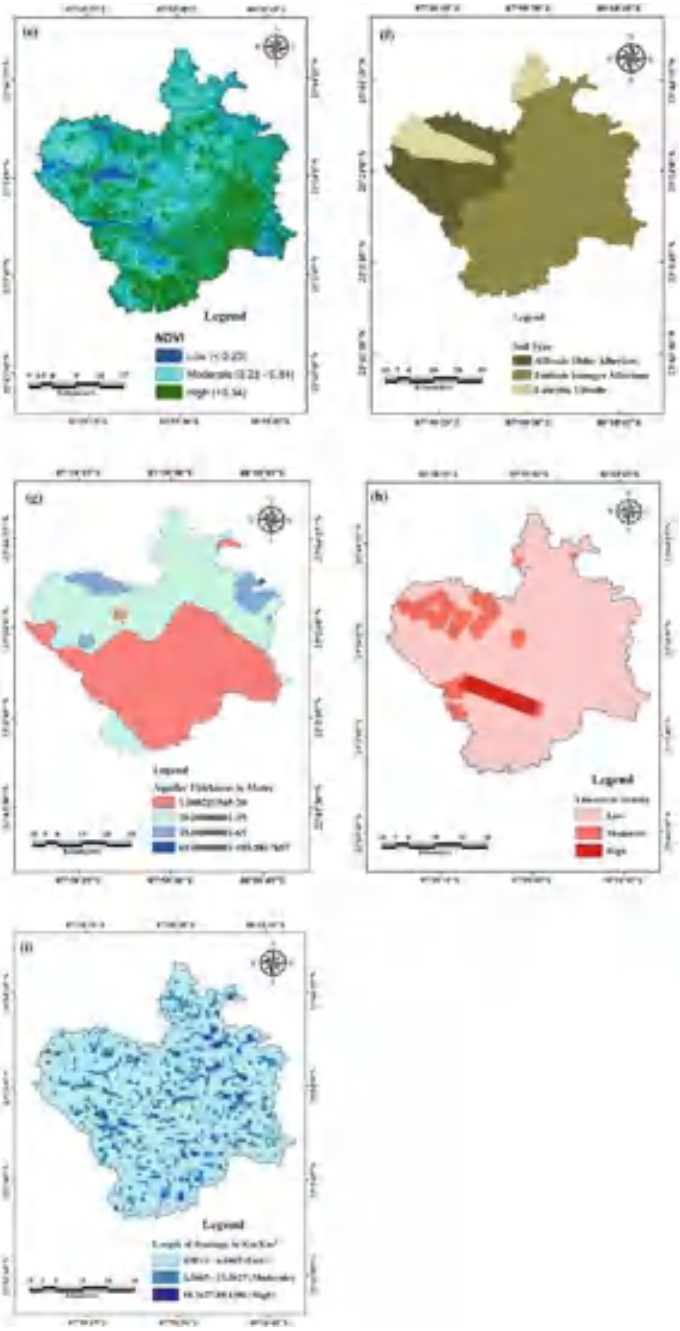


Fig. 4 (continued)

3.1.3 Rainfall

In the hydrological cycle, rainfall plays an important role in groundwater retention, which ultimately determines the groundwater potentiality and fluctuation (Magesh et al. 2012; Agarwal et al. 2013). The study region receives nearly 80% rainfall from south-west monsoon from June to September. Rainfall map has been digitized from the district planning map of NATMO, which has been categorized into three subclasses viz. High (Above 1400 mm), medium (1200–1400 mm), and low (less than 1200 mm). The southeastern portion of the region receives more than 1400 mm rainfall, which carries out 22%. The western part receives below 1200 mm rainfall with 10% areal coverage. The rest part of the study area has experienced a medium category of rain, which ranges from 1200 to 1400 mm and covers 67% area (Fig. 4c).

3.1.4 Land Use and Land Cover

LULC is also an important parameter to identify the extension of the need and use of groundwater (Jhariya et al. 2016). It helps to understand the variation of recharge in different units of land use (Singh et al. 2011). The LULC map has been prepared with Landsat-8 satellite images, which are downloaded from the USGS earth explorer portal, and supervised classification has been done using the maximum likelihood method in ArcGIS 10.5 software. Six types of classes have been extracted in this test area viz. built up, sandy area, current fallow, vegetation, cultivated land, and water bodies (Fig. 4d). As the Waterbody is the best-known source of the unit of groundwater recharge, the highest weightage is assigned for this parameter. Vegetation also acts as an important parameter as the recharger of the groundwater; hence it has been given good weightage after water bodies. Low weightage has been assigned for Built-up areas as this zone has a meager infiltration rate. In the study area, 23.33% area is under the built-up area, 55.59% area is under cultivated land, only 3% is underwater bodies, 2.85% is under the converge of vegetation. As this area belongs to the riverine floodplain, hence major part of the district is under cultivable land.

3.1.5 NDVI

For the identification of vegetation quality, NDVI is an important index, and it has been widely used in the present era of RS & GIS. To identify the potential groundwater zones, NDVI has been considered an important parameter. The values obtained from NDVI ranges from -1 to $+1$, and if the value is >0.4, it indicates as dense vegetation. If the value is <0.1, there is no vegetation i.e., barren land. Moreover, if the value is 0 or less than it, it may be water bodies, wet areas. NDVI map has been prepared from Landsat-8 satellite image in ArcGis 10.5 environment with the help of this formula

$$NDVI = \frac{NIR - RED}{NIR - RED}$$

where NIR denotes Near-Infrared band, and RED denotes the band 4 of Landsat image.

Figure 4e explains that the southeastern part of the test area is characterized by higher NDVI value, which indicates vegetation covers over this part. Moreover, the central and northwestern parts of this district are experienced medium to low NDVI value that means this part has less or no vegetation cover.

3.1.6 Soil Type

Soil type is one of the necessary natural elements that significantly determine the water infiltration rate. The study region is characterized by three types of soil viz. Older Alluvium, Younger Alluvium, and Laterite (Fig. 4f). About 70% area of the region is covered by younger alluvium due to high deposition by the rivers almost every year. This soil is mainly found in the western part of this district. About 19 and 10% of the area are under older alluvium and laterite, respectively. Both the soils are found in the western and northern parts of the district. Newer alluvium is more influencing for groundwater recharge than older alluvium. Moreover, laterite soil strongly accelerates the groundwater recharge due to its high porosity. Hence laterite soil has been given more weightage followed by younger alluvium and older alluvium.

3.1.7 Aquifer Thickness

An aquifer is a layer of unconsolidated porous rock that allows water to flow through it. Aquifer thickness of any area plays a vital role in controlling the groundwater potentiality. As aquifers contain water, therefore areas having higher aquifer thickness will have more groundwater potential. In this area, the width of the aquifers varies from 1.000221565 to 185.9817657 m. The region having lesser aquifer thickness is found in the majority of this district. Some parts of the eastern and northern parts have higher aquifer thickness (Fig. 4g). 51.23% has very little aquifer thickness of 1.000221565 to 20 m, 43% of the study area has 20.00000001–35 m aquifer thickness, 5.71% has 35.00000001–65 m, and only 0.06% has 65.00000001–185.9817657 m aquifer thickness.

3.1.8 Lineament Density

Lineament is tectonically originated features of linear, rectilinear, curvilinear shape, and can be extracted from the satellite image (Magesh et al. 2012; Jhariya et al. 2016). The number of lineaments influences the infiltration rate and hence sufficient groundwater recharge. Spatial data of lineament has been collected from the Bhuvan Geoportal (Das and Mukhopadhyay 2020). An area having higher lineament density is more conducive for the potentiality of groundwater. Therefore, in this study, classes

of higher lineament density have been assigned higher weightage and vice versa. Figure 4h depicts that in the study region, the lineament density is very high only along the Damodar river valley, and the rest of the area has experienced very little lineament density.

3.1.9 Drainage Density

Drainage density means the length of stream per unit area (Horton 1932; Strahler 1952; Das and Mukhopadhyay 2020). Drainage density has a dominant influence on the groundwater potentiality as it has an inverse relation with infiltration (Chowdhury et al. 2009; Agarwal et al. 2013; Magesh et al. 2012; Das and Mukhopadhyay 2020). Higher the drainage density value, the higher will be the surface runoff, and hence lower will be the recharge of groundwater and vice versa. So, higher weightage has been given to the lower drainage density and lower weightage for higher drainage density. In this district, almost above 90% area is under low drainage density zone (Fig. 4i).

3.2 Delineation of Groundwater Potential Zones

Based on Multi-Influencing Factors technique, and arrangement of the pixel of all influencing factors like, rainfall, drainage density, soil type, slope, lineament density, aquifer thickness, LULC and NDVI, the groundwater potential zones map has been prepared (Fig. 5) and three potential zones have been identified which are high, medium and low. Each potential zone has a certain area, i.e., low potential zone covers 1815.1 km^2, moderate potential zone occupies 2453.18 km^2 and high potential zone covers 1110.83 km^2. The percentage of area covered under potential zones is shown in the following Table 5.

Based on the pixel arrangement of all the thematic layers, a final map has been extracted which depicting groundwater potential zones. This map reveals that groundwater potentiality has strongly been influenced by physical factors like geology, river, slope, lineament, etc. (Das and Mukhopadhyay 2020). From Fig. 5, it is observed that a high potential zone is a characteristic feature of laterite formation and clay alternating with silt and clay because it allows a high rate of percolation of groundwater and large storage of groundwater. Moreover, the high potential zone can also be found along the riverside due to the continuous supply of surface water.

In this present context, identification of groundwater potential zone is very much important because the potentiality of any resource provides a new dimension to rethink for sustainable use of that resource to the planner. Therefore, the delineation of these zones of Purba Bardhaman district will help to formulate a suitable regional level plan (Das and Mukhopadhyay 2020).

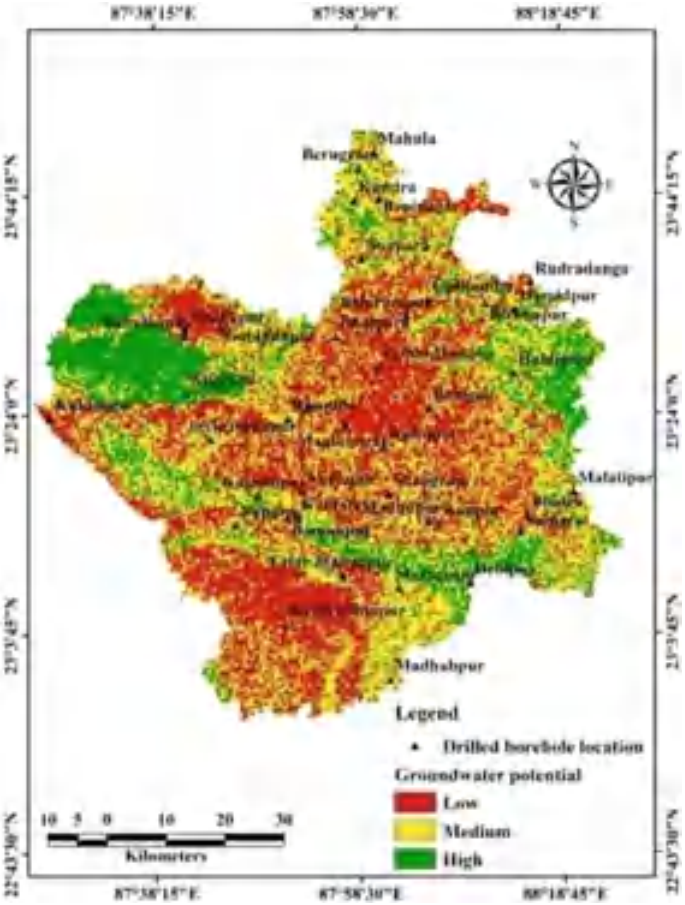


Fig. 5 Groundwater potential zones of Purba Bardhaman district

Table 5 Area under different Groundwater potential zones

Groundwater potential zone	Area (km^2)	Percentage of area
Low potential zone	1815.1	33.74
Moderate potential zone	2453.19	45.61
High potential zone	1110.83	20.65

3.3 Validation of the Groundwater Potential Zones

To validate the finally extracted groundwater potential zones map, 41 drilled boreholes have been selected from where boreholes yield data have been collected. Borehole locations have been plotted in Fig. 6 and actual yield data have been tabled in Table 6. Based on the field data, the yield ranges have been categorized into 3 groups

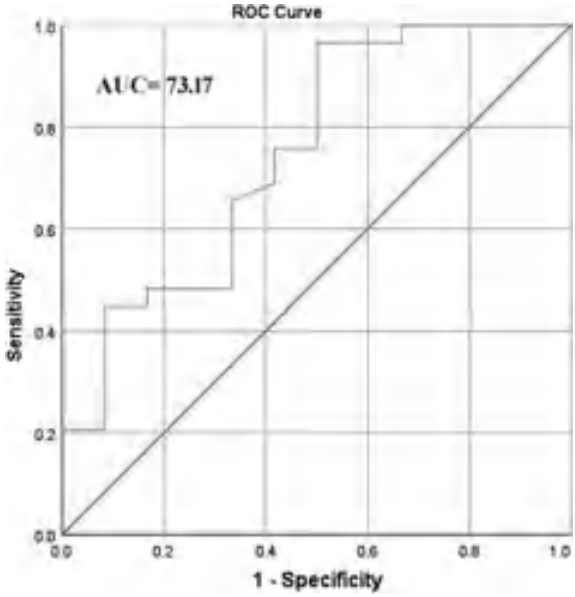


Fig. 6 Receiver Operating Characteristic (ROC) to validate the potential zones

viz. less than 3 lps as low yield zone, 3–6 lps as medium yield zone, and more than 6 lps as high yield zone. The actual yield and expected yield that is predicted from the groundwater potential zones map have been shown in Table 6 and agreement between actual and expected yield have been tabled to explain the remark of agreeing and disagreeing, which represents the consistency between actual yield and predicted yield. For the accuracy assessment of the map following steps have been followed

i. Bore hole surveyed = 41
ii. Number of surveyed boreholes under agreement = 30
iii. Number of surveyed boreholes under disagreement = 11
iv. The accuracy prediction =

$$\frac{\text{No. of boreholes under agreement of coherence}}{\text{Total number of borehole surveryed}} \times 100$$
$$= \frac{31}{41} \times 100$$
$$= 73.17\%$$

The accuracy value 73.17% indicates that the Multi-Influencing Factors technique with the help of remote sensing and GIS can be successfully applied to generate a successful result.

To understand the level of accuracy graphically, Receiver Operating Characteristic (ROC) curve is mostly used (Das and Mukhopadhyay 2020). The area under curve has been drawn against the real and expected yield of groundwater, which represents

Table 6 Accuracy assessment of groundwater potential zones by comparing of actual groundwater yield with the obtained groundwater potential zones

Sl. no.	Location	Latitude	Longitude	Actual yield from drilled borehole (lps)	Actual yield remark	Expected yield predicted from the map	Agreement between actual and expected
1	Berugram	23° 46′ 48″	87° 58′ 40″	3.75	Medium	Medium	Agree
2	Basudha	23° 23′ 40″	87° 51′ 27″	6.87	High	High	Agree
3	Babubandh	23° 31′ 23″	87° 41′ 24″	0.33	Low	High	Disagree
4	Bamanpur	23° 14′ 38″	87° 51′ 22″	1.62	Low	Low	Agree
5	Aligram	23° 25′ 59″	87° 41′ 20″	1.6	Low	Low	Agree
6	Jaykrishnapur	23° 21′ 46″	87° 43′ 47″	5.28	Medium	Medium	Agree
7	Manikbazar	23° 22’ 59″	87° 57′ 9″	3.8	Medium	Medium	Agree
8	Mallikpur	23° 31′ 60″	87° 41′ 30″	1.38	Low	High	Disagree
9	Kandra	23° 43′ 45″	87° 58′ 13″	1.13	Low	High	Disagree
10	Bhatpara	23° 31′ 7″	87° 55′ 52″	6.57	High	High	Agree
11	Napara	23° 13′ 54″	87° 46′ 11″	4.02	Medium	Medium	Agree
12	Kanpur	23° 13′ 57″	88° 6′ 22″	3.92	Medium	Medium	Agree
13	Kashimpur	23° 16′ 35″	87° 48′ 26″	3.63	Medium	Medium	Agree
14	Kubijpur	23° 22′ 14″	87° 59′ 19″	7.2	High	High	Agree
15	Gobindapur	23° 32′ 8″	87° 44′ 40″	3.89	Medium	Medium	Agree
16	Kuldanga	23° 23′ 33″	87° 27′ 37″	3.52	Medium	Medium	Agree
17	Uttar Mahanpur	23° 9′ 25″	87° 56′ 45″	6.7	High	High	Agree
18	Mahula	23° 48′ 15″	88° 0′ 14″	4.12	Medium	Medium	Agree
19	Beninagar	23° 43’ 52″	88° 0′ 38″	6.67	High	High	Agree
20	Natungram	23° 36′ 3″	88° 8′ 7″	7.88	High	High	Agree
21	Hamidpur	23° 33′ 40″	88° 14′ 9″	5.63	Medium	Low	Disagree
22	Balarampur	23° 32′ 45″	88° 2′ 37″	6.63	High	High	Agree
23	Goshumba	23° 33′ 54″	88° 4′ 41″	6.35	High	High	Agree
24	Gobardhanpur	23° 28′ 24″	88° 0′ 59″	1.92	Low	Medium	Disagree
25	Haldipara	23° 27′ 46″	88° 14′ 6″	9.35	High	High	Agree
26	Bishnupur	23° 34′ 12″	88° 11′ 12″	4.12	Medium	Medium	Agree
27	Shaligram	23° 16′ 43″	88° 1′ 24″	3.85	Medium	Low	Disagree
28	Bhojpur	23° 24’ 35″	88° 5′ 33″	4.02	Medium	High	Disagree
29	Masagram	23° 8′ 2″	88° 2′ 24″	7.53	High	Medium	Disagree
30	Debipur	23° 8′ 32″	88° 9′ 31″	5.13	Medium	Low	Disagree
31	Rudradanga	23° 36′ 8″	88° 15′ 56″	7.65	High	High	Agree

(continued)

Table 6 (continued)

Sl. no.	Location	Latitude	Longitude	Actual yield from drilled borehole (lps)	Actual yield remark	Expected yield predicted from the map	Agreement between actual and expected
32	Kalitala	23° 14’ 36″	87° 52′ 20″	3.73	Medium	Medium	Agree
33	Chandipur	23° 24′ 46″	87° 53′ 30″	8.18	High	High	Agree
34	Noapara	23° 38′ 30″	87° 58′ 44″	7.72	High	High	Agree
35	Ramkrishtopur	23° 5′ 47″	87° 49′ 41″	7.62	High	High	Agree
36	Malatipur	23° 16′ 51″	88° 19′ 51″	4.52	Medium	Medium	Agree
37	Madhupur	23° 14′ 10″	88° 5′ 22”	3.37	Medium	Medium	Agree
38	Mirjapur	23° 16′ 56″	87° 52′ 55”	3.05	Medium	Low	Disagree
39	Bhatra	23° 14′ 41″	88° 15′ 12″	4.37	Medium	Medium	Agree
40	Suipara	23° 13′ 13″	88° 14′ 32″	4.45	Medium	Medium	Agree
41	Madhabpur	22° 59′ 34″	88° 1′ 32″	4.92	Medium	Low	Disagree

0.731 or it compared to 73.1% accuracy. So, it can be remarked that this method can be used here to generate a precious result of the groundwater potential map.

4 Conclusion

The delineation of groundwater potential zones with the aid of advanced approach of remote sensing and GIS using multi-influencing factors (MIF) technique in the Purba Bardhaman district may be very much helpful for the sustainable development planning of underground water resources. The result depicts that about 20.65% area is in the category of the high potential zone, and with the help of the ROC curve, it has been proved that this method is about 73% accurate for the assessment of groundwater potential zones. Moreover, Purba Barddhaman is an agriculturally endowed region, so for the better management of groundwater resources, especially for agricultural purposes, this kind of study is very much relevant and justified. Common people can also be benefited from the map because, with the help of this, they can easily identify the proper drilling area to extract water for a long time.

Acknowledgements Authors express their gratitude to Dr. Gopal Chandra Debnath, former Professor, Department of Geography, Visva-Bharati, Santiniketan for his constant supervision, invaluable keen interest, wise counseling, and encouragement. Authors also express their thanks to Dr. Gautam Sen, Assistant Professor, Hiralal Bhakat College, Nalhati, Birbhum, and Dr. Debayan Deb Barman, Assistant Professor, T.H.L.H. Mahavidyalaya, Mollarpur, Birbhum.

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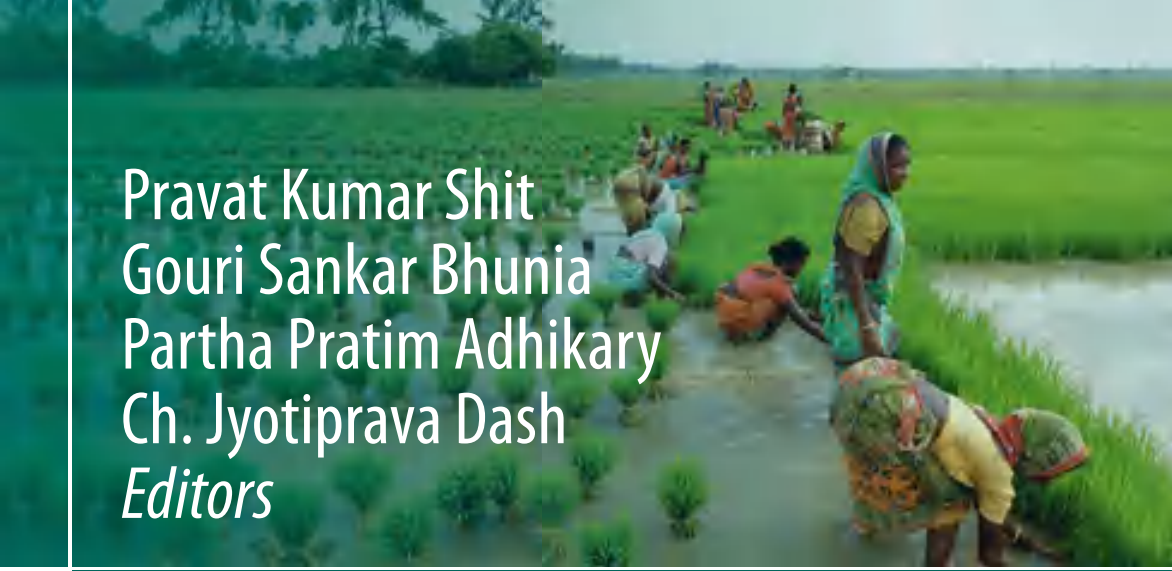
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ISBN 978-3-030-64135-1 ISBN 978-3-030-64136-8 (eBook)
https://doi.org/10.1007/978-3-030-64136-8

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Chapter 12
Multi-criteria Analysis for Groundwater Quality Assessment: A Study in Paschim Barddhaman District of West Bengal, India



Payel Das and Niladri Das

Abstract Groundwater, one of the most valued natural hydrological resources, plays an important character in various sectors, i.e. agriculture, industry, and household. With increasing population pressure, its quality and quantity are affected enormously. Therefore, groundwater quality assessment is of prime necessity to confirm the availability of safe water for consumption and utilization in agriculture purpose. The present study was conducted on Paschim Barddhaman district of West Bengal based on 14 physico-chemical parameters, i.e. pH, EC, TH, Ca, Mg, Na, K, HCO_3, Cl, SO_4, PO_4, F, Fe and SiO_2 of 43 groundwater samples. Multi-criteria analysis, such as factor analysis and cluster analysis, has been done to extract the principal controlling factors of groundwater chemistry. Factor analysis shows that four factors explain the total variance of 71.358%, and it implies that the hydrogeochemistry of groundwater is influenced not only by the interaction of groundwater and geology but also by contamination by the chemical fertilizer, industrial effluent and urban sewage. From the hierarchical cluster analysis, three clusters are identified from the region on the basis of homogenous groundwater chemistry. Gibbs diagram indicates that groundwater hydrochemistry is mainly influenced by the nature and composition of rocks. Water quality indices reveal that the groundwater of the district is safe for drinking purposes except very few locations. Based on irrigation suitability analysis, i.e. sodium percentage, sodium absorption ratio and permeability index, majority of the sample villages show that groundwater is suitable for irrigation purpose except a few villages.

Keywords Hydrochemistry · Hierarchical cluster analysis · Irrigation suitability · Principal component analysis · Water quality index

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P. K. Shit et al. (eds.), *Groundwater and Society*,
https://doi.org/10.1007/978-3-030-64136-8_12

12.1 Introduction

Groundwater plays a crucial part in human life, and it has a strong importance in agriculture, industry and household sectors. With increasing population pressure, the worldwide demand for groundwater resource is gradually escalating. The global population was recorded as 7.6 billion in 2018 and is projected to reach 9.6 billion in 2050 (United Nations 2013). Therefore, in the future, there will be a safe drinking water scarcity. In India, annually about 230 cubic kilometres of groundwater is abstracted for different purposes, i.e. irrigation, drinking, industrial, etc., and greater than 60% of agricultural irrigation and 85% of drinking water supply rely upon the groundwater resource (World Bank 2012). Although groundwater is considered as a replenishable resource, it is not renewed very quickly. The average time of subsurface water renewal is about 14000 years (World Water Balance 1978). So, monitoring of groundwater chemistry and water quality assessment are required for better planning. Jain et al. (2000), Meenakumari and Hosmani (2003), Jain (2004), Gupta et al. (2008), Banoeng-Yakubo et al. (2009), Singh et al. (2010), Nosrati and Eeckhaut (2012), Dhakate et al. (2013), Ghosh and Kanchan (2014), Pazand and Javanshir (2014), Kumar et al. (2015), Adhikary et al. (2015), Bencer et al. (2016), Boateng et al. (2016), Hassen et al. (2016), Longanathan and Ahamed (2017), Kazakis et al. (2017) and some other distinguished persons have deeply studied the groundwater hydro-geochemistry in different slices of the world and evaluated the quality of groundwater for domestic and agricultural purposes.

Groundwater contamination is an urgent matter of concern because people largely depend on the groundwater source for different purposes. Consumption of contaminated groundwater is dreadful for all the biota (Jain et al. 2000; Baba and Tayfur 2011). On a global scale, about three million people die in every year due to the consumption of contaminated water (WHO 2004). Scientific management of groundwater resource is poor in the developing countries. Groundwater quality assessment is important in this context. Surface water quality is severely affected by the intensive use of chemical fertilizer and pesticide in agriculture, industrial wastage, domestic sewage, etc., but the groundwater quality is influenced not only by the agricultural actions and industrial effluents but also geological formation, groundwater level, flow pattern, degree of chemical weathering, etc. Knowledge of subsurface water chemistry is inevitable to detect the source of chemical compounds of groundwater like geogenic or anthropogenic (Srinivasamoorthy et al. 2008; Chenini et al. 2010; Das et al. 2019).

Gupta et al. (2008) studied the hydro-chemical properties of groundwater of the entire Burdwan district to assess the irrigation suitability. Singh et al. (2010) studied about the groundwater quality of Raniganj coal mining area. Thapa et al. (2018a) investigated the manganese-contaminated zones of Burdwan district using the frequency ratio model, and they (2018b) also demarcated the iron-contaminated zone of Burdwan district. For this investigation, Paschim Barddhaman is selected as the study area. Paschim Barddhaman is a mining-based industrial and urbanized district. Asansol and Durgapur Municipal Corporation and Raniganj, Jamuria and Kulti

municipalities collectively generate about 696 tons per day of solid waste (Department of Municipal Affairs 2013). Municipal solid wastes, hazardous wastes and biomedical wastes are being openly dumped in the waste disposal sites (Kalipahari, Asansol, Samdihi, Burnpur) and non-engineered municipal solid waste landfill site (Durgapur) which causes infiltration of leachates in subsurface water (Adhikari and Pal 2016). Urban sewage, untreated industrial effluents, solid wastes and mining wastes are some major vectors of groundwater contamination in the industrial belt of Paschim Barddhaman (Holt 2000; Tiwary 2001). Moreover, in the eastern share of the test area mainly, Kanksa block has been endowed with massive agricultural production. So, the application of chemical fertilizer to obtain more agriculture production may cause the deterioration of groundwater quality. As consumption of contaminated water is harmful for human health, groundwater quality assessment is very urgent to this district. It will help to plan for supportable water resource management. The main aims of this study are to assess the hydro-geochemistry using multivariate statistical techniques like factor analysis and cluster analysis and evaluate the groundwater quality for drinking and irrigation purposes using the parameters sodium percentage (Na%), sodium absorption ratio (SAR), permeability index (PI), magnesium ratio (MR), etc.

12.2 Test Area

Paschim Barddhaman district is located between 23°24′10.25″N to 23°52′40.16″N latitude and 86°47′46.41″E to 87°31′33.81″E longitude, encompassing an area of 1603.17 km^2, and it consists of 2 municipal corporations and 8 community development (CD) blocks (Fig. 12.1). Administratively, the test area is surrounded by the Jharkhand state in the west and north-west, Birbhum district in north, Purba Barddhaman district in the east and Purulia and Bankura district in south. Damodar marks the southern boundary; Barakar forms the western boundary and Ajay separates the district from Birbhum district. Physically, this region is a part of the '*Rarh*' Bengal.

In geological point of view, this district comprises many rock formations, e.g. dissected plateau composed of granitic gneissic complex of Archaean age is present in the north-western portion of the district, while the eastern part of the district is made up of laterite of tertiary period and a few patches of the quaternary alluvium, and in between these two, a large tract is covered by Gondwana deposition (Fig. 12.2). Archaean granite gneiss and migmatite of Chota Nagpur granite gneissic complex are bared in the north-western fringe of the test area constituting the oldest basement rock. Gondwana supergroup sedimentary sequence is deposited within a faulted, subsided semi-graben-type structural trough over the basement rock. Talchair, Barakar, Barren Measure, Raniganj and Panchet formation constitutes the lower Gondwana group composing sandstone, shale, conglomerate and siltstone with coal seams. Raniganj formation is predominant in coal supplying in the district (Table 12.1). Groundwater resource of the study area is largely guided by the

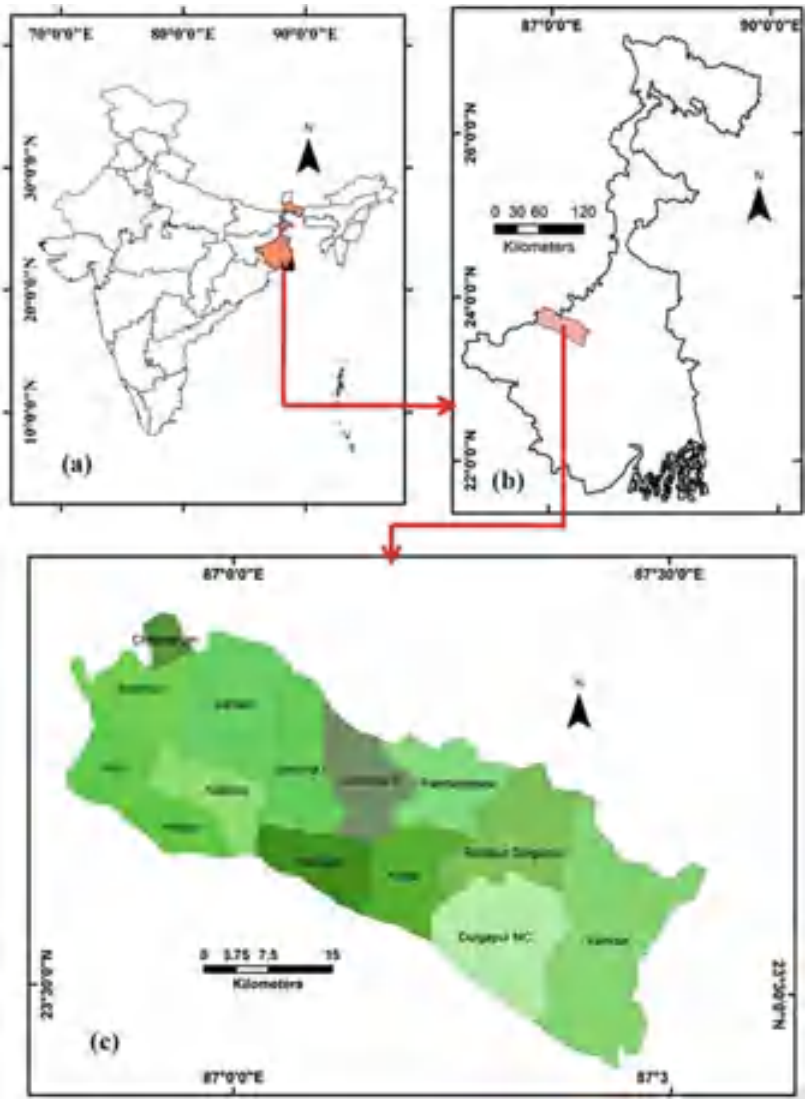


Fig. 12.1 Location map of (**a**) India, (**b**) West Bengal and (**c**) Paschim Barddhaman district

geology and geomorphology of the district (Gupta et al. 2008). Except the east margin, the entire study area is characterized by limited yield prospect (below 50 m^2/h). Tertiary and quaternary deposits of the eastern section of the test area have a large yield potential (above 150 m^2/h). In the westernmost section of the test area, groundwater is restricted under phreatic condition in the weathered residuum and secondary porosities like joints, faults, fractures, etc. (Thapa et al. 2018b). In the

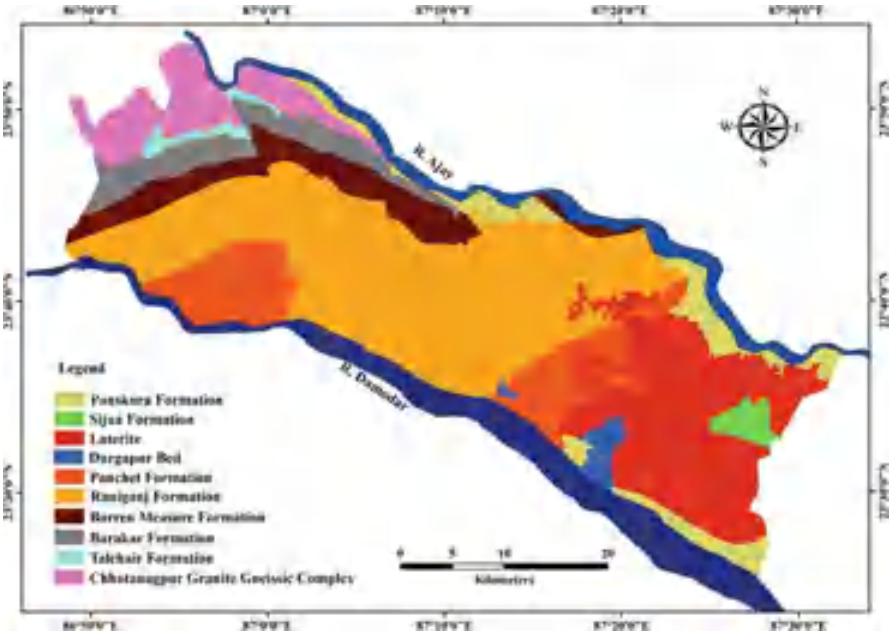


Fig. 12.2 Major geological units of Paschim Barddhaman district

Table 12.1 Major geological succession of Paschim Barddhaman district

Formation	Geological time period	Lithology
Panskura formation	Middle to upper Holocene	Clay alternating with silt and sand
Sijua formation	Upper Pleistocene to middle Holocene	Clay with caliche concretion
Laterite	Cainozoic	Laterite
Durgapur bed	Jurassic	Very coarse sandstone
Panchet formation	Triassic	Red shale, sandstone
Raniganj formation	Permian	Fine-grained sandstone, siltstone with coal seams
Barren Measure formation	Permian	Micaceous shale, sandstone
Barakar formation	Permian	Gritty pebbly sandstone with coal seams
Talchair formation	Carboniferous-Permian	Sandstone, conglomerate
Chota Nagpur granite gneissic complex	Archaean-Proterozoic	Granite gneiss and migmatite

Source: Geological Survey of India

eastern section of the district, groundwater occurs under both confined and unconfined aquifers in tertiary and quaternary deposits (Dutta 2016).

In general, the district is under subtropical monsoon-type climate and receives an average annual rainfall of 1300 mm. Generally the temperature varies between 39°C

in summer and 12°C in winter. But during summer time, the district suffers from very high temperature due to penetration of hot westerly wind from central India.

12.3 Materials and Method

For the entire analysis, 14 parameters, viz. pH, EC, TH, Ca, Mg, Na, K, HCO_3, Cl, SO_4, PO_4, F, Fe and SiO_2, have been taken as test parameters from the groundwater year book of West Bengal and Andaman and Nicobar Islands for the year of 2015–2016, and it has been published by Central Groundwater Board, Government of India. The data was collected for the month of April from 43 bore wells from the entire district.

From the quantitative point of view, multivariate statistical technique has been used for hydro-chemical analysis; principal component analysis (PCA) is one of the important multivariate statistical techniques which help to deduct the dimensionality of a data set consisting of a large number of interconnected variables (Zhang et al. 2009; Bencer et al. 2016; Kazakis et al. 2017). PCA has been calculated by using IBM SPSS version 25 statistical software. This method helps to extract major chemical components which affect groundwater of this region. Here, PCA has been made through varimax rotation with Kaiser normalization. According to the Guttman-Kaiser rule, the factors having the eigenvalue >1 have been taken as major factors (Dhakate et al. 2013; Bencer et al. 2016; Noshadi and Ghafourian 2016). PCA can be expressed through the following equation (Eq. 12.1):

$$Z_{ij} = pc_{i1}x_{1j} + pc_{i2}x2j + \ldots\ldots.pc_{im}x_{mj} \tag{12.1}$$

Hierarchical cluster analysis (HCA) helps to identify the grouping of associated variables of groundwater chemistry (Dhakate et al. 2013; Hassen et al. 2016). The Euclidean distance has been used here to measure the similarity level within the sample sites. Ward's method has been implied to generate dendrogram, which graphically represents the clusters (Gibrilla et al. 2011). HCA has been computed by using the following formula (Eq. 12.2):

$$d^2mn = \sum_{k=1}^{x} (Z_{m,k} - Z_{n,k}) \tag{12.2}$$

where d_{mn} is the Euclidean distance, Z_{mk} and Z_{nk} are the variable k for objects m and n, respectively, and x is the number of variables.

Pearson's correlation matrix has been prepared to identify the bivariate relationship between various groundwater controlling factors (Chapman 1996; Hassen et al. 2016; Das and Nag 2017), and scatter plots have been constructed to represent the trend of correlation between two variables. The co-relation value of >0.5 specifies a

strong correlation between variables, <0.5 indicates a poor correlation between variables, and the value of 0.5 means moderate co-relation between variables (Vasantavigar et al. 2013). For the spatial analysis of the 14 groundwater chemical parameters and the 4 significant factors and magnesium hazard, inverse distance weighting (IDW) technique in spatial analysis tool of ArcGIS 10.5 software has been used and here weighing factors are the chemical parameters, which have been already mentioned Wilcox diagram, USSL diagram and Gibbs diagram have been plotted using AquaChem v. 2011.1 software (evaluation copy) to identify the groundwater suitability for irrigation.

12.4 Result and Discussion

12.4.1 Spatial Distribution of pH

Concentration of pH value in groundwater is varying from 7.4 to 8.1 that indicates that the nature of groundwater is slightly alkaline. The very low standard deviation value of 0.17 indicates that the pH value of all the sample wells is very close to the average value of 7.5 of the test area, which shows negatively skewed distribution (−0.35) and the kurtosis value (0.5) is moderately positive. About 97.67% of the sample wells are within the safe limit as approved by the WHO (2004). Concentration of pH value is low in the eastern section (Kanksa) of the test area. Higher concentration of pH is mainly observed in a few pockets of Kulti, Brabant, Andal and Raniganj (Fig. 12.3a).

12.4.2 Electrical Conductivity (EC)

EC in groundwater indicates the ion concentration which comes from dissolved salts and inorganic chemicals like chloride, calcium, sodium and magnesium (Prasanth et al. 2012). The EC value is ranging from 115 µS to 2020 µS with an average of 781.42 and very high standard deviation of 387.61 (Table 12.2). Both the skewness and kurtosis values are positive. Throughout the study area, distribution of EC value is low except the sample well of Dakshin Khanda of Andal (Fig. 12.3b). As per WHO's guideline (2004), 97.67% of the sample well are within the safe limit and only 2.32% under moderate electrical conductivity. As the pH value in groundwater is slightly alkaline, it retards the solubility of chemical compounds. Presence of low soluble materials causes low concentration of electrical conductivity (Prasanth et al. 2012). EC value becomes low due to the presence of insoluble rock types.

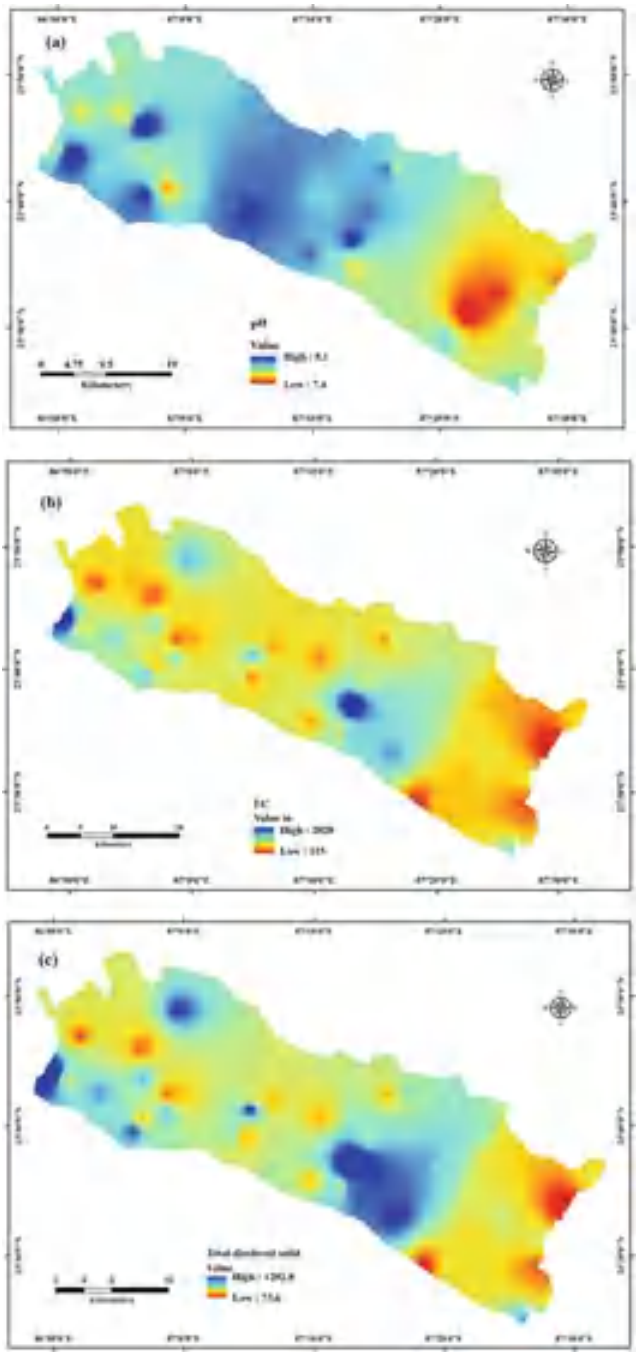


Fig. 12.3 Spatial map of (a). pH (**b**)**.** Electrical conductivity (**c**). Total dissolved solid (**d**)**.** Total hardness (**e**)**.** Calcium (**f**)**.** Magnesium (**g**)**.** Sodium (**h**)**.** Potassium (**i**)**.** Calcium bicarbonate (**j**)**.** Chloride (**k**)**.** Fluoride (**l**)**.** Iron (**m**)**.** Sulphate (**n**)**.** Phosphate (**o**)**.** Silicon oxide

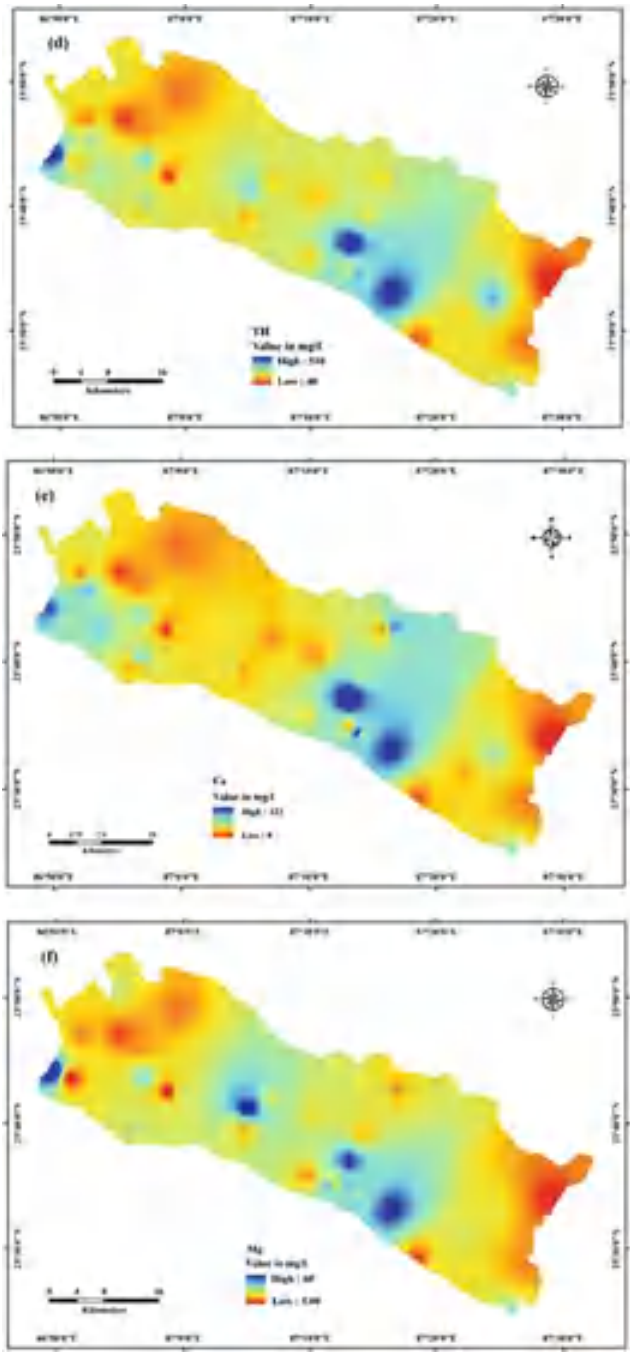


Fig. 12.3 (continued)

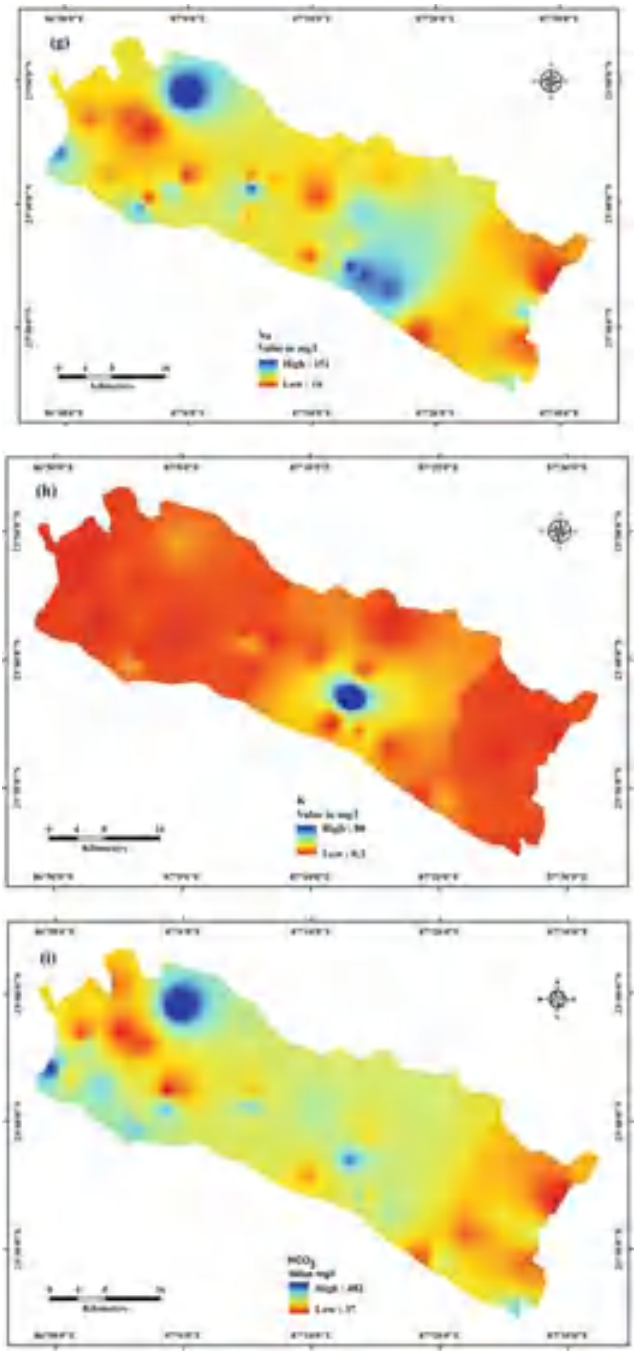


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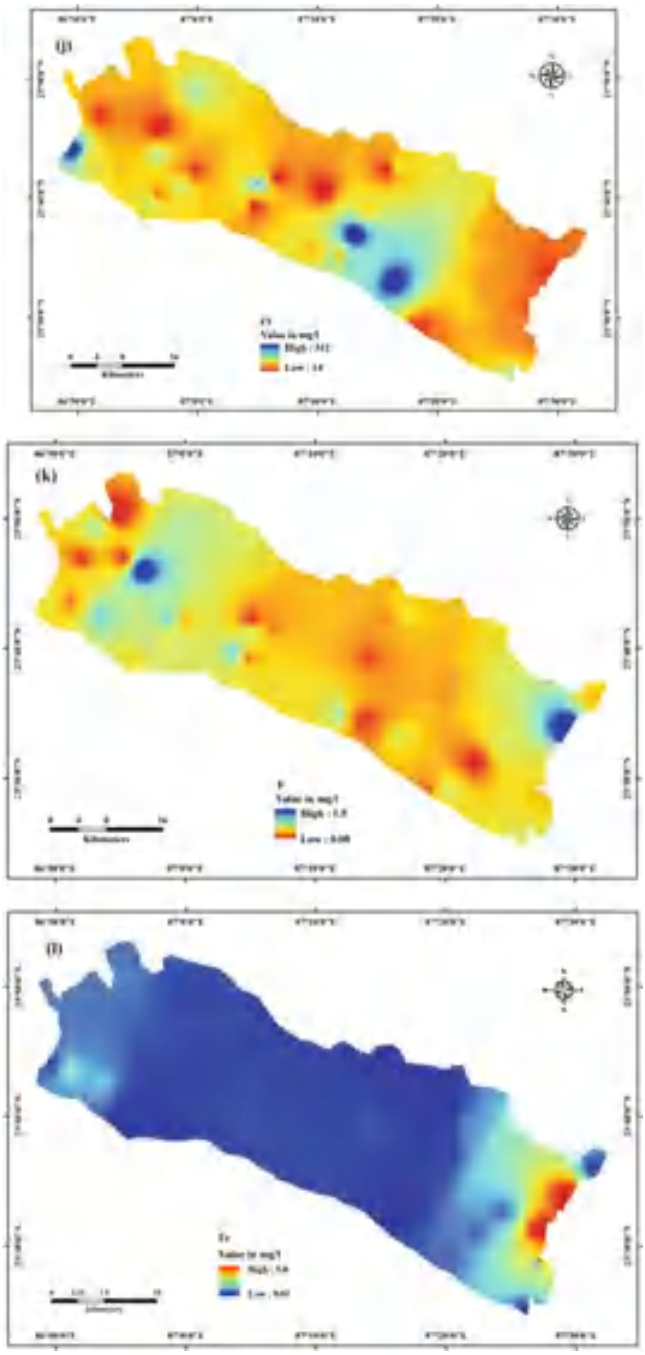


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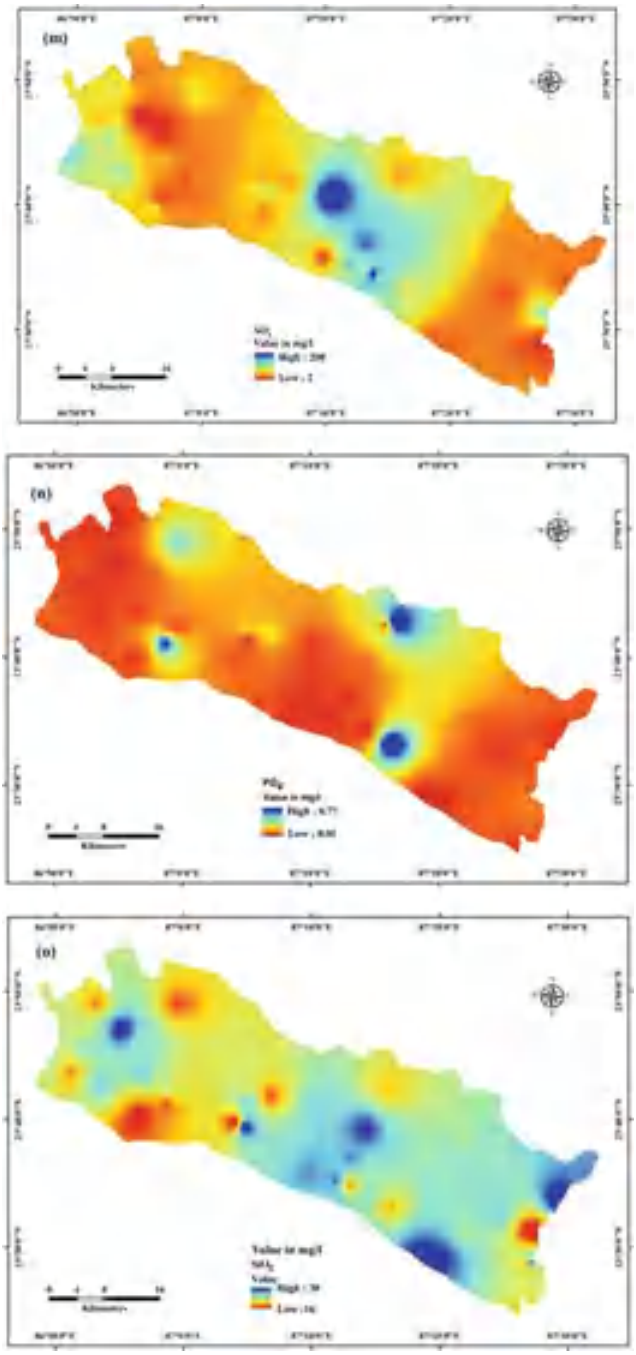


Fig. 12.3 (continued)

Table 12.2 Classification of groundwater based on EC concentration

EC	Type of water	Percentage of sample well
<1500	Low enrichment of salt	97.67
1500–3000	Moderate enrichment of salt	2.32
>3000	High enrichment of salt	0

Table 12.3 Classification of groundwater based on TH concentration (Sawyer and McCarty 1967)

TH	Type of water	Percentage of sample well
<75	Soft	2.32
75–150	Moderately hard	20.93
150–300	Hard	62.79
>300	Very hard	13.95

12.4.3 Total Dissolved Solid (TDS)

Total dissolved solid varies from 73.6 to 1292.8 mg/l with an average value of 523.14 mg/l. As per WHO's guideline, all the sample wells are within the permissible limit, but 44.18% of sample wells are beyond the maximum desirable limit (500 mg/l). Concentration of TDS is high in Andal, Durgapur municipality, Kulti and Barabani blocks (Fig. 12.3c).

12.4.4 Total Hardness (TH)

The presence of cations like magnesium and calcium and anions like carbonate, bicarbonate, sulphate and chloride is the prime cause of total hardness in groundwater (Ravikumar et al. 2010; Dhakate et al. 2013; Das and Nag 2017; Boateng et al. 2016). Total Hardness ranging from 40 to 510 mg/l with an average value of 216.82 mg/l and high standard deviation of 101.15, which shows a huge variation in the concentration of TH in the study area. Both skewness (0.85) and kurtosis (0.89) values are highly positive. According to Sawyer and McCarty's classification (1967), only 2.32% of sample wells are soft; 20.93% are moderately hard; 62.79% are hard and 13.95% are very hard (Table 12.3). Throughout the study area, TH has been concentrated in a few patches of Kanksa, Salanpur, Barabani and Asansol (Fig. 12.3d).

12.4.5 Calcium and Magnesium (Ca and Mg)

Concentration of calcium is ranging from 8 to 122 mg/l with a mean value 46.59 mg/l and standard deviation of 23.54. According to the WHO (2004), the permissible

limit of calcium concentration in groundwater is 200 mg/l which indicates that all the sample wells are within the safe limit. Magnesium concentration in groundwater is observed between 5 and 60 mg/l with an average value of 24.48 mg/l. The permissible limit of magnesium is 150 mg/l recommended by the WHO (2004). Therefore, all the sample wells are under permissible limit of magnesium concentration. The major source of calcium and magnesium is the leaching process of silicate minerals (Srinivasamoorthy et al. 2008).

12.4.6 Sodium and Potassium (Na and K)

Sodium is a vital element for human life, but high sodium content in drinking water causes numerous health complications like high blood pressure, hypertension, nervous system disorder, etc. (Gupta et al. 2008). Higher amount of sodium causes unsuitability for irrigation purpose also. Here, sodium concentration is ranging from 16 to 151 mg/l with a mean value of 64.45 mg/l and standard deviation of 32.97. All the sample wells are within the permissible limit (200 mg/l) by the WHO (2004). Na^+ concentration is relatively higher in Barabani, Durgapur and Andal (Fig. 12.3g) blocks. Sodium is formed here from both natural, i.e. presence of gneissic rocks like feldspar, pyroxene, amphiboles, etc., and anthropogenic sources, i.e. industrial waste, leaching from landfill and sewage, etc. (Gupta et al. 2008; Srinivasamoorthy et al. 2008; Baba and Tayfur 2011).

Potassium, an important natural-occurring element, is formed due to the presence of orthoclase, hornblende and microcline in igneous rock (Gupta et al. 2008). High concentration of potassium causes several health hazards like heart disease, coronary diseases, artery attack, hypertension, etc. (WHO 2009). Potassium concentration in groundwater is found between 0.3 and 80 mg/l. The uppermost permissible limit of potassium concentration in drinking water is 12 mg/l (WHO 2004). Two sample wells, located in Andal and Faridpur Durgapur, are beyond the permissible limit of the WHO (Fig. 12.3h).

12.4.7 Bicarbonate (HCO_3)

Presence of high bicarbonate in groundwater reduces the irrigational suitability of water. According to WHO (2003) recommended that the maximum permissible limit of HCO_3 is 180 mg/l. HCO_3 concentration in groundwater is high in the northwestern section of the study area due to the presence of Chota Nagpur granite gneissic complex made up of granite gneiss and migmatite. In the study area, the value of HCO_3 varies from 37 to 482 mg/l. About 61% of the sample well beats the permissible limit of the WHO. Due to weathering of silicate minerals (quartz, feldspar, etc.), HCO_3 concentration is high (Boateng et al. 2016) in the study region.

12.4.8 Chloride (Cl)

Higher concentration of chloride causes bad taste in drinking water and may result in hypertension and osteoporosis (McCarthy 2004). Chloride, mixing with sodium (Na), forms NaCl which makes the water saline. Chloride is coming from different anthropogenic sources like industrial effluent and sewage and agricultural application, i.e. inorganic fertilizer (Karanth 1987). The concentration of chloride ranges from 14 to 312 mg/l with an average value of 98.18 mg/l and standard deviation of 72.02 which indicates that concentration of Cl varies throughout the region. Concentration is low to moderate except a few patches like Durgapur Municipality Corporation, Andal and Kulti, where the amount is higher than the WHO's permissible limit (250 mg/l) (Fig. 12.3j). As the chloride ion is highly mobile, it can be easily transported. There is a strong positive co-relation with the concentration of chloride and EC (Prasanth et al. 2012).

12.4.9 Fluoride (F)

In drinking water, low level of fluoride concentration (below 1.5 mg/l) is good for human health because it helps in bone development and prevents dental decay. High level of fluoride concentration causes serious health problems like dental fluorosis, skeletal fluorosis, hyperparathyroidism, etc. (Thapa and Reddy 2017). In the present test area, concentration of fluoride varies from 0.08 to 1.5 mg/l. In all the sample wells, fluoride concentration is within the permissible limit recommended by the WHO (2004). Concentration of fluoride is relatively high near Kanksa, Barabani and Salanpur (Fig. 12.3k). Natural sources like alkaline soil and presence of caliche nodules in lateritic soil and the anthropogenic sources like application of phosphate fertilizer in agro-field occur fluoride contamination in groundwater in this area.

12.4.10 Iron (Fe)

Iron is another major element in our human body, but concentration of high amount of iron, i.e. >0.3 mg/l (WHO 2011), in drinking water results in serious health problems, viz. haemochromatosis, digestion problem, diabetes, skin diseases, etc. (WHO 2011). Iron concentration is relatively high in the lateritic terrain of the eastern section of the study area due to presence of iron nodules (Thapa et al. 2018b).

12.4.11 Sulphate (SO_4) and Phosphate (PO_4)

Sulphate does not create any health hazard, but the presence of higher concentration of sulphate makes water bitter taste and bad odour. Concentration of sulphate varies from 2 to 200 mg/l with standard deviation of 45.64 and a mean value of 59.84 mg/l. All the sample wells are within the allowable limit (400 mg/l) of the WHO (2004). Sulphate has been originated both naturally and anthropogenically. Although sulphate-bearing minerals, i.e. gypsum, are absent in the test area, the concentration of SO_4 is high (Fig. 12.3m). Here, seepage of chemical fertilizer, organic material, industrial effluent and sewage collectively influence the sulphate concentration (Baruah et al. 2008; Jeevanandam et al. 2012).

Phosphate concentration is low to average throughout the area except a few pockets near Durgapur, Pandabeswar, Asansol and Barabani. The concentration of phosphate ranges between 0.01 and 0.7 mg/l with a mean value of 0.1. The rocks, containing phosphate ion, apatite, amphibolite, biotite and garnet, all have a significant influence on the occurrence of PO_4 in the present study area (Srinivasa Rao and Rajendra Prasad 1997). Agricultural fertilizers, industrial effluents and sewage rich with phosphate are other important sources of PO_4 in groundwater (Akpabli and Drah 2001; Sinha et al. 2000; Akoto et al. 2010). Figure 12.3n shows that high concentration is mainly found in the industrial area.

12.4.12 Silica (SiO_2)

Silica concentration varies from 16 to 30 mg/l with a standard deviation of 3.98. Weathering of silicate minerals within rocks and agricultural activates are major responsible factors for silica dissolved in subsurface water. In the study area, maximum silica concentration is observed in the plateau fringe area (Fig. 12.3o), where weathering of silicate minerals is predominant.

12.4.13 Co-relation Analysis

Table 12.4 shows the correlation matrix of the chemical parameters of groundwater which depicts the linear relationship between two or more variables (Rawat and Tripathi 2015). The result illustrates a strong positive association between TH and EC (0.817), Ca (0.887) and Mg (0.848) and moderate correlation with HCO_3 (0.557) and SO_4 (0.477). Those parameters are responsible for permanent hardness of groundwater. The ions Cl, TH, Ca, Mg and Na all are positively associated with EC, and there is a moderate positive association between EC and K (0.561) and SO_4 (0.538) (Table 12.4). It confirms that the electrical conductivity is fully controlled by the presence of soluble salt content. The correlation matrix shows the significant

Table 12.4 Correlation matrix showing the relation between groundwater quality parameters

Correlation	pH	TDS	EC	TH	Ca	Mg	Na	K	HCO_3	Cl	F	Fe	SO_4	PO_4	SiO_2
pH	1.000	0.101	0.101	0.082	0.156	0.076	−0.007	0.216	0.216	−0.023	0.152	−0.246	0.127	−0.135	−0.118
TDS	0.101	1.000	1.000	0.817	0.718	0.750	0.744	0.561	0.786	0.914	−0.108	−0.335	0.538	0.196	−0.190
EC	0.101	1.000	1.000	0.817	0.718	0.750	0.744	0.561	0.786	0.914	−0.108	−0.335	0.538	0.196	−0.190
TH	0.082	0.817	0.817	1.000	0.887	0.848	0.450	0.420	0.557	0.798	−0.135	−0.363	0.477	0.189	−0.086
Ca	0.156	0.718	0.718	0.887	1.000	0.543	0.307	0.410	0.507	0.662	−0.103	−0.302	0.527	0.246	−0.073
Mg	0.076	0.750	0.750	0.848	0.543	1.000	0.520	0.357	0.501	0.789	−0.151	−0.342	0.349	0.107	−0.111
Na	−0.007	0.744	0.744	0.450	0.307	0.520	1.000	0.176	0.669	0.712	−0.139	−0.240	0.418	0.276	−0.392
K	0.216	0.561	0.561	0.420	0.410	0.357	0.176	1.000	0.297	0.550	−0.084	−0.094	0.303	−0.110	0.104
HCO_3	0.216	0.786	0.786	0.557	0.507	0.501	0.669	0.297	1.000	0.583	0.006	−0.316	0.502	0.280	−0.344
Cl	−0.023	0.914	0.914	0.798	0.662	0.789	0.712	0.550	0.583	1.000	−0.075	−0.240	0.403	0.283	−0.118
F	0.152	−0.108	−0.108	−0.135	−0.103	−0.151	−0.139	−0.084	0.006	−0.075	1.000	0.221	−0.173	0.024	0.003
Fe	−0.246	−0.335	−0.335	−0.363	−0.302	−0.342	−0.240	−0.094	−0.316	−0.240	0.221	1.000	−0.103	−0.151	0.127
SO_4	0.127	0.538	0.538	0.477	0.527	0.349	0.418	0.303	0.502	0.403	−0.173	−0.103	1.000	−0.098	0.004
PO_4	−0.135	0.196	0.196	0.189	0.246	0.107	0.276	−0.110	0.280	0.283	0.024	−0.151	−0.098	1.000	−0.343
SiO_2	−0.118	−0.190	−0.190	−0.086	−0.073	−0.111	−0.392	0.104	−0.344	−0.118	0.003	0.127	0.004	−0.343	1.000

relationship between Cl, SO_4, Na, Mg, Ca and K which indicates the subsurface hydrology is largely controlled by the leaching process and dissolution of soluble salts. Due to the presence of soluble substances, the nature of groundwater is mild alkaline.

12.4.14 Factor Analysis

To extract the factors, here, principal component analysis was performed using varimax rotation with Kaiser normalization. In this method, four significant factors were extracted with eigenvalue of greater than one (Davis 1986) which explain total variance of 71.358%. Factor 1 has 42.456% of total variance with positive loadings on electrical conductivity (0.936), total hardness (0.890), calcium (0.794), magnesium (0.792), sodium (0.597), potassium (0.650), bicarbonate (0.663), chloride (0.907) and sulphate (0.634) (Table 12.5). Factor 1 can be considered as salinity factor. Those chemical components represent the contribution of both natural (dissolution of rocks and minerals) and anthropogenic sources (chemical fertilizer, industrial effluent, sewage, etc.). Factor 2 explains 11.796% of total variance with strong positive loadings on phosphate (0.728) and sodium (0.597), and the negative loading is on SiO_2 (−0.781), which implies that the geochemistry of groundwater is controlled not only by the interaction with geology but also by contamination by the chemical fertilizer, industrial effluent and urban sewage. Third and fourth factors explain 9.099% and 8.007% of total variance, respectively. Factor 3 shows a very

Table 12.5 Rotated component matrix

	Component			
	1	2	3	4
pH	0.082	−0.046	0.920	0.073
TDS	0.952	0.220	0.052	−0.045
EC	0.952	0.220	0.052	−0.045
TH	0.880	0.070	0.027	−0.199
Ca	0.782	0.035	0.113	−0.140
Mg	0.789	0.112	−0.008	−0.207
Na	0.625	0.538	−0.066	−0.049
K	0.645	−0.339	0.165	0.092
HCO_3	0.685	0.448	0.253	0.045
Cl	0.916	0.198	−0.142	−0.004
F	−0.088	0.089	0.208	0.841
Fe	−0.228	−0.235	−0.442	0.638
SO_4	0.625	−0.125	0.125	−0.071
PO_4	0.097	0.724	−0.210	−0.022
SiO_2	−0.017	−0.781	−0.205	−0.001

Extraction method: Principal component analysis
Rotation method: Varimax with Kaiser normalization[a]

strong positive value of pH (0.920), and factor 4 has a strong positive loading on fluoride (0.850) and iron (0.636). pH is controlled by the presence of soluble ions like Na^+, Ca^{2+}, Mg^{2+}, Cl^-, HCO_3^- and SO_4. Presence of clay minerals, i.e. kaolinite and illite, also controls the pH level of groundwater. Fluoride and iron both are originated due to dissolution of minerals and rocks.

12.4.15 Hierarchical Cluster Analysis

Cluster is also a multivariate statistical measure for the categorization of homogeneous groups of the variables. In statistics, there are various methods to prepare clustering, viz. K-means cluster, step clustering, hierarchical cluster, etc. In this study, hierarchical cluster has been applied to identify the homogeneous grouping as it has been a widely accepted technique, and for grouping of homogeneous chemical variables, it is the most applied method (Davis 1986).

With the help of Euclidean distance method, hierarchical cluster programming has been done using the of 43 subsurface chemical water samples data, and the dendrogram shows three clusters on the basis of homogeneous chemical composition. Within cluster 1, there are 13 villages with higher amount of TH (301.54), Ca (60.31), Mg (36.77), Cl (175.85), SO_4 (76.69) and PO_4 (0.22). Cluster 2 is comprised of 67.44% of sample villages with higher concentration of F (0.58 mg/l) and Fe (0.12 mg/l). Cluster 3 shows that only one sample falls under this group due to high concentration of pH (8.00), TDS (794.88), EC (1242), Na (112), K (9.80), HCO_3 (323.0) and SiO_2 (27.0) (Fig. 12.4).

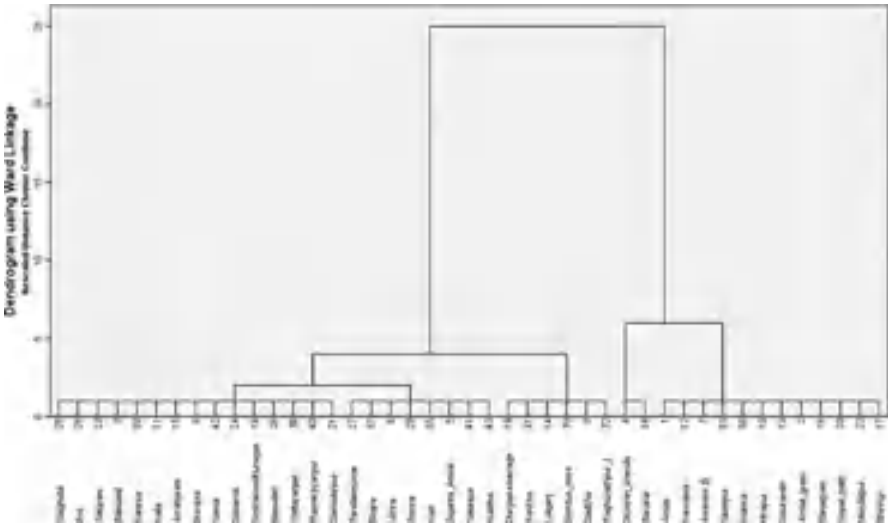


Fig. 12.4 Hierarchical cluster analysis

12.4.16 Mechanism Regulating the Groundwater Chemistry

With the help of Gibbs diagram, one can easily assess the mechanism which regulates the groundwater chemistry. In the year 1970, Gibb depicted three functional sources, i.e. evaporation dominance, rock dominance and precipitation dominance, which affect the groundwater chemistry as well as the quality (Loganathan and Ahamed 2017). Gibbs ratio was represented in formulas 12.3 and 12.4:

$$\text{Gibbs Ratio I}\,(\text{for anions}) = \frac{\text{cl}^-}{(\text{Cl}^- + \text{HCO}_3{}^-)} \tag{12.3}$$

$$\text{Gibbs Ratio II}\,(\text{for cations}) = \frac{\text{Na}^+ + \text{K}^+}{\left(\text{Na}^+ + \text{K}^+ + \text{Ca}^{2+}\right)} \tag{12.4}$$

Figures 12.5 and 12.6 reveal that above 90% samples fit to the category of rock dominance. So, this result designates that almost all samples of the study area are influenced by the rock weathering.

12.4.17 Evaluation of Groundwater Quality

12.4.17.1 Water Quality Index

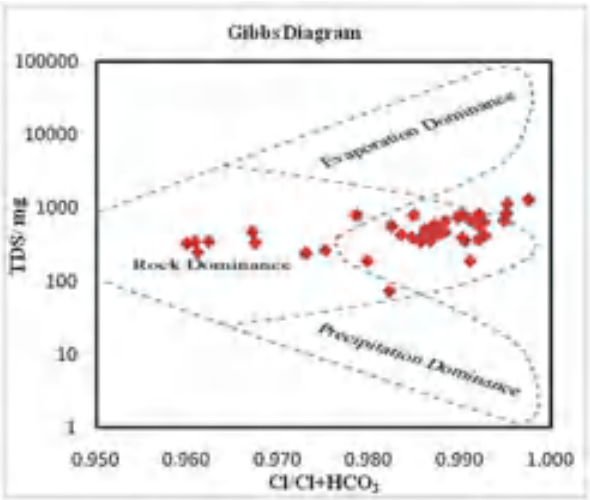
To extract the quality of groundwater for drinking propose, water quality index has been widely used (Tiwari and Mishra 1985; Subba Rao 1997; Mishra and Patel 2001). Here, 12 chemical parameters (pH, EC, Ca, Mg, Na, K, HCO_3, Cl, F, SO_4, PO_4, TDS) of 43 sample villages from Paschim Barddhaman district have been used to regulate the water quality of subsurface water. There are five steps to calculate the WQI.

In the **first step**, weightage (w_i) has been given to all the parameters in referenced to their importance. Higher weight has been given to parameter which has a major importance in water quality and vice versa.

In the **second step**, the relative weightage (Rw_i) has been calculated using equation no. 12.5:

$$Rw_i = w_i / \sum w_i \tag{12.5}$$

where w_i is the weightage of the individual parameter and $\sum w_i$ is the summation of individual parameter.



Figs. 12.5 and 12.6 Mechanism controlling the chemistry of groundwater. (After Gibbs 1970)

In the **third step**, quality rating scale (Qi) has been calculated from the following equation:

$$Qi = (Ai/Si) * 100 \tag{12.6}$$

where Ai is the actual value of the parameter and Si is the drinking water quality standard prescribed by the WHO (2011).

In the **fourth step**, Sub indices (SI) has been calculated by $SI = Rw_i * Q_i$ (12.7)

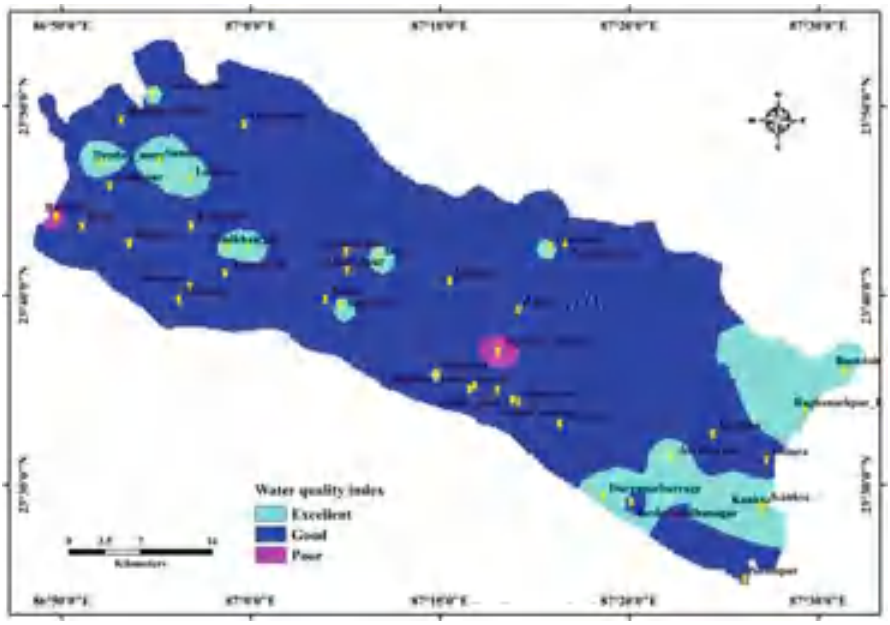


Fig. 12.7 Drinking water quality map

And finally WQI has been computed using the following formula:

$$WQI = \sum SI_i \tag{12.8}$$

Groundwater quality indices are ranging from 30.60 to 136.05 value, and on the basis of WQI value, 39.53% of the sample villages fall under excellent category, and 55.81% of samples fall into good category, and only 4.65% of samples are under poor category (Fig. 12.7).

12.4.17.2 Irrigation Suitability

As Indian rainfall is irregular and seasonal, irrigation is a prime factor for the agricultural development of a region and groundwater accounted as the secure source of irrigation. The quality of groundwater largely affects the cropping yield. Therefore, the evaluation of groundwater suitability is very much needed for the irrigation potentiality analysis (Prasanth et al. 2012; Nagarajua et al. 2014; Singh et al. 2015). The parameters like sodium percentage (Na%), sodium absorption ratio (SAR) and permeability index (PI) have been applied to evaluate the groundwater suitability for irrigation purpose.

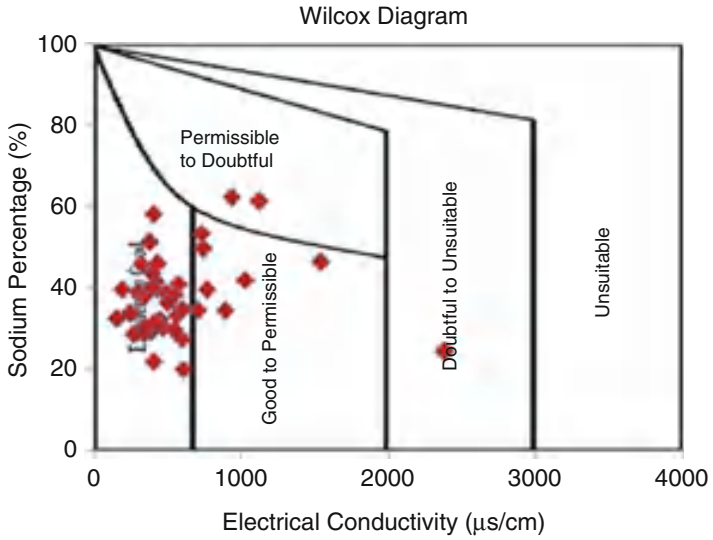


Fig. 12.8 Quality for irrigation through the Wilcox diagram

(i) *Sodium Percentage*

For irrigation purpose, the determination of sodium percentage of water is urgent because excessive sodium content affects the soil structure which has a negative impact on agriculture (Gupta et al. 2008). Sodium percentage is calculated as

$$\mathrm{Na\%} = \frac{(\mathrm{Na^+} + \mathrm{K^+}) \times 100}{(\mathrm{Ca^+} + \mathrm{Mg^+ Na^+} + \mathrm{K^+})} \tag{12.9}$$

According to sodium percentage, the groundwater can be categorized into five groups, i.e. excellent (<20%), good (20–40%), permissible (40–60%), doubtful (60–80%) and unsuitable (>80%) (Wilcox 1955). Here sodium percentage ranges from 21.21 to 72.06%. About 67.44% of samples fit to the good category, 27.90% in permissible category, and only 4.65% in doubtful category (Fig. 12.8). Single one sample falls neither in the excellent nor unsuitable category. Here, the Wilcox diagram has been taken up to classify the groundwater for irrigation purpose. It shows that groundwater samples occupy the field of excellent to good (76.74%), good to permissible (16.28%), permissible to doubtful (4.65%) and doubtful to unsuitable (2.33%) for irrigation.

(ii) *Salinity and Alkalinity Hazard*

Highest concentration of salinity content in irrigation water stunts the plants' growth because of the osmotic pressure in soil and specific ion toxicities (Läuchli and Epstein 1990). High amount of sodium in groundwater decreases the soil permeability which reduces the soil infiltration capacity and leads to water

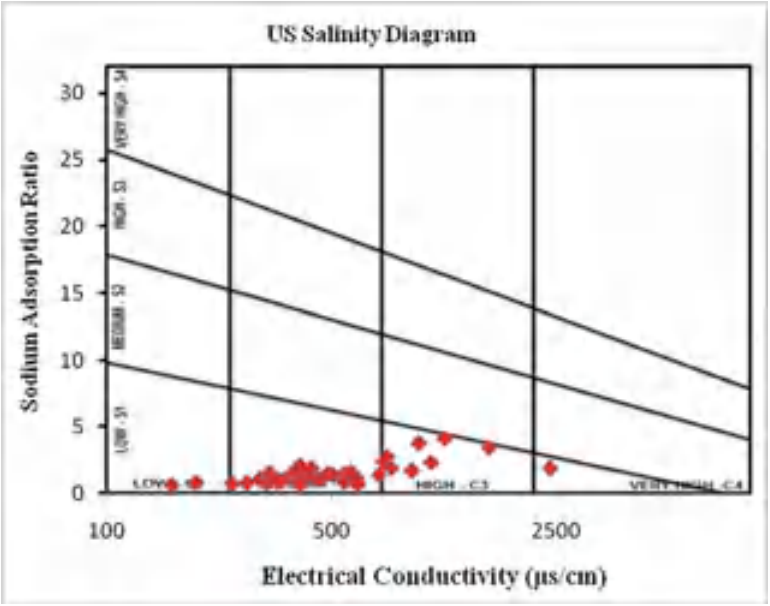


Fig. 12.9 US salinity diagram indicating the groundwater quality for irrigation

stagnation. High sodium content also affects the soil structure because it displaces calcium and magnesium ion in soil which diminishes the soil aggregation capability (Arveti et al. 2011). To determine the sodium hazard, sodium absorption ratio (SAR) is one of the most significant criteria (Todd and Mays 2005). The sodium absorption ratio has been computed using the following equation:

$$\mathrm{SAR} = \frac{\mathrm{Na}^{+}}{\left[\left(\mathrm{Ca}^{2+} + \mathrm{Mg}^{2}\right)/2\right]^{0.5}} \tag{12.10}$$

In the study area, SAR value ranges between 0.89 and 5.72 which indicates that most of the samples belong to excellent category (Richards 1954). The US Salinity Laboratory Diagram (US Salinity Laboratory Staff 1954) has been employed to classify the groundwater based on salinity and alkalinity or sodium hazard, and it shows that the ion part of the samples (95.34%) falls within the group of C3S1 (high salinity and low alkalinity) and C2S1 (medium salinity and low alkalinity). Only two samples, i.e. Raghunathpur and Gourandhi, belong to the group of C1S1 (low salinity and low alkalinity) and C3S2 (high salinity and medium alkalinity), respectively. Salt-tolerant crops should be cultivated in those areas where groundwater falls in the group of C3S2 and C3S1. Land with a good drainage status is needed for that category of water (Fig. 12.9). The samples belonging to the C1S1 and C2S1 categories are favourable for irrigation purpose in all types of soil.

(iii) Permeability Index

Based on PI, irrigation water can be classified into three categories good, moderate and poor (Donnen 1964). Permeability index has been calculated using the following formula:

$$\mathrm{PI} = \frac{\left\{\mathrm{NA} + (\mathrm{HCO_3})^{0.5}\right\} \times 100}{(\mathrm{Na} + \mathrm{Ca} + \mathrm{Mg})} \tag{12.11}$$

In the study area, PI value ranges from 22.78 to 74.69, which reveals that all the samples are under the good category.

(iv) Magnesium Hazard

Calcium and magnesium collectively conserve the equilibriumity of water. Excess amount of magnesium in irrigational water causes low agricultural production (Nagarajua et al. 2014). To calculate the magnesium ratio, the following formula has been computed (Paliwal 1972):

$$\text{Magnesium ratio} = \frac{\mathrm{Mg^{2+}} \times 100}{\left(\mathrm{Ca^{2+}} + \mathrm{Mg^{2+}}\right)} \tag{12.12}$$

In the present study area, MH varies from 16.11 to 72.22. About 34.88% of samples belong to the unsuitable category, and 65.12% are suitable for irrigation. Irrigational water is unsuitable for agriculture in Jamuria I and II.

12.5 Conclusion

Groundwater hydro-geochemistry of Paschim Barddhaman district has been evaluated to identify groundwater quality for domestic and agricultural purposes and also to identify the major determinants of groundwater quality. Hydro-chemical data of sample villages reveal that the nature of subsurface water is slightly alkaline and most of the parameters are within the allowable limit recommended by the WHO for drinking water purpose. But the concentration of bicarbonate, chloride and potassium is beyond the permissible limit of the WHO in a few sample villages. The PCA results determine that the physico-chemical character of groundwater is not only controlled by the dissolution of rocks and minerals but also the leaching process from chemical fertilizers, industrial effluents, sewage, etc. due to anthropogenic activities. Gibbs plot shows that the hydrochemistry of the groundwater is influenced by rock weathering as the major part of the test area belongs to plateau fringe of Chota Nagpur. Water quality index informs that about 93% of the sample villages have excellent to good category of water. Majority of the sample villages show that groundwater is suitable for irrigation purpose except a few villages. Therefore, this

kind of study not only help to assess the present quality of groundwater, but also it may help the decision makers to take appropriate policy design in management of subsurface water quality in such kind of problematic region.

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INDIAN CARTOGRAPHER

Journal of the Indian National Cartographic Association (INCA)



Digital Mapping Innovations in Make India Initiatives

Volume 40, 2020

NATIONAL ATLAS AND THEMATIC MAPPING ORGANISATION

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Geomorphological Analysis of Bolpur-sriniketan Block, Birbhum District, West Bengal, India

Abstract: In this paper, an attempt has been made to analyse the landforms and theirCharacteristics. The study area (Bolpur-Sriniketan Block) is characterised by Lateritic features,and riverine features. The study area includs the parts of Ajay River basin and the Kopai river basin. It is located between 23°33'N to 23°46'N Latitudes and 87°34'E to 87°51'E longitudes. It covers the total area is 331.8 Km2.

The geomorphological feature of this study area is mainly the result ofExogenetic or climogenetic processes. The role of climate characteristics and theLithology is very significant. An attempt has also been made to analyse the Geomorphic fatures with morphogenetic features such as Absolute relief, RelativeRelief, Dissection index as well as the gullies are analyse by stream order, lengthBifurcation ratio etc. This paper also provides the types and their morphogenesis.

1 INTRODUCTION

Landscape analysis is an important way of geographical enquiry since the initiation period of the geographical development to the modern age. The riverine bad land topography shaped by the fluvial processes on the porous lateritic soil around the Santiniketan area is defined by Gurudev Rabindranath Tagore , as "Khaoai" is derived from the Sanskrit word " Kshaya" (meaning depleted/ degenerated / disfigured / denuded).The fluvio-dynamics and active tectonics together produce characteristic geomorphological features manifesting surface deformation in any area (Jain et.al, 2005). The slope and geomorphology is important in understanding the water course dynamics has been emphasized for land planning and environmental protection (Brandolini et.al. 2008).Thornbury (1969) observed that vertical cutting of drainage indicates land emergence and anomalous river widening indicates land subsidence. In West Bengal the lateritic upland are found in the NNE-SSW linear belt bordering the chhotonagpur plateau and rajmahal hill areas. Extensively dissected by the West bank tributary system of the Bhagirathi-Hooghly river, the high gradient fringe area of this formation is

MANOHAR

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Edited by

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SUDIT KRISHNA KUMAR
SUVOBRATA SARKAR

MANOHAR
2021

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First published 2021

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This edition is for sale in India, Sri Lanka, Nepal, Bangladesh, Afghanistan, Pakistan and Bhutan

ISBN 978-93-90035-54-0

Published by
Ajay Jain *for*
Manohar Publishers & Distributors
4753/23 Ansari Road, Daryaganj
New Delhi 110002

Typeset by
Ravi Shanker
Delhi 110095

Printed at
Replika Press Pvt. Ltd.

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—ড. কল্যাণকুমার সরকার

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মনোজিৎ দাস
সহকারী অধ্যাপক, ইতিহাস বিভাগ
হীরালাল ভকত কলেজ, নলহাটি, বীরভূম

খ্রিষ্ট জন্মের বহুপূর্ব থেকে যা ছিল সীমান্ত চীনের আদিবাসীদের পানীয়, ব্রিটিশ শাসনের আগে যা ছিল সীমান্ত অসমের সিংফো উপজাতিদের প্রিয় পানীয় 'পাইন-আপ' তাই আজ আমাদের প্রাত্যহিকের উষ্ণ আমেজমাখা 'চা' গত দেড় শতকের বাণিজ্য ছোঁইয়ায় চা এক বিরাট পরিবর্তন আনে উত্তর-পূর্ব ভারতসহ দেশের বেশ কিছু অংশে। বিশেষ করে আমাদের জলপাইগুড়ি ও সংলগ্ন দার্জিলিঙে। মাত্র একশো পঁচিশ বছর হল জলপাইগুড়ি জেলার সঙ্গে চায়ের সংযোগ। এই সময়কালে গোটা অর্থব্যবস্থা, সমাজ জীবন, জনগোষ্ঠীর সামগ্রিক বিবর্তনে প্রবলভাবে উপস্থিত এই উষ্ণ পানীয়টি। চায়ের পাশাপাশি এসেছে চা-শিল্প, চা শ্রমিক। বিস্তীর্ণ চা-গালিচার সবুজ নান্দনিক রূপ বা সকালের চায়ের কাপের উষ্ণতার পেছনে যে দীর্ঘ ইতিহাস, হাজার হাজার শ্রমিকের অশ্রুগাথা রয়েছে তার অনুরণন মাটিতে কান পাতলে আজও শোনা যাবে। মাটিতে কান পেতে এই ইতিহাসকে জানার জন্য। আমাদের ফিরতে হবে গত শতকের মধ্য ভাগে, যখন চীনের একচেটিয়া চা-বাজারে ভাগ বসাতে ব্রিটিশরা চেষ্টা করছে তাদের অন্যান্য উপনিবেশে চা-চাষের।১

ভারতে চায়ের চাষ শুরু অসমে; তবে ব্রিটিশরা একে তাদের আবিস্কার বললেও চা-পানকরা অসমের সিংফো, খামতিদের পুরনো অভ্যাস। চা তাদের কাছে ছিল 'পাইন আপ', মহাচীনের আফিম যুদ্ধের পরবর্তীতে চা-বাণিজ্য বিষয়ে চীনের উপর নির্ভরশীল থাকা সম্ভব হচ্ছিল না ব্রিটিশ বেনিয়াদের।২

উত্তরবঙ্গের ইতিহাস ও সমাজ-৬



ড. আনন্দগোপাল ঘোষ
মনোজিৎ দাস
সুব্রত বাড়ই

উত্তরবঙ্গের ইতিহাস ও সমাজ-৬

সুকৃতি সুন্দরী: প্রসঙ্গ কোচবিহার রাজ পরিবারের
এক রাজকুমারীর সাতকাহন— পৃ. ১১৬

স্বাধীনতা সংগ্রামী-রাজনীতিবিদ্-সমাজসেবী
রবীন্দ্রনাথ সিকদার— পৃ. ১২২

দার্জিলিং জেলার নক্সালবাড়ি বিপ্লবী আন্দোলনের ইতিবৃত্ত— পৃ. ১২৬

মনোজিৎ দাস

রাজবংশী সমাজ সংগঠনে মনীষী পঞ্চানন বর্মার অবদান– -পৃ. ১৩৫

স্বাধীনতা পরবর্তী উত্তরাখন্ড আন্দোলন:
একটি ঐতিহাসিক পর্যালোচনা– -পৃ. ১৪৭

দেশ বিভাজন: প্রসঙ্গ সম্পত্তি বিনিময়— পৃ. ১৫৪

নতুন তথ্যের আলোকে পূর্বতন দেশীয় রাজ্য কোচবিহারের সংযুক্তিকরণ
আন্দোলনের উৎপত্তি ও বিকাশ— পৃ. ১৬০

সুব্রত বাড়ই

স্বাধীনোত্তর উত্তরবঙ্গের কৃষি অর্থনীতি ও আদিবাসী সমাজ—পৃ. ১৬৮

স্বাধীনোত্তর হিমালয়বঙ্গে জাতপাতের রাজনীতিতে
অনগ্রসর সম্প্রদায়ের ভূমিকা— পৃ. ১৭৬

চা-বাগান পত্তনের আদি পর্বে শ্রমিকদের
দাসত্ব জীবন ও বর্তমান অবস্থা: প্রসঙ্গত ডুয়ার্স— পৃ.১৮৭

উত্তরবঙ্গের চা-বাগানে আদিবাসী সমাজে মধ্যবিত্ত শ্রেণি
গড়ে ওঠার কথা– -পৃ. ১৯৫

রাজবংশী সমাজ সংগঠনে মনীষী পঞ্চানন বর্মার অবদান

মনোজিৎ দাস

এই বাংলায় সামাজিক অনাচারের বিরুদ্ধে রুখে দাঁড়াবার কথা, সমাজ সংস্কারকের কথা যখনই উঠে পড়ে, তখনই তিন মণীষীর নাম অবধারিত রূপেই উচ্চারিত হয়। রাজা রামমোহন রায়, ঈশ্বরচন্দ্র বন্দোপাধ্যায় ও স্বামী বিবেকানন্দ। সমাজ সংস্কারের কাজ, বিশেষ করে নারী জাতির প্রতি সামাজিক পীড়ণের বিরুদ্ধে যেভাবে দ্বীপ্ত তেজে তাঁরা জ্বলে উঠেছিলেন এবং সামাজিক নিষ্ঠুর বিধানের নাগপাশ থেকে নারীজাতির মুক্তির জন্য যে বিপুল কর্মযজ্ঞের আয়োজন করেছিলেন, জাতি আজ শ্রদ্ধার সঙ্গে সে কথা স্মরণ করে। পরিতাপের বিষয়, এই তিন মণীষীর নামের সঙ্গে আরো একটি নাম একই নিঃশ্বাসে উচ্চারিত হয় না। সে নাম রায়সাহেব পঞ্চানন বর্মার নাম।

সমকালের অপেক্ষা প্রাগ্রসর চিন্তন মননে উদ্বেলিত রামমোহনের হৃদয়াবেগ, বীর সন্ন্যাসী বিবেকানন্দের দৃপ্ত তেজ আর করুণাঘন বিদ্যাসাগরের হৃদয়রসের মিশ্রিত রসায়নে যে নব রসায়নের উৎপত্তি হতে পারত। রায়সাহেব পঞ্চানন বর্মার হৃদয় থেকে নিঃসারিত হত সেই নব রসায়ন।[১]

ভারতের তৎকালীন করদ রাজ্য কোচবিহারের মাথাভাঙ্গা মহকুমার শীতলকুচি থানার অন্তর্গত খলিসামারী গ্রামের এক রাজবংশী পরিবারে জন্মগ্রহণ করলেও তৎকালীন সমাজব্যবস্থার জাতি বৈষম্য, অর্থনৈতিক শোষণ প্রভৃতি বিষয়গুলি তাঁর মনে গভীরভাবে রেখাপাত করে। তাঁর দীর্ঘ কর্মজীবনে, সমাজ সংস্কার, রাজনীতিসহ অর্থনৈতিক চিন্তাভাবনা বহুগুণের পরিচয় পাওয়া যায়। রাজবংশী জাতির আত্মমর্যাদা প্রতিষ্ঠা করে তিনি এই জাতির জনক হিসাবে পরিচিত হয়ে আছেন।[২] উত্তরপূর্ব ভারতের বিশেষত রাজবংশী সমাজ জীবনে নবজাগরণের অগ্রদূত মণীষী পঞ্চানন। অসম, পশ্চিমবঙ্গ, বিহার এবং নেপালে তাঁর ক্ষত্রিয় আন্দোলন প্রভাব বিস্তার করেছিল। রাজবংশী সমাজে তিনি ঠাকুর, রায়সাহেব, ক্ষত্রাবতার, জননায়ক, মহাত্মা এবং মণীষী নামে পরিচিত।[৩]

রাজবংশী ক্ষত্রিয় সমাজের ঐতিহ্য অন্বেষার প্রধান পুরুষ রায় সাহেব

উত্তরবঙ্গের ইতিহাস ও সমাজ-৬



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সুকৃতি সুন্দরী: প্রসঙ্গ কোচবিহার রাজ পরিবারের
এক রাজকুমারীর সাতকাহন— পৃ. ১১৬

স্বাধীনতা সংগ্রামী-রাজনীতিবিদ্-সমাজসেবী
রবীন্দ্রনাথ সিকদার— পৃ. ১২২

দার্জিলিং জেলার নক্সালবাড়ি বিপ্লবী আন্দোলনের ইতিবৃত্ত— পৃ. ১২৬

মনোজিৎ দাস

রাজবংশী সমাজ সংগঠনে মনীষী পঞ্চানন বর্মার অবদান– -পৃ. ১৩৫

স্বাধীনতা পরবর্তী উত্তরাখন্ড আন্দোলন:
একটি ঐতিহাসিক পর্যালোচনা– -পৃ. ১৪৭

দেশ বিভাজন: প্রসঙ্গ সম্পত্তি বিনিময়— পৃ. ১৫৪

নতুন তথ্যের আলোকে পূর্বতন দেশীয় রাজ্য কোচবিহারের সংযুক্তিকরণ
আন্দোলনের উৎপত্তি ও বিকাশ— পৃ. ১৬০

সুব্রত বাড়ই

স্বাধীনোত্তর উত্তরবঙ্গের কৃষি অর্থনীতি ও আদিবাসী সমাজ— পৃ. ১৬৮

স্বাধীনোত্তর হিমালয়বঙ্গে জাতপাতের রাজনীতিতে
অনগ্রসর সম্প্রদায়ের ভূমিকা— পৃ. ১৭৬

চা-বাগান পত্তনের আদি পর্বে শ্রমিকদের
দাসত্ব জীবন ও বর্তমান অবস্থা: প্রসঙ্গত ডুয়ার্স— পৃ.১৮৭

উত্তরবঙ্গের চা-বাগানে আদিবাসী সমাজে মধ্যবিত্ত শ্রেণি
গড়ে ওঠার কথা– -পৃ. ১৯৫

দেশ বিভাজন: প্রসঙ্গ সম্পত্তি বিনিময়

মনোজিৎ দাস

পশ্চিমবঙ্গ ও বাংলাদেশ সীমান্তে যে আঁকাবাঁকা বিলম্বিত চিহ্নটি; ওটা বাঙ্গালীদের মধ্যে ধর্মীয় বিভাজন এবং রক্তারক্তির চিহ্ন। ঐ সীমান্ত রেখাটি কাঁটাতেরের বেড়া দিয়ে তথা সীমান্ত রক্ষী দিয়ে রক্ষা করতে হয়। ১৯৪৭ সালে ধর্মভিত্তিক ভারত বিভাজনের সাথে সাথে ধর্ম ভিত্তিক বাংলা বিভাজনও হয়ে যায়। ওটাই বাংলার চিরন্তন সাম্প্রদায়িক ক্ষত চিহ্ন। সেদিন মানুষের ধর্মভাগ হলো, মন ভাগ হলো, মাটি ভাগ হলো। কিন্তু কৌশল করে মানষু ভাগ হতে দিল না। নানানতরো কারণেই মানুষ মাতৃসম মাটি ছেড়ে যায়। যেমন একুশ শতকের মানুষ স্বেচ্ছায় মাটি ছেড়ে যাচ্ছেন। কিন্তু এই ছেড়ে যাওয়া আর চিরকাঙ্খিত স্বাধীনতার পরে মাটি ছেড়ে আসা-অবস্থানগত দিক থেকে দুই বিপরীত মেরুর বিষয়। সাধারণ মানুষ আকাশচারী নয, মাটিচারী। তাই মাটি হারিয়ে যে শুধূ একান্ত ভূখন্ডই হারায়নি, সর্বস্ব হারিয়েছে। এক্ষেত্রে ব্যতিক্রমটি হচ্ছে সম্পত্তি বিনিময়। তৎকালীন একশ্রেণীর জোতদার তাদের প্রচুর সম্পত্তি ছিল তারা মাটির টানেই দেশত্যাগ করতে পারেননি। এইসব জোতদাররা স্বাধীনতা পরবর্তীকালে পূর্বপাকিস্থান থেকে ভারতে বা ভারত থেকে পূর্ব পাকিস্থানে স্থানান্তরিত হয়েছেন সম্পত্তি বিনিময়ের মাধ্যমে।

দেশবিভাজন উদ্‌বাস্তু জীবন নিয়ে বাংলা ভাষায় সাম্প্রতিককালে বেশ কিছু মূল্যবান গ্রন্থ, পত্রিকার বিশেষ সংখ্যা এবং দৈনিক সংবাদপত্রে কিছু প্রবন্ধ, নিবন্ধ প্রকাশিত হয়েছে। এখানে ইংরাজী ভাষায় লিখিত গ্রন্থ বা প্রবন্ধের কথা আলোচনার পরিসরে আনছি না। দেশ বিভাজন ও উদ্‌বাস্তু জীবন নিয়ে বেশ কিছু স্মৃতিকথামূলক গ্রন্থ এবং স্মৃতিচারণাধর্মী লেখা প্রকাশিত হয়েছে। নানাতর বিষয়ে লেখক, গবেষকরা আলো ফেলেছেন এই বিষয়গুলোর উপরে।

কিন্তু দেশবিভাজন সম্পর্কিত একটি বিষয় হল লোক বিনিময় ও সম্পত্তি বিনিময়। পাঞ্জাবের ক্ষেত্রে প্রধানমন্ত্রী জওহরলাল নেহেরু লোক বিনিময় সূত্র মেনে নিলেও বঙ্গদেশের ক্ষেত্রে সেই সূত্র তিনি কোন ভাবেই গ্রহণ করেননি। আর সম্পত্তি বিনিময় বিষয়টি বেসরকারীস্তরে ঘটেছে। শতাংশের হিসাবে সেটি হয়তো খুব বেশি নয়, তবু দেশবিভাগের পূর্ণাঙ্গ ইতিহাসের সঙ্গে সম্পত্তি

উত্তরবঙ্গের ইতিহাস ও সমাজ-৬



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এক রাজকুমারীর সাতকাহন— পৃ. ১১৬

স্বাধীনতা সংগ্রামী-রাজনীতিবিদ্-সমাজসেবী
রবীন্দ্রনাথ সিকদার— পৃ. ১২২

দার্জিলিং জেলার নক্সালবাড়ি বিপ্লবী আন্দোলনের ইতিবৃত্ত— পৃ. ১২৬

মনোজিৎ দাস

রাজবংশী সমাজ সংগঠনে মনীষী পঞ্চানন বর্মার অবদান— পৃ. ১৩৫

স্বাধীনতা পরবর্তী উত্তরাখণ্ড আন্দোলন:
একটি ঐতিহাসিক পর্যালোচনা— পৃ. ১৪৭

দেশ বিভাজন: প্রসঙ্গ সম্পত্তি বিনিময়— পৃ. ১৫৪

নতুন তথ্যের আলোকে পূর্বতন দেশীয় রাজ্য কোচবিহারের সংযুক্তিকরণ
আন্দোলনের উৎপত্তি ও বিকাশ— পৃ. ১৬০

সুব্রত বাড়ই

স্বাধীনোত্তর উত্তরবঙ্গের কৃষি অর্থনীতি ও আদিবাসী সমাজ— পৃ. ১৬৮

স্বাধীনোত্তর হিমালয়বঙ্গে জাতপাতের রাজনীতিতে
অনগ্রসর সম্প্রদায়ের ভূমিকা— পৃ. ১৭৬

চা-বাগান পত্তনের আদি পর্বে শ্রমিকদের
দাসত্ব জীবন ও বর্তমান অবস্থা: প্রসঙ্গত ডুয়ার্স— পৃ.১৮৭

উত্তরবঙ্গের চা-বাগানে আদিবাসী সমাজে মধ্যবিত্ত শ্রেণি
গড়ে ওঠার কথা— পৃ. ১৯৫

স্বাধীনতা পরবর্তী উত্তরাখন্ড আন্দোলন: একটি ঐতিহাসিক পর্যালোচনা

মনোজিৎ দাস

পশ্চিমবঙ্গের মানচিত্রে 'উত্তরবঙ্গ, বলে কোনো নাম নেই। আসলে পশ্চিমবঙ্গের উত্তরাঞ্চলের সাতটি জেলা—মালদহ, উত্তর দিনাজপুর, দক্ষিণ দিনাজপুর, দার্জিলিং, জলপাইগুড়ি, কোচবিহার ও আলিপুরদুয়ার সরকারি ও বেসরকারি ভাবে উত্তরবঙ্গ নামেই সমধিক পরিচিত।[১] যাকে প্রশাসনিকভাবে 'জলপাইগুড়ি ডিভিশন' বলা হয়।[২] উপরোক্ত অঞ্চলকে নিয়ে পৃথক রাজ্য গঠনের দাবির আন্দোলনই উত্তরখন্ড আন্দোলন নামে পরিচিত। এই দাবির প্রবক্তা উত্তরবঙ্গের একক সংখ্যাগরিষ্ঠ তপশিলি জাতি-রাজবংশী সমাজের একাংশ। এই দাবি আদায়ের জন্য রাজবংশী সমাজের একাংশ উত্তরখন্ড নামে একটি রাজনৈতিক দল গঠন করেছেন ১৯৬৮ সালে। এই দল এখন আবার দ্বিধাবিভক্ত উত্তরখন্ড দল ও কামতাপুর গণপরিষদ নামে।

উত্তরবঙ্গ নাম না দিয়ে উত্তরখন্ড নাম গ্রহণ করলে কেন—এ সম্পর্কে একটি মত আছে সেটি হল জলপাইগুড়ি ডুয়ার্সের চা বাগানে প্রচুর সাঁওতাল শ্রমিক কাজ করেন। এছাড়া মালদহ ও দুই দিনাজপুরের সাঁওতাল রয়েছেন। এদের একটা বিরাট অংশ ঝাড়খন্ড আন্দোলনের প্রতি সহানুভূতিসম্পন্ন। এদের সমর্থন পাওয়ার উদ্দেশ্যেই উত্তরাখন্ড নামটি গ্রহণ করা হয়েছিল। উত্তরবঙ্গের উত্তর ও ঝাড়খন্ডের উত্তরাখন্ড নাম হয়েছিল। তবে রাজ্যের নাম হিসাবে তাঁরা কামতাপুর নামের ঐতিহাসিক অঞ্চলের নামেই বেছে নিয়েছিলেন। কজামতাপুর নামে রাজ্য কেন চাইছেন তাও পরিস্কার নয়। কারণ কামতাপুর রাজ্যের গৌরব ছিল খেন রাজবংশ। খেন বংশের পতনের পর কোচ রাজশক্তির উদ্ভব হয়। খেন এবং কোচ কোনও রাজবংশের সঙ্গেই উত্তরখন্ড দলের রাজবংশী ক্ষত্রিয়রা ঐতিহাসিকভাবে একাত্মতা অনুভব করেন না। কারণ কোচ ও খেন উভয় জনগোষ্ঠি থেকেই উত্তরবঙ্গের রাজবংশী ক্ষত্রিয়রা নিজেদের আলাদা ভাবেন। সর্বোপরি কামতাপুর নামক রাজ্যের আদি প্রতিষ্ঠাতা ছিলেন কায়স্থ পালবংশের বৈদ্যদেব।[৩]

উত্তরবঙ্গের ইতিহাস ও সমাজ-৬



ড. আনন্দগোপাল ঘোষ
মনোজিৎ দাস
সুব্রত বাড়ই

উত্তরবঙ্গের ইতিহাস ও সমাজ-৬

সুকৃতি সুন্দরী: প্রসঙ্গ কোচবিহার রাজ পরিবারের
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মনোজিৎ দাস

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সুব্রত বাড়ই

স্বাধীনোত্তর উত্তরবঙ্গের কৃষি অর্থনীতি ও আদিবাসী সমাজ— পৃ. ১৬৮

স্বাধীনোত্তর হিমালয়বঙ্গে জাতপাতের রাজনীতিতে
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চা-বাগান পত্তনের আদি পর্বে শ্রমিকদের
দাসত্ব জীবন ও বর্তমান অবস্থা: প্রসঙ্গত ডুয়ার্স— পৃ.১৮৭

উত্তরবঙ্গের চা-বাগানে আদিবাসী সমাজে মধ্যবিত্ত শ্রেণি
গড়ে ওঠার কথা– পৃ. ১৯৫

নতুন তথ্যের আলোকে —

পূর্বতন দেশীয় রাজ্য কোচবিহারের সংযুক্তিকরণ আন্দোলনের উৎপত্তি ও বিকাশ

মনোজিৎ দাস

১৯৪৭ সালের ১৫ই আগষ্ট ভারতবর্ষ স্বাধীন হলে দেশীয় রাজ্যগুলির ভবিষত নিয়ে নানা ধরণের চিন্তাভাবনা শুরু হয়েছিল। এটা ঠিক যে ৫৬৩টি দেশীয় রাজ্যের মধ্যে অধিকাংশ দেশীয় রাজ্যেই Instrument of Accession-এ স্বাক্ষর দিয়েছিল ১৫ই আগষ্টের পূর্বেই।[১] কেউ কেউ দীর্ঘদিন স্বাধীনসত্তা বজায় রাখে এবং ভারত অথবা পাকিস্থান-এর কোনটির অধীনতা স্বীকার করবে তা মনস্থির করতে পারেনা। উত্তরপূর্ব ভারতের কোচবিহার রাজ্যটি এরকম ত্রিশঙ্কু অবস্থায় পড়ে যায়। সুদীর্ঘ দু'বছর টানাপোড়নের পর কোচবিহারের মহারাজা জগদ্দীপেন্দ্র ভূপবাহাদুর ১৯৪৯ সালের ১২ই সেপ্টেম্বর Instrumant of Accession স্বাক্ষর করে ভারতে যোগদান করেন। ১৯৫০ সালের ১লা জানুয়ারি কোচবিহার রাজ্য পশ্চিমবঙ্গের সঙ্গে যুক্ত হয় এবং একটি জেলার মর্যাদা পায়।[২]

কোচবিহার রাজ্যের ভারতভুক্তি এবং পরে পশ্চিমবঙ্গের জেলা হিসাবে যোগদান কিন্তু খুব সহজে সম্ভব হয়নি। ১৯৪৭ সালের ১৫ই আগষ্ট থেকে ১৯৫০ সালের ১লা জানুয়ারি এই সুদীর্ঘ আড়াই বৎসর কাল কোচবিহার রাজ্যের রাজনীতি আঁকাবাঁকা পথে প্রবাহিত হয়ে সঙ্কটময় অবস্থা সৃষ্টি করেছিল।[৩]

কোচবিহারের এই সঙ্কটের কারণ ছিল, রাজ্যের ভৌগলিক অবস্থান ও জনবৈচিত্র। কোচবিহার রাজ্যটি আসাম, পশ্চিমবঙ্গ, পূর্ব পাকিস্থান(বর্তমান বাংলাদেশ) ও ভুটান দ্বারা পরিবেষ্টিত। জনসংখ্যায় ৬৭শতাংশ হিন্দু ও ৩০ শতাংশ মুসলমান। বাদবাকি অন্যান্য সম্প্রদায়ভুক্ত। হিন্দুদের অধিকাংশই রাজবংশী গোষ্ঠীভুক্ত। আসাম প্রদেশ কংগ্রেস কমিটি আনুষ্ঠানিকভাবে দাবি জানিয়ে ছিল যে কোচবিহার রাজ্যকে আসামের অন্তর্ভূক্ত করতে হবে। কারণ সাংস্কৃতিক, নৃতাত্ত্বিক, সমাজব্যবস্থা, ভূমি ব্যবস্থা ও শাসনতান্ত্রিক গঠণপ্রণালী বিশ্লেষন করলে দেখা যাবে কোচবিহাররাজ্য আসামের সঙ্গে অঙ্গাঙ্গীভাবে জড়িত। তাছাড়া ইতিহাসে এক বিশেষ সময়ে কোচবিহার রাজ্য প্রাগজ্যোতিষপুর ও

ISSN 0976-2132

UTKAL HISTORICAL RESEARCH JOURNAL

VOLUME:-34-No-2

2021

DEPARTMENT OF HISTORY
UTKAL UNIVERSITY, VANI VIHAR
BHUBANESWAR-751004, (ODISHA) INDIA

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FROM MERGER TO DE-MERGER: A STUDY ON THE PRINCELY STATE OF MANIPUR (1949 - 1958)

Manojit Das
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Policy of the interim Government of India towards the Native States was more or less clearly defined in July, 1947. Consequent on the creation of the States Ministry under the charge of Sardar Patel, the Deputy Prime Minister. Such policy visualizes the merger of the Native States with Indian Dominion after the British transfer of powers to the Indian hands. Thus, merger of Manipur with India was inevitable for the Successful implementation of such policy.[1]

On the 15th of October, Manipur was merged into India. This historic event marked the end of an era of "Independent" Kingdom of Manipur and the beginning of a new one, that of a "Constituent State" of the Indian Union. This political integration was a significant development in the Political History of Manipur.[2]

The merger of Manipur into the political boundary of the Indian Union was a great significant political development in the history of Manipur. It produced two important Historical impacts. Firstly, this event marked the end of an era of the 'Independent Kingdom of Manipur' and secondly beginning of a new historical period of a constituent state of the India Union. Many factors were responsible for the emergence of this compelling phenomenon. But the immediate factor may be directly related with the result of the election of 1948.

It is a well-known fact that right from the very beginning the leaders of the congress party of India had adopted a firm policy to bring all princely states (either protectorate of Colonial State) during the British regime into the political boundary of the Indian Union. It was clearly evident by the resolution of the Congress party held on 15th June, 1947 in which they openly declared that no princely state in India should be allowed to keep aloof as a Sovereign independent state. While this feeling was in the minds of the political leaders, Budhachandra Singh, the Maharaja of Manipur gave a very good opportunity to them to open their trump card by signing the 'Stand Still Agreement' on the 11th January, 1947. According to this agreement, the Maharaja agreed to hand over some items of administration like defence, external affairs, Coinage, Communication, etc. to the responsibilities of the Indian Government. The relationship between Manipur and India was also practiced through the office of the Dominion Agent. The acceptance of this conditions by Maharaja had created a lot of confusion to the political status of the state. This was the opportunity enjoyed by the leaders of the Congress Party of India. Then in order to materialize their plan and to carry out their action very smoothly, they appointed one Deveshwar Sharma who was the Chief Whip of the Manipur. The appointment of Deveshwar Sharma itself was a great achievement of the Indian Government and through his office, the leaders of the Indian Congress Party of India had made a successful effort to make Manipur as a political unit of the Indian Political boundary. His appointment as a Dominion Agent was a deliberate calculated move of the congress leaders of India. in order to materialize the objectives, we always misused his position and power and it is mentioned that even Sir Akbar Hydary, the Governor of Assam decided to abolish this position. In these connections the position of 'Dominion Agent' was abolished on the 22nd August, 1948.[3]

Imposition of the India Government policy for interferences in the internal affairs of Manipur through its Dominion Agent at Imphal was considered as having provoked criticism / opposition of Manipuris against the

2021

Bicentennial Commemoration Volume of Malda District (1813-2013)

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A Study On The Society, Economy, Culture And Politics



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The Kaleidoscopic Canvas of the Growth and Development of Education in Malda District (1813 – 2013)

Ananda Gopal Ghosh & Manojit Das

(I)

Malda is the only district of present North Bengal which has already completed the bi - centenary years in 2013. But if we take into considerations the history of the un- partioned North Bengal, then we can say that Malda is the third oldest district after Dinajpur and Rangpur. History told us that Malda was born as a separate district out of Dinajpur,Rajshahi and Purnea. Arithmetically it is not only old but from the civilization perspective, it has been carried the legacy of pundravardhana, the glorious past of the pala kingdom, the cultural heritage of the varendrabhumi , the glamorous capitals such as Gauda, Pandua, and Rajmahal. It was the Buddhist Educational hub of the early medieval Bengal. The Jagdala and Jagajibanpur Mahavihars were meeting places of the transnational Buddhist Scholars. Moreover, the liberal patronage of the Husain Shahi dynasty of Bengal had given the birth of a new life for the Bengali Language and Literature and translation of the Indian Classics into vernacular. Frankly speaking, Gauda's literary and learning fame had been extended to the different parts of North India or Aryabarta. The Classic example was Kabi Kirtibash. He came to North Bengal for pursuing higher education. He wrote about his education :

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SOCIAL MOVEMENTS IN INDIA IN CONTEMPORARY ERA



Editors

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ISBN: 978-93-90863-69-3

Price: 699/-

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Published By:

National Press Associates

Head Office: *C-24, Ground Floor, Panchsheel Vihar, Malviya Nagar, New Delhi-110017, India*

Regional Office: *79, GAD Nagar, Flower Enclave, Dugri, Ludhiana, Punjab-141013, India*

Branch Office: *G-1003,Prakriti Society, Baner-Balewadi Road, Balewadi Pune, 411045 Mharashtra, India*

Email: *npapublishing@gmail.com | www.npapublishing.in*

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 ISBN: 978-93-90863-69-3

TEBHAGA MOVEMENT: AN UPSURGE TO CHOKE THE BLOOD SUCKING LEECHES OF SOCIETY AS DEPICTED IN ABU ISHAK'S SHORT STORY 'JONK'

Sudipta Singha

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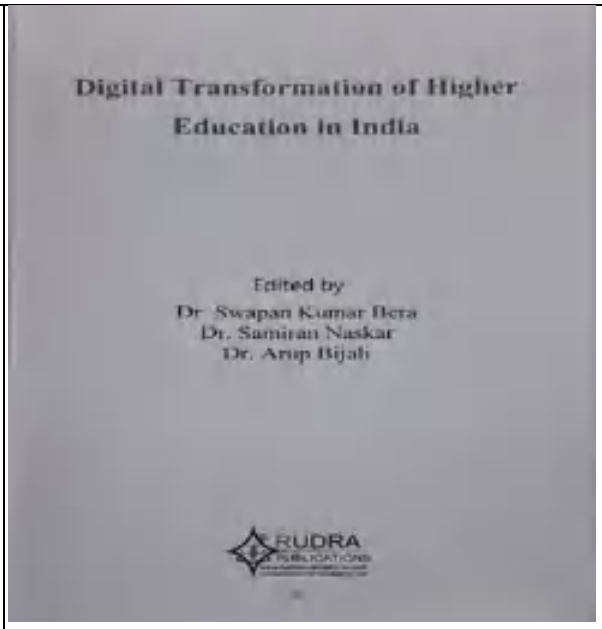
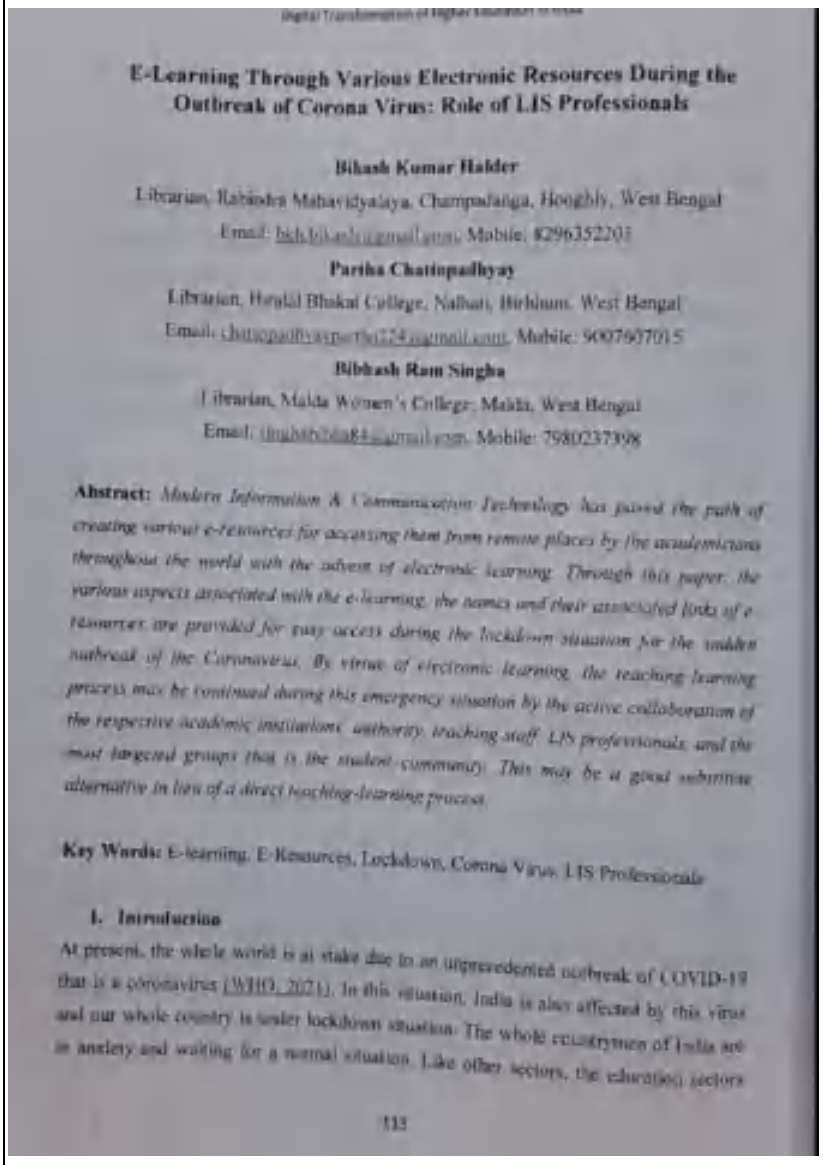
ABSTRACT

Sitting at a dinner table having a plate full of boiled rice, have we ever thought of those peasants who are actually responsible for providing our plate with such foods. Many of us have a tendency to keep leftovers or most of the time our much more foods are left on our plate. While doing so have we ever thought how much labour is given to produce the crops from which we get our food or do we have any idea of the dilapidated condition of the life of a peasant. No...the answer will be no. I, having been born and brought up at a village surrounded with paddy fields, my rural eyes and my rural mind are very much familiar with the green fields as well as the lives of those peasants, their clay smitten feet, their sun burnt appearance. They never care for beauty creams like fair & lovely or fair and handsome. What they do care is how to produce a hansome quality and a fair amount of crops In their fields. And for that they make the land, the soil their second abode. However, once there had been a time when a peasant did not have the right over the complete production they made in their land. After giving untiring toil as well as bearing the whole expenditure to produce their erops there had been a group of people like jamindars, jotedars who claimed their share over the half of the production and thus took almost a huge part of the whole one. We know the history. The tradition of giving agrarian tax(khajna) to jamindars, to jotedars is very much well-known to us. But the situation became worse after East India company won the civil benefits in 1765 and the permanent settlement headed by Lord Cornwallis was brought into effect in 1793 to fix the tax over production. Retrospecting the pictures of the peasants being exploited under that situation really makes goose bumps. In my present paper , a thorough light is, therefore, being given on the pathetic situation undergone by those unfortunate peasants as well as the fact that how they once got organised to bring a revolutionary change into this society through the so-called movement called 'Tebhaga' as depicted in some pieces of literature. I'll, therefore, here discuss the movement in brief and then will throw light on the horrific history of the time as depicted in Abu Ishak's short story 'Jonk' .

Keywords: Tebhaga, jotedars, bargadars, movement, agrerian, reveneu, upsirge, sharecropper, adhiar, khalan.

INTRODUCTION

It is the story of the sharecroppers, the adhiars, the peasants, their untiring toil and of the question who should actually be the owner of the whole green field. They did never long for the decadent life of a zamindar lying half on cushioned bed piping on a hukka. Rather what they just want is the the 'tebhaga'- the two third share of the whole production of crops they made on their land out of their own untiring physical and mental labour. That little amount of produce, though, is not much for anyone. However they are seen to be satisfied with that little amount. They arc the Charudutta of human society. They only know to give, to contribute in a society. They never long for anything high in their life, never care for themselves. They are the real hero. They are the one providing food for us remaining fast most of the days of a year. The kings, the zamindars, the jotedars of every ages, the british colonizers have been taking advantages to this simple nature of these people. These leeches like people have been sucking their blood , squizing their lives only for their game of profit and loss. This was the year of 1946, just a year before India got independence in 1947 that with the initiative of the All India Krishak Sabha of peasant front of the Communist Party of India there was upsurged a significant peasant agitation in Bengal. This peasant agitation is well known in the history of Bengal as Tebhaga Movement.

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E-Learning Through Various Electronic Resources During the Outbreak of Corona Virus: Role of LIS Professionals

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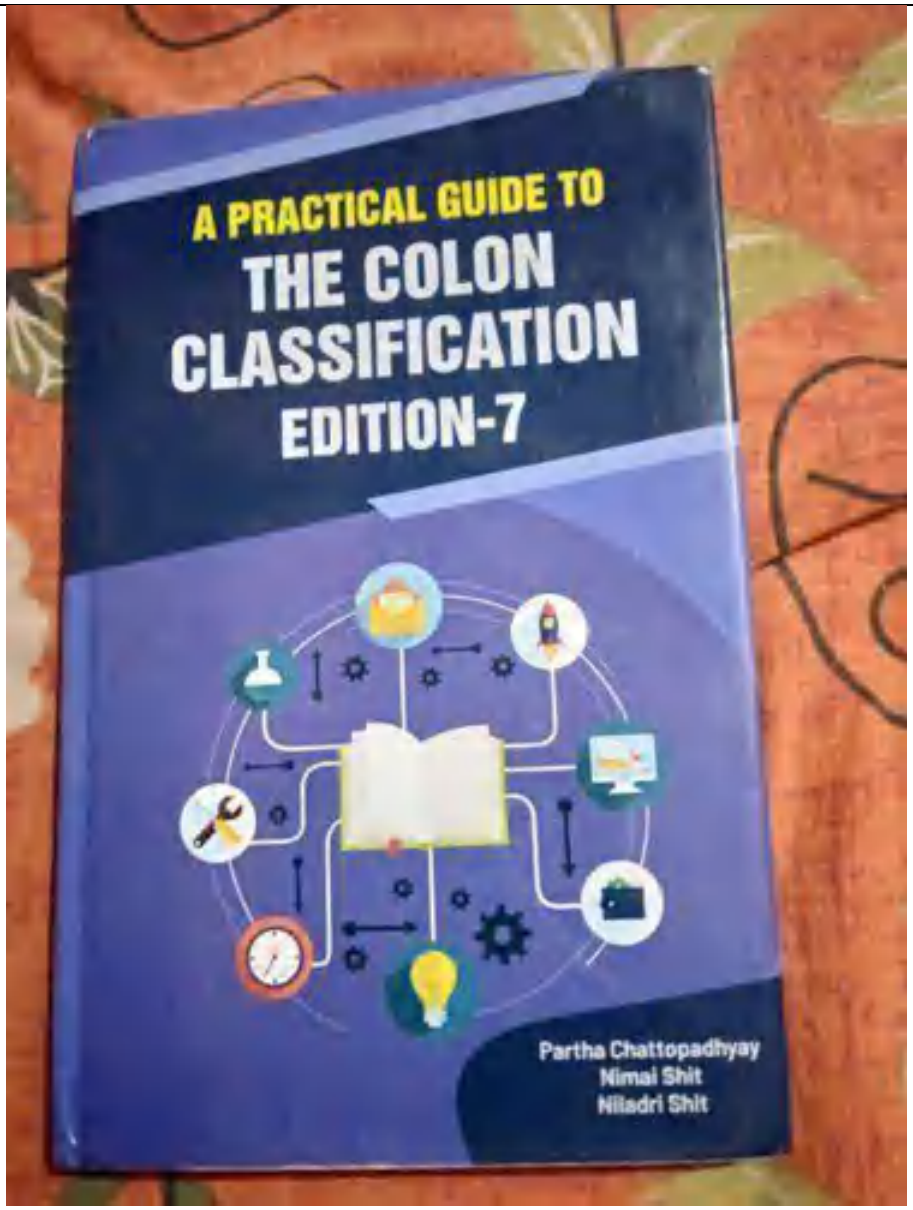
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Abstract: *Modern Information & Communication Technology has paved the path of creating various e-resources for accessing them from remote places by the academicians throughout the world with the advent of electronic learning. Through this paper, the various aspects associated with the e-learning, the names and their associated links of e-resources are provided for easy access during the lockdown situation for the sudden outbreak of the Coronavirus. By virtue of electronic learning, the teaching learning process may be continued during this emergency situation by the active collaboration of the respective academic institutions' authority, teaching staff, LIS professionals, and the most targeted groups that is the student community. This may be a good substitute alternative in lieu of a direct teaching-learning process.*

Key Words: E-learning, E-Resources, Lockdown, Corona Virus, LIS Professionals

1. Introduction

At present, the whole world is at stake due to an unprecedented outbreak of COVID-19 that is a coronavirus (WHO, 2021). In this situation, India is also affected by this virus and our whole country is under lockdown situation. The whole countrymen of India are in anxiety and waiting for a normal situation. Like other sectors, the education sectors

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Role of Academic Libraries in the Modern ICT Environment

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Editors

Hiralal Bhakat College
Nalhati-731220, Birbhum
West Bengal, India

First published 2023 in India
By Hiralal Bbakat Cnllege
Naibati-731220, Birbbum
West Bengal, India

Hiralal Bhakal College is a general degree college affiliated to Tbe University of Burdwan, recognized by UGC and accredited by NAAC.

© 2023 Principal, Hiralal Bbakat College

Typeset, printed, and bounded in India by
Shila Art Press
Bbagahatipur, Abmedpur-731201
Birbhum, West Bengal, India

Cnver designed by
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ISBN: 978-81-965519-0-2

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PRICE: ₹ 300

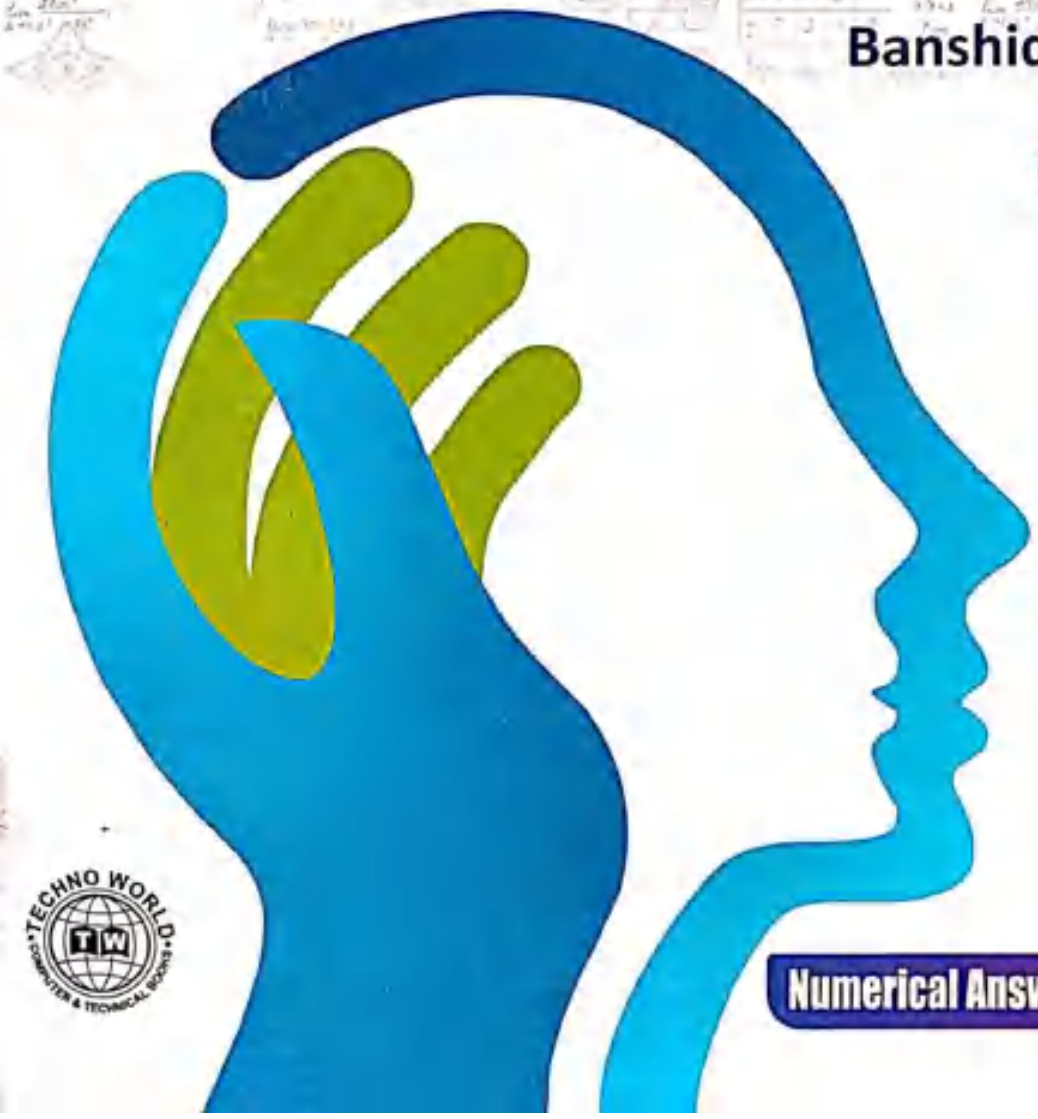
ISBN 978-81-965519-0-2

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MCQ Mathematics By Banshidhar Sahoo

Published by:
TECHNO WORLD
90/6A, M. G. Road, Kolkata - 700 007
☎(033) 2219 6116, 2257 1650
E-mail: technoworldcal@gmail.com

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First Edition : Nov. 2016
Second Edition : June 2017
Third Edition : July 2018
Fourth Edition : May 2019
Fifth Edition : Sept 2020
Sixth Edition : Sept 2022

ISBN - 978-93-92145-69-8

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Rs: 795.00

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☎ Tel. : +91-33-22196116, +91-33-22571650
e-mail : technoworldcal@gmail.com

© *Reserved by the Publisher*

First Published : July, 2022

Type Setting :
Rittika Graphics
Kolkata-700 009

Printed by :
D. G. Offset
Kolkata

Binding by :
Standard Binding Works

ISBN : 978-93-92145-08-7

Price : ₹ 575/-

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প্রাচীন ভারতের ইতিহাস

(প্রাগৈতিহাসিক - ষষ্ঠ শতক)

সুকুমার মন্ডল



Prachin Bharater Itihas (Pragaitihasik-600 Saal): A textbook of History for three year degree course (Semester System Prepared as per the new C.B.C.S. system) of all the Universities of West Bengal & Tripura, written by **Sukumar Mandal** (M.A.) Assistant Professor, Department of History, Hiralal Bhakat College, Nalhati, Birbhum.

BOOK CODE - WB - 021

ISBN-13: 978-93-5594-179-4 (HB)
ISBN-13: 978-93-5594-183-1 (PB)

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First Published in 2022

Published and Printed by

Concept
Since 1974

Concept Publishing Company Pvt. Ltd.
A/15-16, Commercial Block, Mohan Garden
New Delhi-110059 (India)
Phones : +91 11 41101460
Email : publishing@conceptpub.com,
Website: www.conceptpub.com

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As per C.B.C.S.
Semester System

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- পরিবেশ দূষণ এবং ব্যবস্থাপনা: বায়ু দূষণ, শব্দ দূষণ, মৃত্তিকা দূষণ, পারমানবিক দূষণ, জল দূষণ। 90-92
- বায়ু দূষণ, জল দূষণ, মৃত্তিকা দূষণ, শব্দ দূষণ, পারমাণবিক দূষণ, প্রকৃতি, কারণ,

ROLE OF ACADEMIC LIBRARIES IN THE MODERN ICT ENVIRONMENT



Editors

Partha Chattopadhyay

Indranil Mondal

HIRALAL BHAKAT COLLEGE

NALHATI, BIRBHUM

Role of Academic Libraries in the Modern ICT Environment

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Dr. Indranil Mondal
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Hiralal Bhakat College
Nalhati-731220, Birbhum
West Bengal, India

First published 2023 in India
By Hiralal Bhakat College
Nalhati-731220, Birbhum
West Bengal, India

Hiralal Bhakat College is a general degree college affiliated to The University of Burdwan, recognized by UGC and accredited by NAAC.

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Typeset, printed, and bounded in India by
Shila Art Press
Bhagabatipur, Ahmedpur-731201
Birbhum, West Bengal, India

Cover designed by
Niladri Das

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ISBN: 970-81-965519-0-2

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History of Geographical Thought

Written by Sajal Ghosh

Published by : Dev Prakasani

Rs.400/-

ভৌগোলিক চিন্তার ইতিহাস

সজল ঘোষ

Syllabus অনুযায়ী লিখিত

(B.A./B.Sc./M.A./M.Sc./NET/SET)

ভৌগোলিক চিন্তার ইতিহাস

(History of Geographical Thought)

Ancient to Modern Period



সজল ঘোষ

সূচীপত্র

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♦ সহায়ক গ্রন্থপঞ্জী 281











ISBN 978-93-5788-259-0

asian press

9 789357 882590

MRP ₹300/-

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Geomorphological Analysis of Bolpur Sriniketan and Surrounding Area

BIRBHUM DISTRICT, WEST BENGAL, INDIA

Sajal Ghosh



GEOMORPHOLOGICAL ANALYSIS OF BOLPUR SRINIKETAN AND SURROUNDING AREA, BIRBHUM DISTRICT, WEST BENGAL, INDIA

By
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asian press

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Publisher
ASIAN PRESS BOOKS
509, Saltee Plaza, 5th Floor,
1/G Khudiram Bose Sarani
Jessore Road, Kolkata-700080
Mob: 7001813717
www.asianpress.in

ISBN: 978-93-5788-259-0

1st Edition August 2023

MRP ₹300/-

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IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

AGRICULTURAL REGIONALISATION WITH SPECIAL REFERENCE TO CROPPING INTENSITY USING GEOSPATIAL TECHNIQUE – A CASE STUDY OF BIRBHUM DISTRICT, WEST BENGAL, INDIA

SAJAL GHOSH

TEACHER

HIRALAL BHAKAT COLLEGE , BURDWAN UNIVERSITY

ABSTRACT: This study presents a Cropping Intensity with related to different physical and socio-economic factors in Birbhum District. The diversified nature of land use pattern, cropping intensity, irrigation intensity and cropping pattern of all blocks have increased the cropping intensity of the land. Cropping Intensity plays an important role in the agricultural development of any region. The study area is characterized by lateritic features and riverine features. The study area observed that Cropping Intensity highest in Nalhati-II block is 229.9195 and lowest in Rajnagar block is 112.3470 in 2015. Irrigation is considered as driven elements that both surface and groundwater sources have almost equal important to the development of Cropping Intensity in this districts.

Key Words: Cropping Intensity, Groundwater, Agricultural Development, Socio-economic factors

INTRODUCTION: Agriculture is the back bone of the Indian Economy. Agricultural productivity is closely influenced by physical , socio-economic , political, institutional and organizational factors. (Saha & Rudra, 2019). Agriculture is an essential occupation for income and employment in developing countries , and particularly for the rural poor, and is widely considered to be the major " engine" of economic growth in most of the developing countries. Regionalisation is the process of dividing an aryea into territorial units of uniformities and is the result of a set of processes(Chakraborty, 2015).Delimitation or delineation of agricultural region is known as agricultural regionalization. The agricultural regionalization may be done with the help of following methods like – Cropping pattern, Crop combination, Crop Concentration, Cropping Intensity, Agricultural productivity etc(Paul et al., 2020).The major sources of agricultural growth during this period were the spread of mdern crop.Land degradation due to over cropping, over irrigation, loss of biodiversity, declining agricultural genetic diversity and climate change are some of the challenges that potentiality threatened the future viability ofagricultural systems.(Priyadharshini, 2014) .

GEOMORPHOLOGICAL STUDY OF WEATHERING PROCESS IN MAMA BHAGNE PAHAR, BIRBHUM DISTRICT, WEST BENGAL

SAJAL GHOSH

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Abstract

Granite landscape are characterized by the presence of sharply defined residual hills rising abruptly from the surrounding plain. It's average elevation from sea level is 77 metre of 252 feet Mama Bhagne pahar is a rock formation near Dubrajpur town in the Indian state of West Bengal, the balancing of the rocks are so surprising that it is a famous landmark in West Bengal. In Mama Bhagne Pahar region weathering process is very active. This research is characterizes the weathering of natural building stone using an field observation and instrumental methods. Weathering is the disintegration, decomposition and breakdown earth material in situ, differences in weathering from place to place thus play a key role I defining the character of a landscape. A distinct boundary between unweathered and weathered rock that moves downward as weathering proceeds is known as weathering front.

Key Words: Mama Bhagne Pahar, Granite landscape, Weathering, Weathering Front, Disintegration

INTRODUCTION: The study area (Mama Bhagne Pahar) is characterised by both physical or mechanical weathering and chemical with bio-chemical weathering probe area. It is the extreme eastern part of the chotanagpur plateau region where the granite is gray and composed of glassy quartz pink, gray feldspar and black mica. Granite landscape are characterized by the presence of sharply defined residual hills rising abruptly from the surrounding plain. In this paper an attempt has also been made to abuse the geomorphic features with different weathering process like mechanical weathering, chemical weathering and biological weathering. Weathering is the change of ground materials under influence of the Earth atmosphere, hydrosphere, cryosphere, biosphere, and by nuclear radiation , mostly causing hard ground to become soft ground. (Hack, 2019). Weathering being part of geomorphic processes is the disintegration and decomposition of rocks and minerals on the earth's surface as a result of physical and chemical action. Weathering is a diverse process that has implications for a wide range of earth and surface processes . (Shalkowski et al., 2009). The surface relief of any land is not permanent on the earth. Every block of rock is subjected to modifications. Over a period of geological time, these surface blocks and rocks break down into smaller and finer pieces. (Balasubramanian, 2016). The effect of weathering on rocks may be reflected by changes in index properties such as dry density, void ratio, clay content and P- wave velocity. Because these properties of rocks have geotechnical significance , it is important for geotechnical engineers to assess the weatherability of rocks

ROLE OF ACADEMIC LIBRARIES IN THE MODERN ICT ENVIRONMENT



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Partha Chattopadhyay

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Digital Initiative of Higher Education in India in 21st Century

Sajal Ghosh
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Department of Geography, Hiralal Bhakat College, Nalhati, Birbhum

Abstract

The number of people using the internet is increasing at a record rate every year. It is expected that 25 percent of people in India will use the internet by 2025. Along with this, the use of ICT in higher education is also increasing. The Government of India launched the Digital India initiative in 2015 to improve the quality of Internet services in rural areas of India and to enable every citizen of India to access government services digitally. Education is a very socially oriented activity and ICT has become an integral part of today's teaching learning process. Digital technologies have had a considerable impact on institutional administration and governance, as well as higher education institution certification and rating. The COVID-19 pandemic tested these claims like never before, as higher education systems seemingly overnight had to move teaching online. This paper highlights about various digital initiatives in India such as Umang MobileApplication, GyanVani, GIAN, National Academic Depository, SWAYAM, SWAYAM PRABHA, VIDWAN, Digilocker, Shodh Ganga, E-Yantra, E-Granthalaya etc.

Keywords

Digital India, ICT, COVID-19, SWAYAM, Higher Education

Introduction

Over the past few decades, technology has has completely transformed our lives in all possible ways. India, a successful ICT powered nation, has always laid a lot of accents on the use of ICT, not only for good governance but also in diverse sectors of the economy such as health, agriculture, and education (Raysan, 2020). The higher education system in India is not remarkable due to inadequate access to technology and inequity (Patil & Dhembre, 2019). Higher education playsa pivotal role in the development of a country, as it is viewed as a powerful means to build knowledge-based society. Information and Communication Technology (ICT) plays a very crucial role in shaping of students for information rich life. ICT refers to an umbrella term which incorporates all electronic tools and technologies as a mean to collect process and exchange

ROLE OF ACADEMIC LIBRARIES IN THE MODERN ICT ENVIRONMENT



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Role of Academic Libraries in the Modern ICT Environment

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Hiralal Bhakat College
Nalhati-731220, Birbhum
West Bengal, India

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First published 2023 in India
By Hiralal Bhakat College
Nalhati-731220, Birbhum
West Bengal, India

Hiralal Bhakat College is a general degree college affiliated to The University Burdwan, recognized by UGC and accredited by NAAC.

© 2023 Principal, Hiralal Bhakat College

Typeset, printed, and bounded in India by
Shila Art Press
Bhagabatipur, Ahmedpur-731201
Birbhum, West Bengal, India

Cover designed by
Niladri Das

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ISBN: 978-81-965519-0-2

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Pandemic : History Literature and Psychology



Editors
Brintika Das
Tanusbree Sarkar Deb

First Published 2022

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ISBN 978-93-92302-01-5

Published By
Tandrita Bhaduri for
Rachayita
59/5, Garfa Main Road, Kolkata 700 075
Phone : 9831542192

Cover Illustrated By
Syed Abdul Halim

Typeset By
LTM Graphics
Kolkata-700 144

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Defoe's *A Journal of the Plague Year*: A Retrospectiou to the Plagued Atmosphere of the Great Plague of Loudou 1665-66

Sudipta Singha

Introduction:

The stories of pandemic, plague and epidemic fill the pages of history only with thrilling stories. It tells the stories of panic, of suffering and death. Sometimes this panic emerges as the panic of plague, sometimes of cholera, sometimes of influenza, or sometimes of Tuberculosis or again sometimes as Covid -19. The comings and goings of these diseases often seem arbitrary and simply inexplicable. The more we delve deep into the history of disease, the more will these stories of human sufferings, stories of throwing off the corpses incongruously into the deep long burial pits, whispers into our ears. The study of disease, therefore, is not a very pleasant subject to contemplate. Human beings have frequently been confronting the emergence and spread of contagious diseases with the potentiality of pandemic throughout the history. The Major pandemics and epidemics that afflicted humanity throughout the history are plague, cholera, flu, severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East respiratory syndrome coronavirus (MERS-CoV). Besides, the present generation of people have just had an experience of Covid-19 as a pandemic. The term pandemic refers to a. Infectious disease that spreads globally whereas an epidemic spread to a wider geographic area.

In 1665 England was struck by the great plague. The disease



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A Study on Society, Economy, Politics and Environment

Editors
Dr. Kartik Chandra Sutradhar
Aruu Ghosh • Mauojit Das

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কালের বৃত্তে

দ্বিতীয় খণ্ড

সম্পাদনা

জয়িতা দত্ত



বাংলা ছোটগল্প

কালের বৃত্তে

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> The higher order of realists should rather call themselves illusionists.

লক্ষণীয় যে, প্রতিটি 'অতিপ্রাকৃত' গল্পেই অতিলৌকিক প্রতীতি জাগানোর সঙ্গে অচ্ছেদ্যভাবে জড়িয়ে আছে গল্পের মূল ব্যক্তিচরিত্রের সাময়িক চিত্তবিকার বা চিত্তবিভ্রম। পশ্চিমি সাহিত্যে অতিপ্রাকৃত গল্পের আদিপুরুষ এডগার অ্যালান পো-র এ ধরনের গল্প ও চরিত্রেও এই বিশ্রস্ত ভগ্নপ্রায় সত্তার সাক্ষাৎ মেলে। পো এবং রবীন্দ্রনাথ— উভয়ের 'অতিপ্রাকৃত' গল্পই এই অর্থে ওয়ালটার অ্যালেন কথিত 'Disintegration of the human psyche'[১] -এর অনুপম নিদর্শন।

রবীন্দ্রনাথ শিলাইদহে থাকাকালীন কঙ্কাল গল্পটি রচনা করেন। সাধনা পত্রিকার ফাল্গুন সংখ্যায় ১২৯৮ বঙ্গাব্দে (১৮৯১ খ্রি.) এটি প্রকাশিত হয়। উনবিংশ শতাব্দীর বাঙালি মানসে enlightened scepticism আর outmoded belief-এর দ্বন্দ্ব নিত্যজাগ্রত ছিল— একদিকে ডিরোজিও প্রবর্তিত নব্যবঙ্গীয় যুক্তিবাদ, অক্ষয়কুমার দত্তের যান্ত্রিক জড়বাদ, কোঁত-বেন্থাম অনুপ্রাণিত বুদ্ধিজীবী বাঙালির ধ্রুববাদ আর হিতবাদ অন্যদিকে ব্লাভাটস্কি আর কর্নেল অলকট্ পরিচালিত ভারতের থিওসফি আন্দোলন। এই সময়ই কয়েকজন মিলে কলকাতায় স্থাপন করেন ইউনাইটেড অ্যাসোসিয়েশন অফ স্পিরিচুয়ালিস্টস্। দ্বিজেন্দ্রনাথ ঠাকুর, স্বর্ণকুমারী দেবীর মতো ঠাকুর পরিবারের অনেকেই ছিলেন থিয়োসফিস্ট সম্প্রদায়ভুক্ত। যদিও ঠাকুরপরিবারে থিওসফির প্রভাব বেশিদিন স্থায়ী হয়নি।

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: বিষয় সমিতি :

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মডিউলঃ ১ Module :1	ড. গোবর্ধন অধিকারী, সহকারী অধ্যাপক, বাংলা বিভাগ, চোপড়া কমলাপাল স্মৃতি মহাবিদ্যালয়	অধ্যাপক মনন কুমার মন্ডল বাংলা বিভাগ নেতাজি সুভাষ মুক্ত বিশ্ববিদ্যালয়
মডিউলঃ ২ Module : 2	ড. মৃদুল হক, সহকারী অধ্যাপক, বাংলা বিভাগ দীনবন্ধু মহাবিদ্যালয়	
মিডিউলঃ ৩ Module : 3	অর্পিতা ব্যানার্জি, সহকারী অধ্যাপক, বাংলা বিভাগ হীরালাল ভকত কলেজ, নলহাটি, বীরভূম	
মডিউলঃ ৪ Module : 4	ড. শান্তনু মণ্ডল, সহকারী অধ্যাপক, বাংলা বিভাগ কল্যাণী বিশ্ববিদ্যালয়	

স্নাতক-বাংলা বিষয় সমিতি

ড. শক্তিনাথ ঝা, অবসরপ্রাপ্ত অধ্যাপক কৃষ্ণনাথ কলেজ, মুর্শিদাবাদ

বাণীমঞ্জরী দাস, অবসরপ্রাপ্ত অধ্যাপিকা, বেথুন কলেজ, কলিকাতা

ড. নীহারকান্তি মণ্ডল, সহযোগী অধ্যাপক, মুরলীধর গার্লস কলেজ, কলিকাতা

ড. চিত্রিতা ব্যানার্জি, সহযোগী অধ্যাপক, শ্রীশিক্ষায়তন কলেজ, কলিকাতা

আব্দুল কাফি, বাংলা বিভাগ, যাদবপুর বিশ্ববিদ্যালয়

ড. অনামিকা দাস, সহকারী অধ্যাপক, বাংলা বিভাগ, নেতাজি সুভাষ মুক্ত বিশ্ববিদ্যালয়

অধ্যাপক মননকুমার মণ্ডল, বিভাগীয় প্রধান, বাংলা বিভাগ ও
অধিকর্তা, মানববিদ্যা অনুষদ, নেতাজি সুভাষ মুক্ত বিশ্ববিদ্যালয়

প্রজ্ঞাপন

এই পাঠ-সংকলনের সমুদয় স্বত্ব নেতাজি সুভাষ মুক্ত বিশ্ববিদ্যালয়ের দ্বারা সংরক্ষিত। বিশ্ববিদ্যালয় কর্তৃপক্ষের লিখিত অনুমতি ছাড়া এর কোনোও অংশের পুনর্মুদ্রণ বা কোনোভাবে উদ্ধৃতি সম্পূর্ণ নিষিদ্ধ।

ড. অসিত বরণ আইচ
নিবন্ধক (কার্যকরী)

মডিউল - ৩ প্রবন্ধ ও সমালোচনা

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১৮.৩ প্রবন্ধের সংজ্ঞা, বৈশিষ্ট্য ও লক্ষণ

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১৮.৫ প্রবন্ধের শ্রেণিভেদ

১৮.৫.১ বস্তুনিষ্ঠ প্রবন্ধ

১৮.৫.২ ব্যক্তিনিষ্ঠ প্রবন্ধ

১৮.৬ সারাংশ

১৮.৭ অনুশীলনী

১৮.৮ গ্রন্থপঞ্জি

১৮.১ উদ্দেশ্য

- এই এককটি পাঠ করলে বস্তুনিষ্ঠ ও ব্যক্তিনিষ্ঠ প্রবন্ধ বলতে কী বোঝায় তা জানতে পারবেন।
- এই পাঠের উদ্দেশ্য বাংলা সাহিত্যে প্রবন্ধের উদ্ভব ও বিস্তার সম্পর্কে
- আলোকপাত করা।
- এই এককে প্রবন্ধের শ্রেণিবিভাগ সম্পর্কিত আলোচনা পাবেন।
- বাংলা সাহিত্যের বিভিন্ন প্রাবন্ধিকের উল্লেখযোগ্য বস্তুনিষ্ঠ ও ব্যক্তিনিষ্ঠ প্রবন্ধ সম্পর্কে জানতে পারবেন।

১৮.২ প্রস্তাবনা

প্রবন্ধচর্চা একালে খুব প্রতিষ্ঠা লাভ করলেও এই সাহিত্যিক প্রকরণটির চর্চা নিতান্ত আধুনিক নয়। এর সুদীর্ঘ ধারাবাহিক ঐতিহ্য আছে। এই এককে তারই একটি সংক্ষিপ্ত বিবরণ দেওয়া হয়েছে। প্রবন্ধের সংজ্ঞা ও বৈশিষ্ট্য আলোচনা এবং বাংলা সাহিত্যের প্রথম যুগের প্রবন্ধ রচনার কিছু উদাহরণসহ আলোচনা

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